Restructuring the Receiving Area in the AAR Aircraft Services Company: Designing Different Layouts, 3D Models and Inspection Process Improvement

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***Abstract*— AAR Aircraft Services Company is a leading provider of products and services to the aerospace, government and defence industries located in Saudi Arabia. The AAR Aircraft Services Company maintains different plane types for different Airlines. The Receiving Area is facing complexity in receiving and inspecting the ordered parts/material by the mechanics. In this paper, the focus of the study is to provide two different alternative layout models for the Receiving Department in order to streamline the receiving procedure and improve the inspection process. The first proposed layout model was designed in order to utilize the dropping area outside the Company building. While the second proposed layout was to redesign the current receiving area. Engineering Sketchup and Revit Software were used to make the 3D designs for the first and second proposed layouts respectively. Additionally, Material handling techniques were used as a methodology in order to optimize the efficiency of the two proposed layouts. Furthermore, tangible results and improvements were founded while implementing this paper. Namely, the number of WIP shelves in the receiving area increased by 36%, and the mechanics personnel capacity increased by 11.4%. Finally, several recommendations were founded while working in this paper.**

***Index Terms*—inspection process improvement, receiving department layout model, complexity**

I. Introduction

AAR is a leading provider of products and services to the aerospace, government and defense industries. The Company was incorporated in 1955 and today has revenues of more than two billion dollars with approximately 7,000 employees in 17 countries. AAR has a diverse and balanced portfolio of aviation services and technology products (About AAR, 2013). The AAR Aircraft Services Company provides maintenance service for several Aircraft Companies for different plane types and different Airlines (customers), e.g. Air Canada, ILFC, USAIR, Virgin AME, and Hawaiian. Examples of the plane models are: A319, A320, A321, B737, B757, and B767. Materials, parts, and items are requirements for the Maintenance Department in order to accomplish its job. Ordered materials are categorized as repairable, expandable, and consumables. The orders that are created by the Purchasing Department in the AAR Company are for the Company Storage (stocks) or orders created on behalf of the customers. However, some orders are created by customers themselves and received by the AAR Company. Orders that are received in the Receiving Department are categorized into five categories: Aircraft on Ground (AOG), Aircraft on Move (AOM), Priority, Routine, and Stock. The purpose of categorizing the packages is to identify the shipping method, such as expedited or standard shipping.

The inspection procedure requires updating the AAR Company System (IMOPS) with the package details. The system will notify the Maintenance Department about the package and whether it is ready to be used (stored in the WIP). However, some of the customers require updating their own system as well with the packages orders e.g. USAIR. The most important phase in the inspection procedure is that the received package must be certified and fulfill the order requirements; otherwise, it will be considered as discrepancy (returned) and will be stored in the discrepancy cage.

II. Literature Review

Over thirty years ago, Heskett *et al*. (1973) described the main aspects of warehouse design under three broad headings of determining the requirements, designing the material handling systems, and developing the layout. The sequence of these three broad stages can be found in most of the subsequent literature. Apple (1977) observed that the designer (of facilities) faces a complex task because of the interactions and relationships between each design activity, and suggested a 20-step procedure for facilities design that can be adapted to the 12 steps shown in Table I for warehouse design. Firth *et al*. (1988), Hatton (1990) and Mulcahy (1994) follow a similar approach to the previous authors, but also incorporate features such as the recognition of the warehouse in the overall distribution network, and the comparison of alternative approaches. This basic framework of steps is also set out in Rowley (2000) and Rushton *et al*. (2000), where Oxley was a contributor or

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co-author. In the former publication, a further step is included, namely the use of computer simulation, to test the impact of different volume throughputs and to identify the consequences on the rest of the supply chain. It is stressed that although the steps are set out in sequence, the overall design process is iterative in nature. Govindaraj *et al*. (2000) and Bodner *et al*. (2002) used ethnographic study techniques to identify how experts actually design warehouses. They focus on the procedures that are used by designers and experts in the field, trying to understand the decisions they make and the processes they follow when developing a design project. They state that the designer must consider some very complex tradeoffs. Four to five steps are identified in these papers, plus the need for reiteration of these steps. The authors state their future intention to use these steps to develop computational aids for warehouse design.

III. Problem Statement

The growth and expansion of AAR Company resulted into an increase in the number of packages received for inspection. IMOPS System is used for storing information regarding the parcels such as, content, weight, dimensions, and clients. When packages are received, AAR must update the IMOPS System and sometimes reenter the same information details in the customer system e.g. USAIR or others. This is considered as burden in the inspection process. Moreover, most of the orders are created by default, as an AOG instead of categorizing them properly. It is done in this way to secure that the order is to be considered urgent and to be available soonest. This behavior put a great pressure on the inspection process in the Receiving Department, because such orders must take priority and inspected immediately. Moreover, workers from the Maintenance Department sometimes enter the receiving area and ask for AOG package to be inspected because it is essential to do their work. The orders that are categorized as AOG are expedited for shipping. The fact is AOG packages are received in the Receiving Department and not inspected for days; because some of these packages should have not been ordered under AOG category. Therefore, miss categorizing of AOG orders result in an overhead cost and not useful for some orders, which lead to higher inventory level. On the other hand, the dropping area space outside the company building is not fully utilized. Also, the current receiving area is not designed effectively to provide an optimum receiving procedure. All these concerns and issues lead to increase in the inspection process cycle time and reduce the efficiency of the whole procedure.

IV. Methodology

The Material Handling techniques were used to optimize the efficiency of the 2 proposed layouts. To optimize the efficiency of the systems in the receiving and inspection areas, several procedures were used in designing the areas.

A. First Proposed Layout Methodology

Defining System Requirements:

- Utilize the space more efficiently to streamline the procedure of receiving the parts/ materials.
- Have at least 3 workstations in the area to inspect the dropped parts.
- Have at most three conveyer belts, one conveyer is assigned for AOG packages. The conveyer belt will enter from the outside dropping area to the current inside receiving area.
- A special stock room for storing the parts.
- Racks to store big parts for different customers.

Define and Obtain Data:

- The current system works as follows:

(a). The cargo company brings the parts from suppliers and drops it randomly in the receiving area of AAR.
(b). Personnel in the Receiving Department go outside the inspection area to the dropping area and pick up parts to be inspected.
(c). Then they move the parts to the inspection area.
(d). Finally, the inspectors do their job and store the parts on the WIP shelves or put it in the discrepancy cage if certificates were not there.

- Obtain data regarding the customer. Currently, the customers are US Airways, United Airways, Virgin, American Airlines, Air Canada, and Hawaiian Airlines.
- Obtain data about the categories of the parts being dropped at AAR. The categories are: Aircraft on Ground (AOG), Aircraft on Move (AOM), Priority, Routine, and Stock.
- Measurements regarding the site area were requested from the management in order to build the new layouts on it.

Analyze Date:

- Several issues were discovered after analyzing the data:

(a). The dropping area was used completely wrong.
(b). Parts were dropped randomly in the dropping area, for example US Airways parts may be mixed with United Airways parts.
(c). Big parts were dropped beside the small parts in the dropping area that will take more time when picking the requested parts.
(d). Parts may be outside the inspection area for days under the sun even if it is an AOG parts.
(e). There is only one entrance to the conveyer belt inside the inspection area which is considered a bottleneck especially in the peak time.
(f). Each workstation is responsible for entering the data and inspecting the parts being dropped.

Determine Operating Procedures for the New System:

- The new system should work as follow:

(a). After dropping the parts, a receiver should sort them according to their sizes.
(b). The small parts will stored on the shelves, and the big parts will be placed on the pallets.

(c). The shelves and the pallets will be divided for each customer.
(d). Then the receiver should print the associated tags for the parts.
(e). A receiver will pick the requested parts, inspect it, and then transfer it to the inspection area through the conveyer belts.

Prepare Possible Layouts: Several layouts were developed for the new dropping area that satisfies the management requirements. Factors that were considered during the design are:

- Improve efficiency of the system by ensuring the right quantity of materials delivered at the right place at the right time.
- Reduce damage of materials during storage and movement.
- Maximize space utilization by proper storage of materials and thereby reduce storage and handling cost.
- Minimize accident during materials handling.

B. Second Layout Proposed Methodology

Define System Requirements:

- Increase storage area.
- Having at least 8 workstations for inspection the parts to improve the efficiency of the system.
- Placing the shelves horizontally to place a door between 2 rows to lock them as their customers want to create a customer cage for the customers.
- Prioritize the conveyer belts and the parts being inspected in a way that will reduce the inspected time for the AOG parts.
- Assure that the received parts will be stored on the shelves.

Define and Obtain Data: The current system works as follow:

(a). Shipment arrives from vendors at the receiving area
(b). Receiver will pick the material and transfer it to the inspectors.
(c). Inspectors will inspect the parts and enter the data in the IMPOS or additional systems as requested by the customers.
(d). Parts will be moved to WIP, stock shelves, or customer cages.

- Obtain data regarding the customer. Currently, the customers are US Airways, United Airways, Virgin, American Airlines, Air Canada, and Hawaiian Airlines.
- Obtain data about the categories of the parts being dropped at AAR. The categories are: Aircraft on Ground (AOG), Aircraft on Move (AOM), Priority, Routine, and Stock.
- Measurements regarding the site area were requested from the management in order to build the new layouts on it. In addition, measurements regarding the tools, and equipment's – such as the stock shelves, big parts shelves, conveyer belt, offices, forklifts, doors, and workstation – were taken by the team.

Analyze Data:

- After analyzing the steps of the current system, several mistakes were discovered:

(a). The parts are dropped randomly outside the warehouse and remains under the sun for several hours and sometimes for several days even if it is an AOG parts.
(b). Receiver has to search in the packages for the requested parts which will take a lot of time, as the parts were dropped randomly.
(c). Receiver puts the parts on the conveyer belt, and most of the time they get accumulated – which will take a lot of time to sort and inspect them. If there is no space on the conveyer belt, the receiver puts the parts on the ground – which affects the movements inside the inspection area.
(d). Entrance to the inspection area is large and is used for storing the parts temporarily before it enters the inspection area.

- Moreover, the AOG parts must get inspected once they dropped in order to send the parts to the maintenance area as soon as possible.

Determine Operating Procedures for the New System:

- The new system should work as follow;

(a). The parts should be sorted by the customers' names from the vendors.
(b). Once they dropped in the receiving area, the parts should be transferred to the entrance of the inspection area where a clerk will sort the parts according to its priorities and print the associated tags.
(c). Then, the parts should enter the inspection area through the conveyer belt.
(d). Inspectors will enter the information in the IMPOS and/ or additional systems as requested by the customers.
(e). Parts will be sent either to the WIP windows or to the shelves.

Prepare Possible Layouts: Several possible layouts were developed using computer aided design (CAD) software, in order to give the management the choice to choose among the designs. The primary concern in any warehouse is storage space. Once knowing the space of the inspection area, it is important to estimate the amount of storage space that will be allotted in the warehouse. It is impossible to fill the entire space, since there has to be room made for conveyors, passageways, and so on. It is always a good idea to have conveyer belts as they reduce the time spent in transporting and sorting out goods inside the area. If the conveyer belts are placed well, it will be noticed that a lot of the work gets done very soon, and a lot of time will be saved as well. After removing some of the offices inside the inspection area, a huge space was found. So, the storage area will be increased inside the inspection area.

V. Design

Two layout designs were created in order to address The Receiving Department issues and problems. The goal of the two layouts is to utilize the space more efficiently

in order to streamline the procedure of receiving the parts/ material. The proposed designs of the receiving area will lead to improvement in the inspection process. The focus of the first layout is to utilize the dropping area of the company, which is located outside its building. While the purpose of the second layout is to redesign the current inspection area, which is located inside the building, in order to increase the efficiency of the whole procedure.

A. 1st Proposed Layout

The first proposed layout was assigned in order to help the company to improve the inspection process efficiency. The focus in the first proposed layout was to redesign the dropping area that is available outside the Company building. The purpose is to use the dropping area as a new receiving and inspection area. Engineering Sketchup software was used in order to make the model of the first proposed layout. Fig. 1 illustrates the floor plan of the new proposed layout. The proposed layout will facilitate the procedure of receiving and inspection by creating the following:

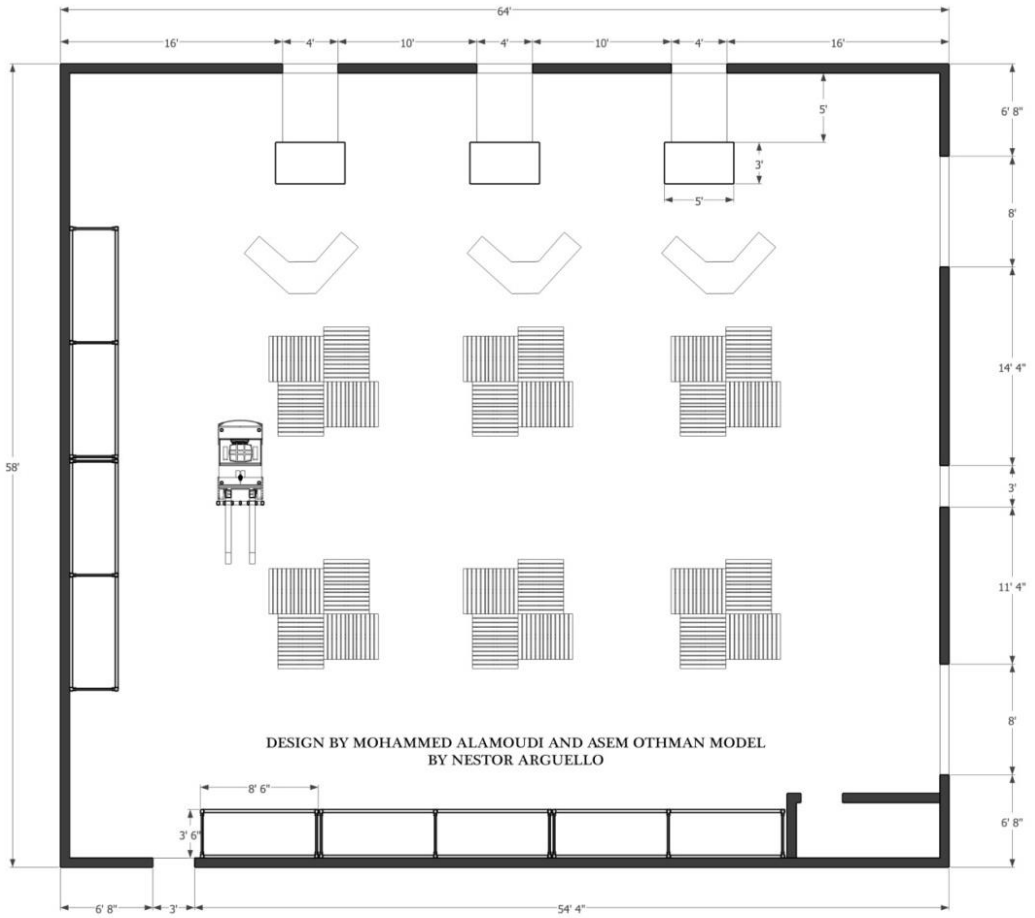

Figure 1. The 2D floor plan of the 1st proposed layout

- Six workstations to do the inspection process, which can be all activated in peak times.
- Three conveyer belts, one conveyer is assigned for AOG packages and the other two are for normal packages. The conveyer belt will enter from the outside dropping area to the current inside receiving area.
- Nine different cages with three racks for specific Airlines for big parts to be sorted. Each cage will be labeled by the name or the logo of the Airline.
- A forklift and twelve pallets to be used to lift big parts and sorted in the racks.

Fig. 2 and Fig. 3 illustrate the first proposed layout design in 3D Model.

B. 2nd Proposed Layout

The second proposed layout was to streamline the current Receiving and Inspection Area. Revit software was used to make the model of the second proposed layout. Fig. 4 shows the floor plan of the new layout. All the parts either small or big parts – will be sorted from the vendors or the cargo truck that will drop the packages into the AAR Company, in order to save a huge amount of time. The new layout has 48 stock racks, 64 WIP racks – while now they have only 47 WIP racks - and 14 shelves for the big parts. In addition, it was taken into account in designing the aisles the movements and rotation of the hand pallet truck, in order to move them smoothly inside the area.

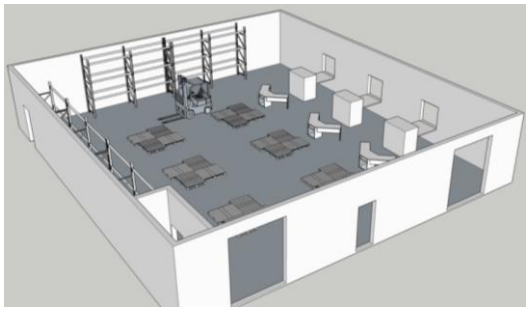

Figure 2. The 3D model of the 1st proposed layout (1)

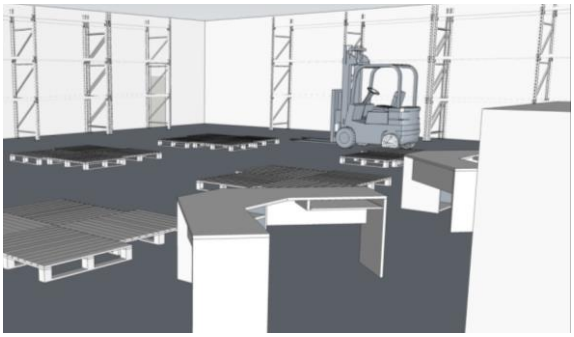

Figure 3. The 3D model of the 1st proposed layout (2)

The proposed layout will facilitate the procedure of receiving and inspection by creating the following:

- The parts will be dropped in front of the receiving area.
- The big parts that will be stored for more than four days will go to the big parts storage directly.
- A clerk will sort the parts according to its priority – AOG parts will precede the other parts – and send it through the conveyer belt to the inspectors in the inspection area.
- Inside the inspection area will be four conveyer belts branched from the original one, and each belt will have two inspectors on it. The first two belts will be for the AOG parts particularly, and the other two will be for the regular parts.

After inspecting the parts and entering its data to the IMPOS and/or additional system, the receiver will store the parts either on the big parts shelves or on the small parts shelves – small parts shelves will be divided into WIP shelves or stock shelves.

VI. Picking Process

A. Current Picking Process

While the mechanics are working on the planes, they need parts in order to install or use it in maintaining the planes. The current picking process consists of several steps;

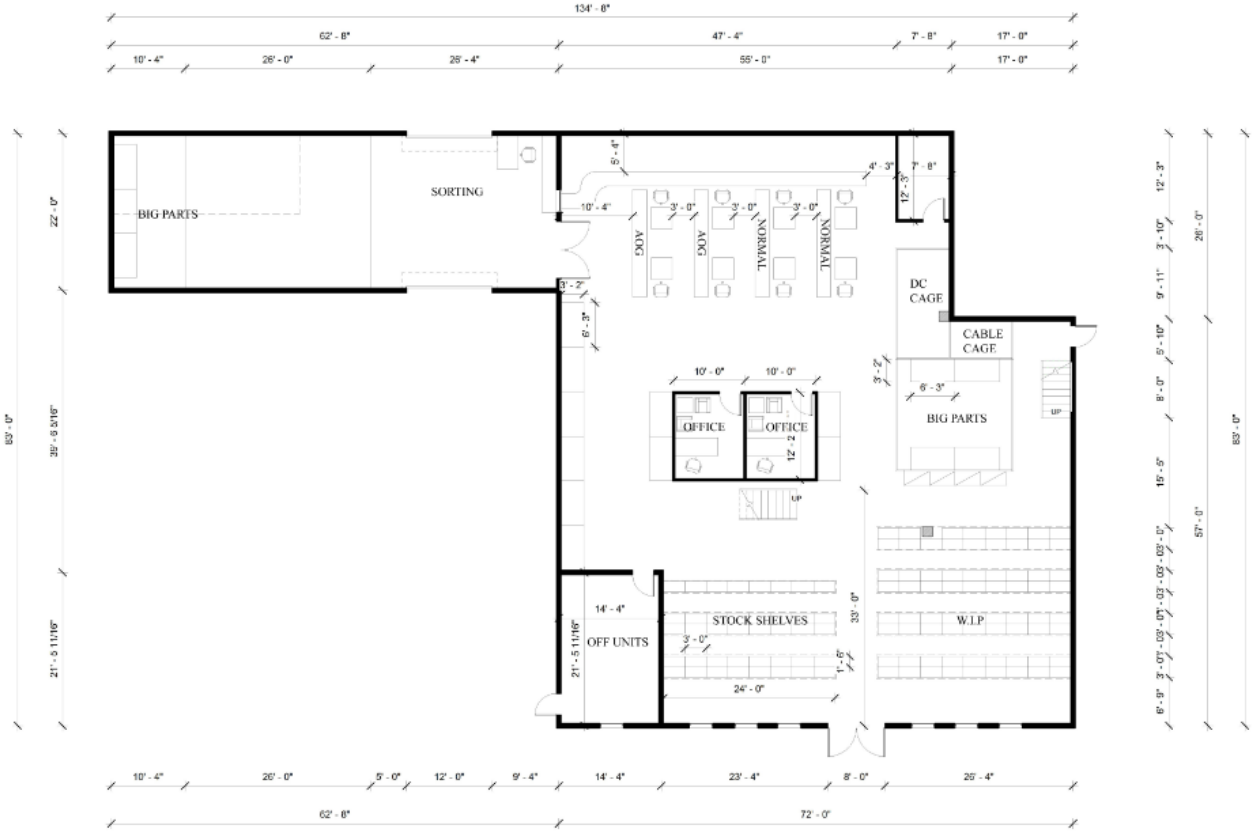

Figure 4. The 2D floor plan of the 2nd proposed layout

- When the plane arrives to the maintenance area, the mechanic goes to the plane and start working on it.
- While he is working, he will notice that some parts are required for the maintenance, so he will go to the WIP windows in order to ask for the part and

get it. The time it takes the mechanic to reach the WIP window is 5 minutes.
- After he asked for the required part, he is going to wait on average for 2 minutes in order to bring the part for him. The clerk inside the inspection area will search for the required part and bring to the mechanic.
- After that, the mechanic will get back to the plane and start working. Again the time it takes him is 5 minutes.

The total time that the mechanic lost while the plane is idle is 12 minutes just in picking the required parts. In addition, mechanics visit the WIP window 4 to 5 times per shift. So, from the prospective of industrial engineering a picking process was proposed to the AAR management that will save a huge amount of time and money.

B. Proposed Picking Process

At AAR, they consider each plane that should be maintained as a single project that need a supervisor to mentor the activities of the project in order to assure that everything will run smoothly. The proposed picking process consists of several steps:

- After inspecting the parts, the inspector will sort on the shelves all the essential parts that are needed for the coming plane. The shelves will have a tag that represents the plane name, task number, and the quantity.
- When the plane arrives to the maintenance area, the supervisor goes to the WIP window and picks the cart that has all the required parts for the plane only once.
- When he reaches the plane, the mechanics go to the cart and pick the required parts. The cart will be there until they mechanics finish their job on the plane.

So, if the management of AAR applies the proposed picking they process, they will save 12 min X 4 times/ shift = 48 minutes/shift/ mechanic instead of wasting this time. So, if the saved time is divided by the total minutes per shift – 7 hours/ shift X 60 = 420 minutes/ shift – the result is 11.4%. This percentage represents the increase that occurs in the capacity of mechanics in each shift.

VII. RESULTS

A humongous amount of time in the Maintenance Department was saved after implementing the 2nd proposed layout. Where, each time the personnel require essential parts to do maintenance spent on WIP windows on average 12 minutes waiting. It was founded that on average each personnel visits the WIP windows 3 to 4 times a day. However, fulfilling the second proposed layout requirements will allow the supervisor to pick the required parts for the maintenance service for a specific plane once at time. The AAR facility works 24/7 and 365 days a year. Each day is divided into 3 shifts, each shift is 8 hours, and the number of personnel differs from shift to shift. But on average 300, 300, and 150 personnel are in the first, second, and third shifts respectively. The 2nd proposed layout investment cost the AAR $40,000. But return on investment will be by saving 48 minutes per personnel per shift. Table I illustrates the savings that the AAR Company acquired after implementing the layout in one-year timeline. Table I shows that the AAR Company will save $21,000 a day and therefore will save $42,000 in two days. This means, the AAR Company will be able to cover the expense of implementing the layout in two days only.

TABLE I. TOTAL SAVINGS AFTER IMPLEMENTING THE LAYOUT

Shift	# of personnel	# of hours per shift	Avg. daily # of visits to WIP	Avg. # of hours spent on each visit	Personnel Wage Rate / hour ($)	Savings / year ($)
1	300	8	4	0.2	35	3,066,000
2	300					3,066,000
3	150					1,533,000
Total						**7,665,000**

VIII. RECOMMENDATIONS

A number of recommendations that we came up with should be applied at the Receiving and Inspection areas in order to help AAR to streamline the jobs and the time required. The recommendations are;

- AOG+1 or AOG++ could be added to system to be used in order to break the routine of ordering AOG.
- Mark the package (FedEx or Courier Company).
- Barcode scan for regular items (most frequent ordered).
- Dispatch AOG orders as soon as possible that require entering details in the customer systems and do it in idle times.
- Each product should have a bar code. So by scanning them, the data will enter to the computer automatically.
- The shelves should be divided for each customer – each customer will have several numbers of shelves – in order to reduce the time of sorting.

- In addition, each conveyer belt should be assigned for a specific customer each time in order to reduce the time of sorting the parts.

The first and the closest shelves and conveyer belt should be assigned for the AOG parts in order to reduce the time for inspecting them and delivering them to the WIP area.

IX. Conclusion

In any industry, be it big or small, involving manufacturing type work, materials have to be handled as raw materials, intermediate goods or finished products from the point of receipt and storage of raw materials, through production processes and up to finished goods storage and dispatch points. Materials handling as such is not a production process and hence does not add to the value of the product. It also costs money; therefore it should be eliminated or at least reduced as much as possible. Based on the need to be of optimum design and application specific to different type of industries, materials handling can be as diverse as industries themselves. As a consequence, unfortunately, there is no universally accepted definition of materials handling. One of the definitions adopted way back by the American Materials Handling Society is: Materials handling is the art and science involving the moving, packaging and storing of substances in any form. It is referred to as an art and science because to most of the materials handling problem no unique solution exists and more than one solution may be prescribed. Moreover, materials handling has already been referred to as a system, and it will be repeated many times in future. At AAR, the most important requirement is improve the process of the parts being received and the process of inspecting them. In addition, several requirements were mentioned, such as; efficient and safe movement of materials to the desired place, supply of materials at the desired rate and storing of materials utilizing minimum space. The foremost importance of materials handling is that it helps productivity and thereby increases profitability of an industry. A layout for the receiving area was proposed to the management of AAR that will ease and mitigate the process of receiving the parts being dropped. Moreover, the proposed layout utilizes the space of the area in an efficient way. In addition, the new layout will streamline the inspection process, and storing the parts. Another layout was developed for the both receiving and inspecting the parts being dropped from the vendors or the cargo companies. The layout will improve the process of receiving, sorting, inspecting, and storing the parts. The layout increase the storing area of the WIP shelves by 36% - increased from 47 shelves to 64 shelves. Also, it contains 48 stock shelves, and 14 big parts shelves. In addition, the mechanics personnel capacity increased by 11.4%. Moreover, several recommendations were mentioned that might help others to apply it or seek for solutions.

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