Service Management Model Based on Lean Manufacturing and SLP to Improve the Service Level in a Company of the Metalworking Sector

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***Abstract*—The metalworking sector has had remarkable growth in recent years, which has a great influence on the country's economy. However, there is no adequate level of service in Peru, since it currently has 67.62%, when the standard is 85%, this originates due to several factors, the delay in the dispatch threads, non-compliance with orders, disorder in the warehouse, among others. According to the above, it is necessary to plan an adequate service management. For this reason, a service management model based on Lean Manufacturing tools (5S and Standardized Work) and SLP was developed to improve the level of service in the aforementioned sector. The model was validated through the Arena software where an increase in the level of service from 75% to 91% was obtained, a reduction in effort and distances traveled thanks to the use of SLP, and a significant increase in the audit rating through 5S. The results obtained show the effectiveness of the proposed model to improve the level of service in the metalworking sector.**

Keywords*—Level service, 5S, standard work, metalworking

I. Introduction

Nowadays, industries in the metalworking sector are in constant competition with the new demands of the world, which leads them to seek a series of factors that give them a competitive advantage in terms of efficiency and productivity (Cárdenas, Giraldo, Parra, & Sarache., 2007). In 2019, metalworking companies in Peru contribute 1.6% of GDP and 12.1% of the GVA of the manufacturing industry (Manufacturing Production Report, 2020). According to CVN (Peruvian Industry Magazine, 2019), this sector in Peru has alow capacity of 79.8%. Likewise, the level of service is67.62% (Espinoza, & Sanchez, 2021), when the standard percentage is 95% (NG LOGISTICA, 2022). This shows that there are operational restrictions and problems in the country that need to be solved.

According to the literature, in a study conducted, it is proposed that solutions to the problems of low efficiency andavailability of machinery can be obtained through Lean Manufacturing tools, thus improving its efficiency indicator by 5% (Nallusamy, 2016). In another case study, to solve the delays of finished products, it is proposed to reduce this time, a series of tools such as VSM, SMED, TPM, among others, were applied; thus, achieving an order delivery rate of 6.10% (Lorente, 2018). And finally, in another case study, the combined techniques of 5S, VSM and Heijunka (production leveling) were used, achieving a 10% increase in PCE (Process cycle efficiency) (Ahamed, & Nallusamy, 2017).

The analysis indicates that the main problem of the company is the poor management of the finished product warehouse, which is caused by inadequate warehouse and aisle design, lack of Standardized Work and disorder in the warehouse. According to the problems encountered, an improvement model was developed combining the 5S, Standardization of Work and SLP tools, all under the Lean methodology. The proposed model aims to improve the level of service in terms of quality, quantity, and delivery time.

It should be noted that the scientific articles reviewed do not contain much information on the implementation of engineering tools in the same case for this sector. Therefore, the need for this research arose. This scientific article is divided into seven parts: Introduction, State of the Art, Contribution, Validation, Conclusions and References.

II. State of the Art

A. Service Level in the Metalworking Sector

Companies in the metalworking sector continuously present a low percentage in the level of service, so the focus on the level of service provided is crucial to be able to meet and satisfy the needs of customers, likewise, it is important for the competitiveness of companies and meet customer needs (López, &Torero, 2022).

The low level of service generates deficiencies such as delays in the dispatch subprocesses, which increases the shipping time, and therefore results in a poor level of service for the customer, and increased costs for the company (Daultani, Daultani, Mohapatra, Tiwari, & Zuting, 2014). Service management in companies has a positive impact on the level of service, i.e., the customer is satisfied with his order in an adequate manner, which is related to the time needed to replenish the shelves, adequate inventory control, order fulfillment, savings in inventory optimization, which generates customer loyalty and an

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increase in customers (López, & Torero, 2022; Jorge, Marques, & Reis, 2022; Alvarez, Cano, Martínez, & Sánchez, 2020; Amorrortu, Apaolaza, Kortabarria, & Lizarralde, 2018).

B. Lean Manufacturing (5S and Standardized Work)

Lean manufacturing is a process and quality methodology that emphasizes customer needs, employee involvement and continuous improvement. Its central element is the identification and elimination of waste in all its forms (Gomez, Marchant, Seestadt, & Yerian, 2012). The 5S methodology is a tool that focuses on efficient organization of the workplace, simplification of the work environment, and reduction of waste while improving quality and safety management (Jha, & Verma, 2019). Standardized work is a tool that aims to standardize work procedures, allowing greater flexibility and production, as well as decreasing waste and assembly errors (Costa, & Bragança, 2015).

It was identified that the application of the 5S tool in various case studies reduces production cycle time, reduces non-value and inventory time, allows for better utilization of recourses effectively. In one case study, the time required for crankshaft is better utilization of resources effectively. In one case study the time required for crankshaft inspection was reduced from 101 seconds to 71 seconds for personnel 1, from 103 seconds to 73 seconds for personnel 2, from 106 seconds to 76 seconds for staff 3, from 98 seconds to 76 seconds for staff 3, from 98 seconds to 69 seconds for staff 4, 76 seconds from 96 seconds for staff 5, thereby increasing productivity (Karthik, & Silksonjohn, 2019). The application of standardized work reduces processing time, provides a better organized space, saves costs and eliminates inefficient events from each station. In one case, with the implementation of Standardized Work, a reduction in the number of workers required is achieved, from 4 to 3. Also, the displacements in the line studied are reduced and the objectives were adjusted to the actual capacity and availability of the production environment in question which allowed an increase of 16% in the average overall efficiency of the line (OEE) (Antoniolli, Ferreira, Guariente, Pereira, & Silva, 2017). Finally, according to Silva and Vega (2022), with the implementation of 5S and Standardized Work, it was possible to reduce the order return rate from 8.99% to 4.95% and to reduce costs from 13.26% to 7.30% of revenues.

C. SLP

Systematic Layout Planning (SPL) is a tool used to organize a workplace by locating areas with logical relationships close to each other, while allowing the rapid flow of material with the least amount of handling time (Nagi and Altarazi, 2017). Likewise, it stands out as a successful tool, especially for improving productivity, operation control and material handling (Lista *et al.*, 2021). The efficiency of the enterprise design and interrelated productivity can affect the throughput, quality and overall productivity of the system (Suhardi *et al.*, 2019).

The application of SPL, in one of the cases, reduced the total material handling cost by 22.92 % and material transfer time by 34.01 % (Suhardi *et al.*, 2019). In another, there was better space utilization by 22 %, reduced material flow from 320 m to 140 m, decreased fuel cost to $127.92, decreased diesel carbon footprint to 440.4 kg and decreased electricity cost to $1200 (Atir, Fahad, Naqvi, Shehzad, & Zubair, 2017). Likewise, Seminario and Soto (2022), seek to increase productivity in a metalworking company, so through the implementation of the SLP, they managed to reduce the process route to 75.64 meters, which meant a reduction of 27.83 minutes of cycle time, resulting in a decrease of up to 32.92 days per year.

III. CONTRIBUTION

A. Base of the Model

The articles collected show the application of the techniques described above in comparison with those used in the present investigation, all this is shown in Table I.

TABLE I. COMPARISION MATRIX OF CAUSES OF THE PROBLEM VERSUS THE STATE OF THE ART

Causes / Articles	Inadequate warehouse design and corridors	Lack of standardization	Warehouse disorder
Jha, & Verma (2019)			5S
Alves, Carvalho, Monteiro, (2017).		Standardized work	
López, & Torero, (2022)	SLP		5S
Silva, & Vega, (2022)		Standardized work	5S
Huamán, & Poma, (2022)	SLP		5S
Proposal	SLP	Standardized work	5S

B. Proposed Model

This research work proposes a model is proposed to improve the level of service based on the tools of Systemic Layout Planning (SLP), 5S and standardized work, as can be seen in Fig. 1. To develop it, we will start with the application of the VSM to identify the improvement points of the process. The Pareto diagram will be used for this purpose. Then, the SLP tool will be implemented to organize a workplace by locating areas with logical relationships close to each other. Next, the 5S tool will be implemented, which focuses on efficient organization of the workplace, simplification of the work environment and waste reduction. Then the standardization of work will be implemented which reduces processing time, gives a better working space, saves costs and eliminates inefficient events from each station. Finally, we will evaluate the indicators of the implemented proposal, the results obtained and evaluate whether the proposed objectives were achieved. The INPUTS and OUTPUTS of the process will be detailed in order to better understand the case study. The INPUTS of the model are the historical data and the low service levels. The OUTPUTS would be an optimal level of service.

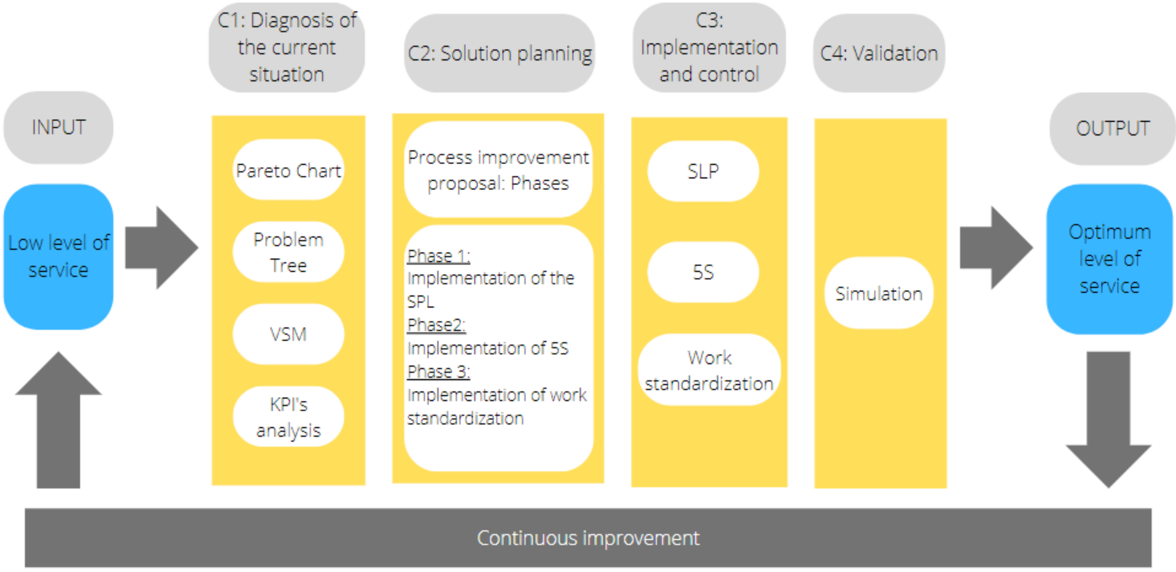

Figure 1. Proposed model

C. Model Components

1) Component 1: Diagnosis of current situation

In this component, a previous data collection is carried out taking into consideration the company's problems. With the data, an analysis of the most important KPIs will be made and the Pareto diagram will be used to determine the most frequent causes. Next, the root causes are found in the problem tree and, finally, a VSM of the process is elaborated in order to have a better understanding of the process.

2) Component 2: Solution planning

The project is organized, the work teams are formed and the tasks and objectives to be achieved with the implementation of each tool are distributed. The phases are developed in which the implementation of the tool is developed for each one.

3) Component 3: Implementation and control

The three phases are developed. The implementation of the SLP tool is carried out, with the objective of redesigning the workplace in a more efficient way. Then the implementation of the 5S tool is carried out, to help to have a more organized work area complying with different standards, which also influences the reduction of time in the development of each activity. Finally, the standardization of work is implemented to standardize the different activities that occur in the process and to reduce time and costs.

4) Indicators

For the present investigation, the following will be used indicators, which will make it possible to evaluate progress and verify the improvements obtained.

- Service level: The percentage of the number of orders that a company can fulfill in relation to the customer's request while meeting all the requirements.

$$\% \, Servicel \, Level = \frac{Orders \, delivered \, on \, time, complete \, and \, with \, good \, quality}{Orders \, delivered} \times 100\%$$

The traffic light scorecard shows that a percentage below 70 % is a critical value. A value between 71% and 85% is an acceptable level. An efficient value is those above 86%.

- Effort: It is the weight of the order over the distance traveled per order.

$$\text{Effort} = \frac{Order \, Weight}{Distance \, covered}$$

- Audit rating: It is the total score over the maximum audit score.

$$\% \, \text{Audit Rating} = \frac{Total \, Score}{Max \, Score} \times 100\%$$

The traffic light scorecard shows that a percentage below 70% is a critical value. A value between 71% and 85% is an acceptable level. An efficient value is those above 86%.

- Cycle time: It is the time of the activities to pack the product of the order.

$$\text{Cycle Time} = \text{Sum of times of each activity}$$

The methodology that was followed in this article was the analysis of the sector, with which the technical gap was found, to then analyze the problem, with which a service management model was developed based on different tools, for its Arena software was used for validation.

IV. Validation

In the present research, the validation of the proposed improvement was performed using Arena software.

A. Initial Diagnosis

Upon analyzing the company's current situation, it became evident that the company's general problem is the low level of service in the lighting fixtures manufacturing line, due to non-compliance with order delivery times and incomplete orders. After the analysis, a service level indicator value of 75% was obtained. All these inefficiencies cost the company S/. 139808.38, which represents 12.3% of the total cost. A detailed analysis was carried out, where the first cause, noncompliance in order delivery times, represents 53%, which was generated by long trips in the search for product, the root cause being the inadequate design of the warehouse and aisles, as well as the loss of time in the preparation of orders, due to the lack of standardization of work. On the other hand, incomplete orders were caused by the difficulty in identifying finished product, due to the disorder of the warehouse.

B. Validation Design and Comparison with Initial Diagnosis

For the validation of the proposed model, a pilot test was carried out for 3 months to evaluate the impact of the 5S tool. Likewise, a simulation of the SLP methodology was carried out to achieve a reduction in effort and distances traveled. Also, of the standardization of work to reduce the cycle time. Below are the current indicators of the company area versus the expectation that we propose after the implementation and simulation of the model as shown in Table II.

TABLE II. Current Comparison Matrix Versus Expectated

Indicators	Current	Expectation
Service level (%)	75	91
Effort (Kg-m / month)	67.180	56.214
Distance (meters)	30	22,78
Audit rating (%)	49.6	94.4
Cycle time (min)	4.08	3.06

C. Simulation of Improvement Proposal

The implementation of the model was developed thanks to a simulation done in arena software in order to corroborate the efficiency and validate the implementation of the improvement. Two simulations were carried out, one for the current process and the other for the process with the implemented improvements. The representation of the current and improved model is showed in Figs. 2 and 3 below.

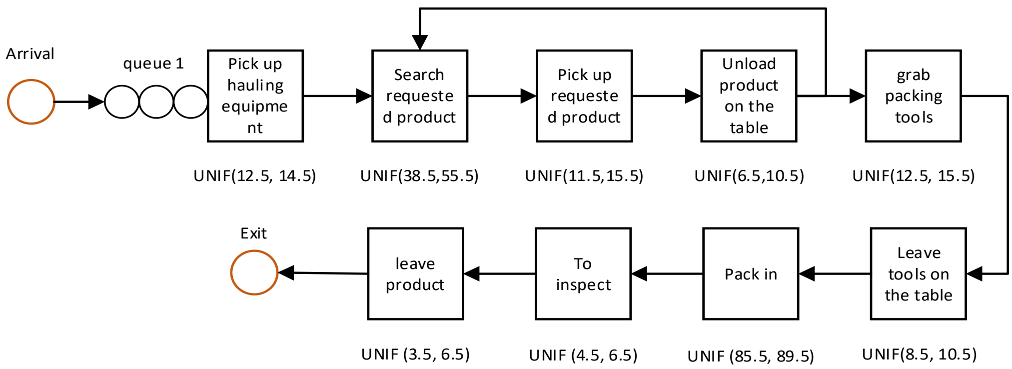

Figure 2. Representation of current model

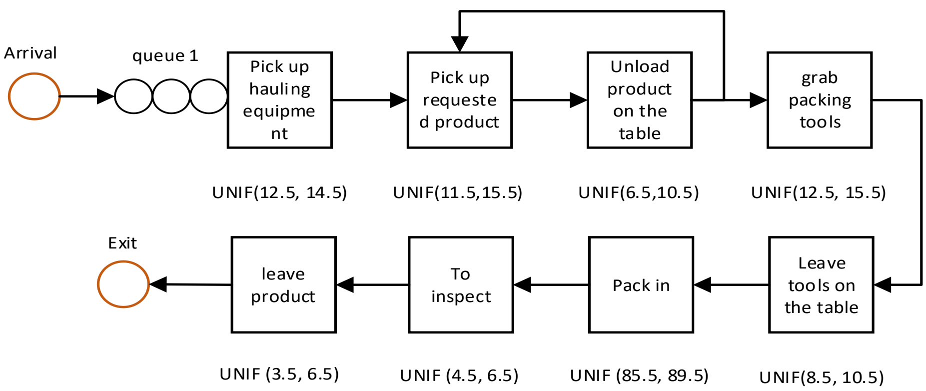

Figure 3. Representation of improved model

In the second simulation, the cycle time was improved thanks to the implementation of 5S thanks to the order, in addition to using SLP it was also possible to reduce times thanks to a redistribution of the warehouse based on the products that are most invoiced in the company. In addition, the standardized time tool was also used, which helped to establish the procedures for placing an order in a safe, fast and efficient manner. The results are shown in the following Table III.

TABLE III. CURRENT VERSUS IMPROVED SITUATION

Indicators	Current	Improved
Service level (%)	75	95
Effort (Kg -m / month)	67 180	54 242
Distance (meters)	30	22,78
Audit rating (%)	49,6	87.2
Cycle time (min)	4,08	2,94

Thanks to the information obtained, it is possible to see an improvement in each of the proposed indicators of up to 20%, which validates the improvement model proposed in this research.

V. CONCLUSIONS

An analysis shows that by improving the indicators, the level of service improved by 20%, and the redistribution of the plant improved by 19%, since unnecessary routes were eliminated and the areas where the greatest amount of effort is made were placed closer together.

The audit rating improved by 37.6%, rising from the current rating of 49.6% to 87.2%.

For the standardized time indicators, it can be seen that there was a 28% improvement in the cycle time per product.

It can be concluded that the model implemented is successful in companies in the metalworking sector if the factors to be improved are cycle time, distance traveled or effort.

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHOR CONTRIBUTIONS

Arazely Melendez conducted the standardized work and 5s implementation; Emilio Garofolin conducted the SLP implementation and simulation models; Arazely Melendez conducted the data collecting, both wrote the paper and had approved the final version.

REFERENCES

Adil Ahamed, M., & Nallusamy, S. 2017. Implementation of lean tools in an automotive industry for productivity enhancement-A case study, ***International Journal of Engineering Research in Africa***, vol 29: 175–185. Doi: https://doi.org/10.4028/www.scientific.net/JERA.29.175

Aleaga, A., Garcia, A., Herrera, I., Huaca, M., Lorente, L., Montero, Y., Orges, C., & Saraguro, R. 2018. Applying lean manufacturing in the production process of rolling doors: A case study, *J. Eng. Appl. Sci.*, *13*(7): 1774-1781. Doi: https://doi.org /10.3923/jeasci.2018.1774.1781

Altarazi, S., & Nagi, A. 2017. Integration of value stream map and strategic layout planning into DMAIC approach to improve carpeting process, ***Journal of Industrial Engineering and Management***, vol. 10, no. 1: 74-97. Doi: http://dx.doi.org/10.3926/jiem.2040

Alvarez, I., Cano, P., Martínez, J., & Sánchez, D. 2020. Inventory management practices during COVID 19 pandemic to maintain liquidity increasing customer service level in an industrial products company in Mexico. ***Advances in Science, Technology and Engineering Systems***, vol. 5, no. 6: 613-626. Doi: https://doi.org/10.25046/aj050675

Antoniolli, I., Ferreira, L, Guariente, P., Pereira, T., Silva, F. 2017. Standardization and optimization of an automotive components production line. ***Procedia Manufacturing***, vol. 13: 1120-1127. Doi: http://dx.doi.org/10.1016/j.promfg.2017.09.173

Atir, M., Fahad, M., Naqvi, S., Shehzad, M., & Zubair, M. 2017. Energy management in a manufacturing industry through layout design, ***Procedia Manufacturing***, vol. 8: 168-174. Doi: http://dx.doi.org/10.1016/j.promfg.2017.02.020

Bouzona, M., Lista, A., Mostafad, S., Romeroe, D., Tortorella, G. 2021. Lean layout design: A case study applied to the textile industry, ***Production***, vol. 31. Doi: http://dx.doi.org/10.1590/0103-6513.20210090

Bragança, S., & Costa, E. 2015. An application of the lean production tool standard work. ***Jurnal Teknologi***, vol. 76, no. 1: 47-53. Doi: http://dx.doi.org/10.11113/jt.v76.3659

Cárdenas, D., Giraldo J., Parra, J., & Sarache, W. 2007. Procedure to evaluate manufacturing strategy: applications in the metal-mechanic industry. A***dministration books***, vol. 20, no. 33: 103-123. Available: https://revistas.javeriana.edu.co/index.php/cuadernos_admon/article/view/4085

Daultani, Y., Mohapatra, P., Tiwari, M., & Zuting, K. 2014. A synchronized strategy to minimize vehicle dispatching time: A real example of steel industry. ***Advances in Manufacturing***, vol. 2, no. 4:333-343. Doi: https://doi.org/10.1007/s40436-014-0082-1

Eldiana, J., Rahmaniyah, A., & Suhardi, B. 2019. Facility layout improvement in sewing department with systematic layout planning and ergonomics approach. ***Cogent Engineering***, vol. 6, no.1. Doi: http://dx.doi.org/10.1080/23311916.2019.1597412

Espinoza, N. & Sanchez, P. March 2021. Implementation of lean and logistics principles to reduce non-conformities of a warehouse in the metalworking industry. ***Proceedings of 10th International Congress on Technology and Industrial Management (ICITM)***, 89-93. Doi: 10.1109/ICITM52822.2021.00024.

Evaluating last mile dispatch efficiency. 2022. ***NG LOGISTICA***. Available*:* http://www.emb.cl/negociosglobales/articulo.mvc?xid=3849&srch=nivel%20de%20servicio%20&act=4&tip=3&xit=

Gomez, E., Marchant, K., Seestadt, J., & Yerian, L. 2012. A collaborative approach to lean laboratory workstation design reduces wasted technologist travel. ***American Journal of Clinical Pathology***, vol. 138, no. 2: 273-280. Doi: http://dx.doi.org/10.1309/AJCPE0PI2ENWYWMU

Jha, S., & Verma, R. 2019. Implementation of 5s framework and barriers modelling through interpretive structure modelling in a micro small medium enterprise. ***International Journal of Recent Technology and Engineering***, vol. 8, no. 3: 7010-7019. Doi: http://dx.doi.org/10.35940/ijrte.C6041.098319

Jorge, D., Marques,P., & Reis, J. 2022. Using lean to improve operational performance in a retail store and E-commerce service: A portuguese case study. ***Sustainability (Switzerland)***, vol. 14, no. 10. Doi: https://doi.org/10.3390/su14105913

Karthik,S., & Silksonjohn, J. 2019. A case study of 5s implementation in inspection process. ***International Journal of Mechanical and***

Production Engineering Research and Development, vol. 9, no.3: 1469-1476. Doi: http://dx.doi.org/10.24247/ijmperdjun2019154

Kortabarria, A., Apaolaza, U., Lizarralde, A., Amorrortu, I. 2018. Material management without forecasting: From MRP to demand driven MRP. ***Journal of Industrial Engineering and Management***, vol. 11, no. 4: 632-650. Doi: http://dx.doi.org/10.3926/jiem.2654

López, C., & Torero, C. 2022. ***Lean Warehouse Model to Improve the Level of Service in a Distribution Center of a Commercializing Company in the Beverage Industry***, WCSE Proceedings.

Manufacturing Production Report. 2020. ***Peruvian Ministry of Production.***

Nallusamy, S. 2016. Enhancement of productivity and efficiency of CNC machines in a small-scale industry using total productive maintenance. ***Int. J. Eng. Res. Africa.***, vol. 25: 119-126.

Peruvian Industry Magazine. 2019. ***National Society of Industries.***

Seminario, C., & Soto, A. February 2022. Production model based on total productive maintenance and systematic layout planning to increase productivity in the metalworking industry. ***Proceedings of 11th International Conference on Industrial Technology and Management,*** Oxford, Reino Unido.

Silva, D., & Vega, D. 2022. Improvement proposal applying standardized work and 5's to reduce the rate of returned orders of a poultry company under the pdca cycle. ***Proceedings of 7th North American International Conference on Industrial Engineering and Operations Management,*** Orlando, Florida, USA.