INNOVATION PROCESS IMPROVEMENT – A BEST PRACTICE APPROACH

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ABSTRACT

Many process improvements attempt to predict and measure but lack a systematic and scientific process of verification and validation. This paper proposes an innovative idea to improve the packaging claiming area in Dubai airport using a best practice approach which integrates discrete event simulation modelling and several lean tools such as value stream mapping (VSM), Kanban system and Pareto analysis. This will allow a thorough examination of the proposed improvements and also permit quick verification and validation without any financial implication. The obtained results proved the feasibility of the proposed innovative idea in this paper and the concerned performance measure are improved massively. In addition, the introduction of the Kanban Cards and operating in a pull system environment make the arrival terminal at Dubai airport as a state of the art terminal.

Keywords: lean tools, innovation, process improvement, best practice

1. BACKGROUND

The Dubai government's diversification is from a trade-based oil country to an extended empire of import and export sectors and other services. The diversification has made Dubai a world centre and a number one destination for work, business, investment and leisure, resulting in a property boom from 2004 to 2014. In November 2015, Dubai won the Expo 2020 over many competitors. The theme of Dubai's World Expo is 'Connecting Minds, Creating the Future' and its focus is on three areas: sustainability, mobility and opportunity, which are the key drivers of global development (Dubai Airport, 2015). All of these activities have attracted millions of people to visit and live in Dubai; the statistics from Dubai Airport indicate that the 2010 total passenger inflow of 47.26 million increased to 78.01 million passengers in 2015 (Dubai Airport, 2016).

The above development process has occurred on a huge scale and accordingly has caused a dramatic rise in the quality and efficiency requirements in airport operations, which has required the rapid enhancement of security measures. This puts pressure on passenger service levels and retail income as a consequence of longer waiting times at departure check-in and as well as arrival security check points.

2. INTRODUCTION

Continuous change is characteristic of the majority of processes; therefore modelling a large, complex process can be an intimidating task. Discrete event modelling is the process of describing the behaviour of a complex system as a series of well-defined and ordered events, and works well in virtually any process where there is variability, constrained or limited resources, or complex system interactions (Rockwell Automation, 2016). Modelling is the process of describing the physical system in mathematical terms (Doeblin, 1998); the response refers to the solution of the model that identifies the behaviour of the physical system. Simulation is a method to imitate a real life situation in the form of a model that may be based on a mathematical formula. This model is subjected to different inputs and disturbances, if any, to monitor and record the output. Value stream mapping helps an organisation identify the non-value adding elements in a targeted process. This technique is similar to process mapping, which is frequently used for planning in organisations. In some cases, value stream mapping can be used in the first stage to identify areas in which to target kaizen events for process improvement. Rother and Shook (1999) provided a suitable approach and a practical guide tool for lean implementation. VSM has become the preferable methodology for lean practitioners. In addition to lean tools, several performance metrics have been developed to evaluate improvements in lean implementation, such as overall leanness evaluation. The term leanness describes the process of lean principles (Wan and Chen, 2008); in other words, leanness defines whether or not the company is lean. Many authors and lean practitioners argue that attention must be focused on how to make the company lean rather than on whether the company is lean or not (Wan and Chen, 2008).

3. THE METHODOLOGY: BEST PRACTICE APPROACH

The study objective is to improve the airport process by implementing an integrated system that combines lean tools and simulation modelling. There are eight steps in the proposed methodology to achieve the objectives of the present study.

a. Define the performance indicators for the airport as targets for improvement.
b. Design the process flow for passengers.
c. Carry out survey and data collection.
d. Verify and analyse the present state by value stream mapping and identify the non-added value.
e. Demonstrate the present state using simulation modelling.
f. Identify the gaps and define the problem.
g. Verify and analyse the proposed solution in its future state by value stream mapping.
h. Demonstrate the future state by modelling and simulation.

It has been found that there will be five main performance indicators namely: total queue time; throughput (passenger out); completion time; total number in the queue; and utilisation, corresponding to speed, quality, dependability, flexibility and cost respectively as shown in figure 1. The speed can be seen from the total time that each passenger takes between arriving and being reunited with his luggage and leaving the airport. The quality is determined by the number of passengers processed during the total processing time. Dependability can be determined from the completion time —whether it is short or long—in addition to other factors indicating reliable process flow and equipment. Flexibility can clearly be seen from the total number in queue of all passengers; this can be a sign of bottlenecks during peak times. It will normally contradict utilisation. High utilisation means low flexibility and vice versa. Finally, the cost is related to the full utilisation of the process: it is also related to most of the other factors in the simulation models developed in this paper.

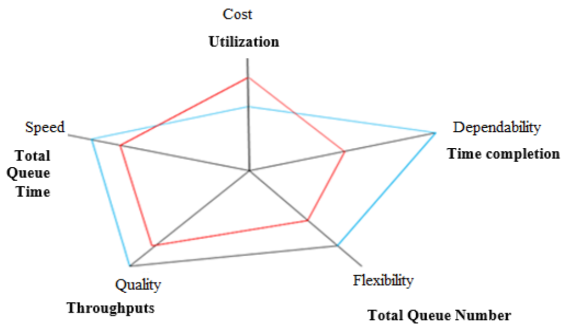

Figure 1: Five performance indicators (Slack et al., 2007)

Several lean tools introduced in the next section indicated several gaps in the area of validation and process improvement. The methodology used in this case study presents an integrated based approach that combines simulation and modelling with lean tools.

In addition, the methods are carefully selected based on their advantages and disadvantages for validation, as well as on the plan to complete this research. Value stream mapping involves gathering information from customers or from the airport as primary data. These collected primary data would be in terms of passenger flow, capacity of the airport and the process time taken.

4. ANALYSIS OF THE PRSENT STATE

In its present state, the complete passenger flow in the terminal building, from check-in to boarding and from de-boarding to luggage claim, as seen in Figure 2, has been analysed by value stream mapping before being modelled in a simulation arena. Two models have been distinguished based on the origin and destination of the passengers.

Once the passenger has completed his de-boarding from the aircraft, he will need sometimes to walk based on Dubai airport or any large international airport for around 10 to 15 minutes until he crosses the passport point and the security checks. Following that, the passenger needs to wait in the luggage claim area for around 20 minutes and up to one hour. The process time is calculated from the time the passenger enters the airport until he is out of the airport.

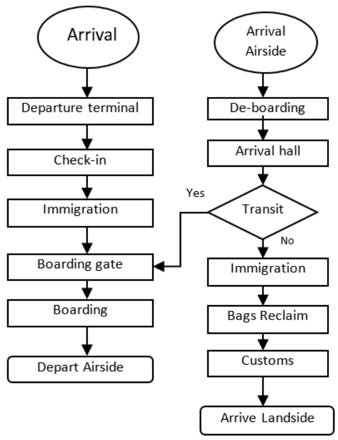

Figure 2: Process of passenger handling

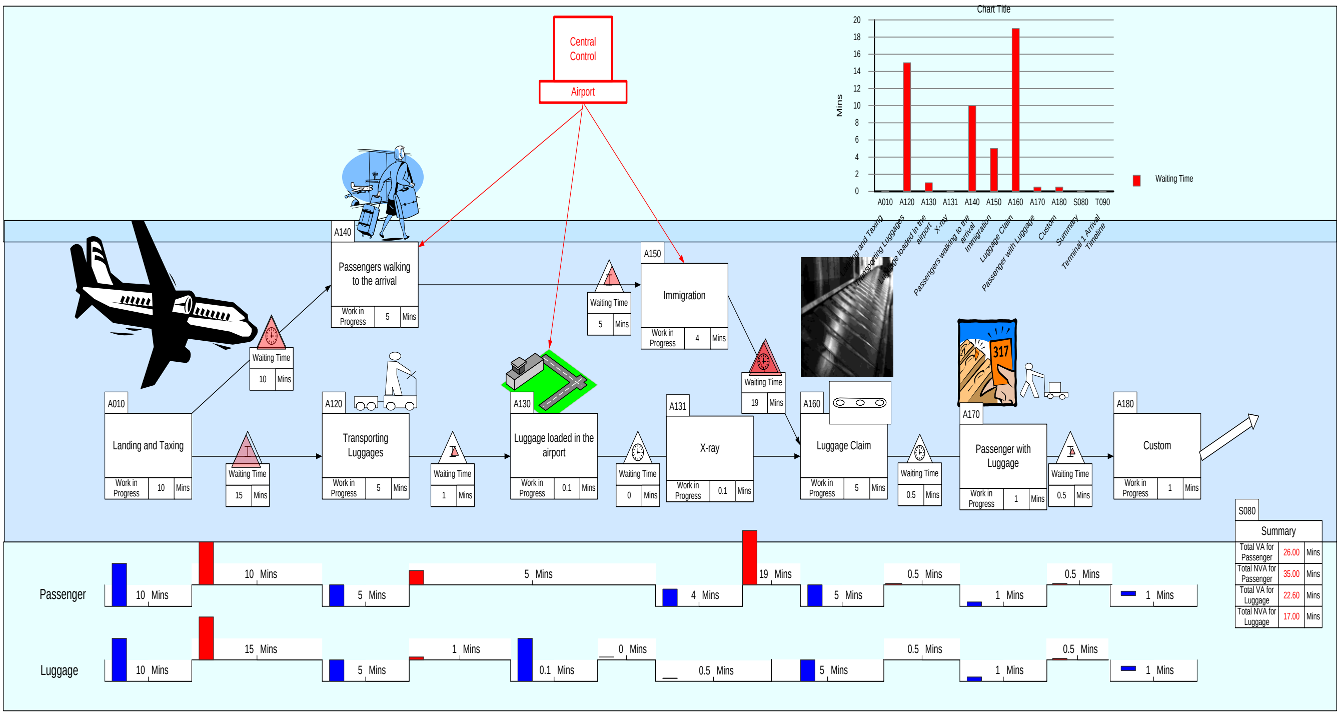

Figure 3: VSM for present state on arrival

In Figure 3, the model for the present state of arrival focuses on luggage claim, passenger handling, immigration process time and the time taken by passengers to complete the process.

In Figure 4, the e-VSM software can generate more than one piece of data in the same bar; this will indicate the ratio between the waiting time and the work in progress. From this figure, the work in progress is shown to be quite good and optimised. Therefore, the direction for focus will be on the waiting and queuing times.

Figure 4 also shows that the longest waiting time is in luggage claim, followed by transporting of luggage and then waiting in the immigration queue. To analyse this further, a Pareto analysis was applied and is displayed in Figure 5. From the Pareto analysis, it is seen that around 80 per cent of the non-value added and the maximum waste time is found in luggage claim and the transport of the luggage. The need for a better solution has now become obvious.

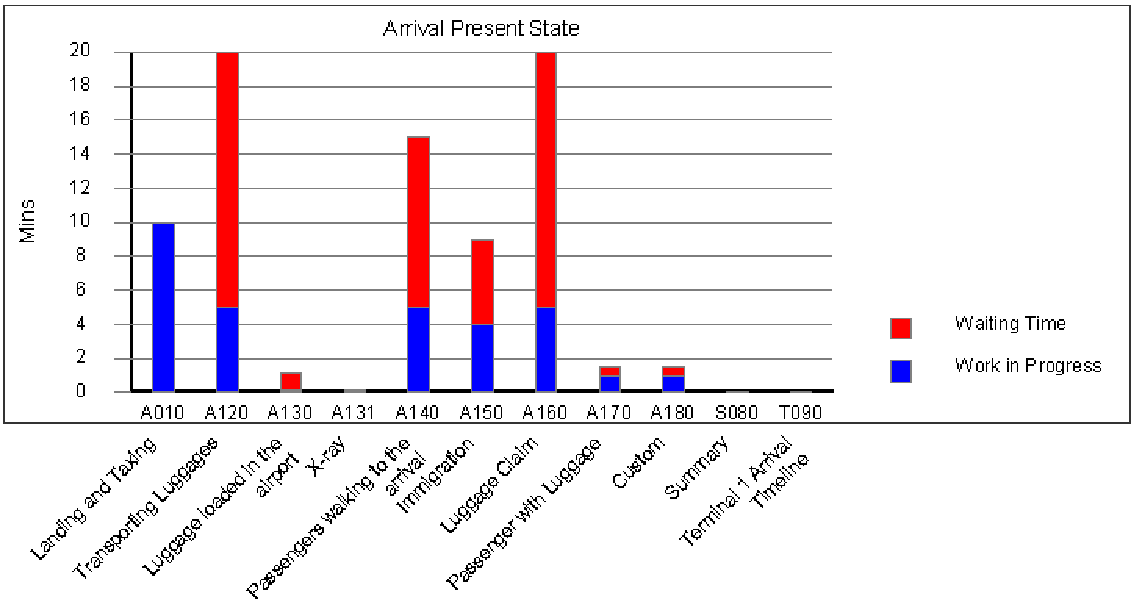

Figure 4: Arrival present state chart

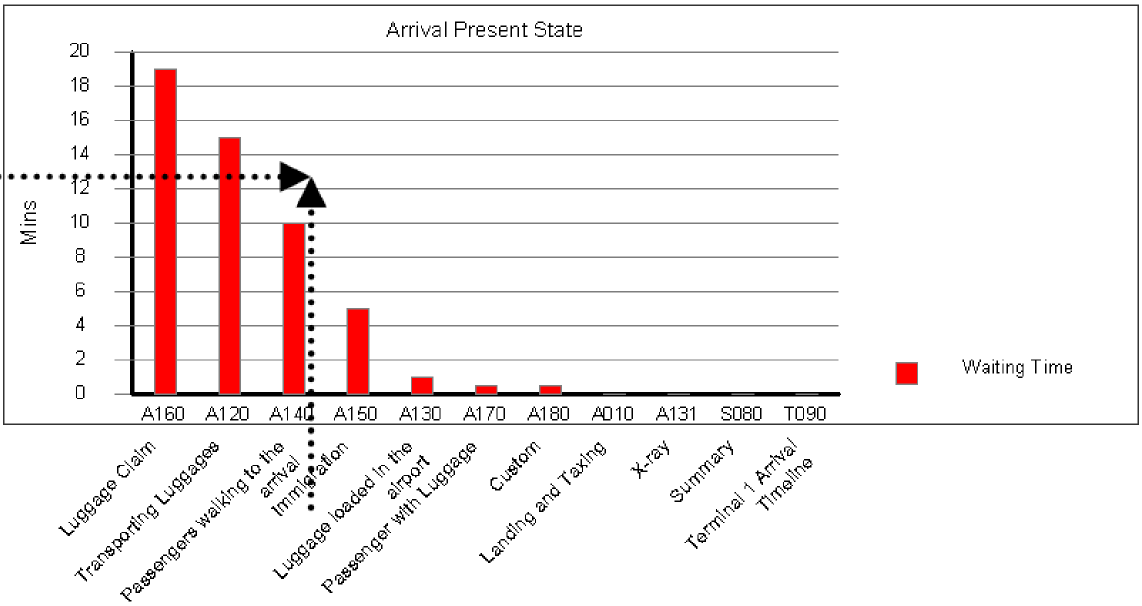

Figure 5: Pareto analysis

5. DEMONSTRATION OF THE PRESENT STATE

Figure 6 demonstrates the arrival present state simulation model, each passenger is reunited with his luggage in the luggage claim area after completing the immigration process. Finally, at the end, a customs point checks the passengers on their way out. The value stream mapping visualises two types of flow: the flow of the luggage and the flow of the passengers.

The VSM identifies the non-value added and the waiting or wasted time, and opens the space for improvement and corrections (Freire and Alarcón, 2002). The simulation will validate and determine the physical dynamic behaviour of the process modelled and will help in making decisions.

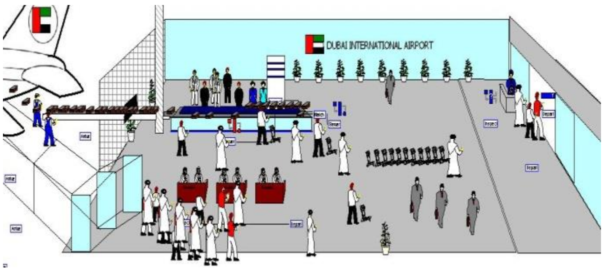

Figure 6: Present state on arrival

6. ANALYSIS OF THE PROPOSED SOLUTION

The VSM shown in Figure 7 analysis the proposed innovative idea and the opportunities of the airport to adopt the concept of the shortest distance between two lines as one straight line.

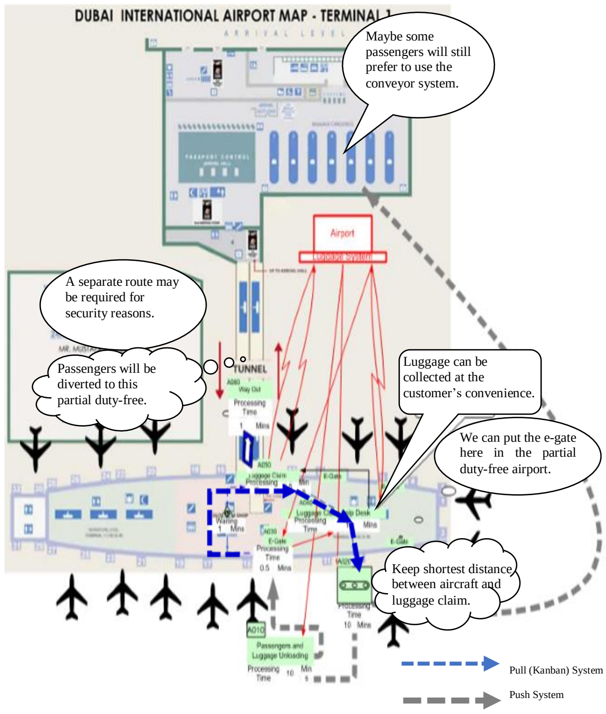

Figure 7: Overview of VSM for future state in arrivals terminal

The process starts from the aircraft tagged with A010, as all process blocks in the stream mapping need to be tagged. The process blocks in the VSM are: aircraft (A010); conveyor belt (A020); e-gate (A030); luggage claim help desk (A040); luggage claim (A050); and way out (A060). The flows of the passengers and luggage are indicated as a push method: once the passenger reaches the airport and after crossing the e-gate, he can be diverted to the duty-free area where his luggage will be waiting for him in the luggage storage. The passenger will need to use state-of-the-art technology—based on kanban methodology, a pull method (Ohno, 1988)—to request a claim for luggage so that the system will notify the robot arms to unload the luggage from the storage unit to the checkout counter. The blue dot lines correspond to the kanban (pull) system and the thick grey arrows indicate the push method. After performing the request at the luggage claim counter, a signal will be sent to the storage area for arranging and, at the same time, information will be displayed on a large screen for those passengers who have requested their luggage giving the counter checkout number in sequence.

In Figure 8 shows the present timeline for arrival; it takes a minimum of one hour to leave the airport. This may be extended to more than two hours during peak times and accumulated delays.

However, it is expected that the timeline for arrival in future state will be shorten massively and the minimum time required for the passenger to complete his process and reach the exit is 35 minutes. However, after some adjustments, this was corrected to 41 minutes by simulation.

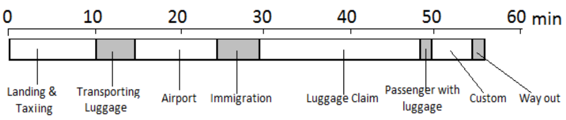

Figure 8: Time line for arrival present state

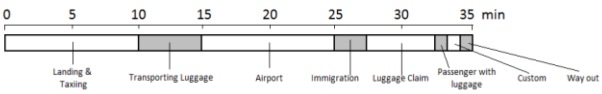

Figure 9: Time line for arrival future state

7. DEMONSTRATION OF THE PROPOSED SOLUTION

The proposal suggests full automation of the handling system similar to Amsterdam airport (Hullegie, 2006) but with storage units for baggage. The concept here is for the luggage to wait for the passenger and not for the passenger to wait for the luggage, so fully automated state-of-the-art technology will be used as the best and most innovative systems, including replacing the conveyor belt with a storage unit that will be loaded and unloaded through robot arms (as seen in Figure 10).

In Figure 11, the proposed simulation model uses a match block to match the passengers and their luggage, with careful disposal of one of the outputs to eliminate the second entity being displayed, always required when dealing with a match block. There are two robots for loading the storage unit, each piece of luggage takes approximately 15 seconds to be loaded by the robot. This value is taken from a similar application where the storage unit is not foreseen. Due to the limited space at airports, this innovation is much needed. In addition to a reduction in operational costs, increased capacity and the adoption of more security regulations will meet customer satisfaction.

Figure 10: Luggage handling by robot at Amsterdam airport (Hullegie, 2006)

The passengers reach the airport within ten minutes. After e-gate facilities and passport counters, they are diverted to the duty-free area. Once the passengers arrive there, a counter for calling the luggage can be used, and as soon as the name of the piece of luggage and each passenger’s identification number is displayed on the wide screens, they will be required to check out at the counter, with an indication of which counter number they need to approach.

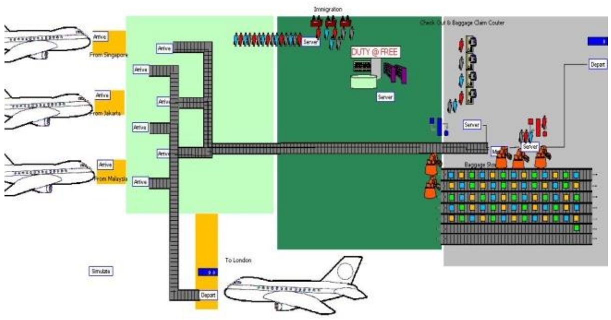

Figure 11: Overview of the proposed replacement of the conveyor luggage with counter and robots

The output of the two simulation models shows the flow of the passengers and luggage; waiting times and other performance indicators; the tally time; the utilisation; the queue time; and the queue number. This information was sent to the output file by Arena Simulation Software. The output file shows the dynamics of the luggage and passenger handling. From the overview chart, the bottlenecks and their causes can be determined. In addition, it estimates the boundaries between which the performances of the luggage and passenger flows are considered to vary.

Figure 12 shows the utilisation in several processes. The utilisation in immigration is around 53 per cent and in customs 17 per cent. However, the remaining utilisation is very poor; this is because all passengers are depending on the process that delivers the luggage to the conveyor belt.

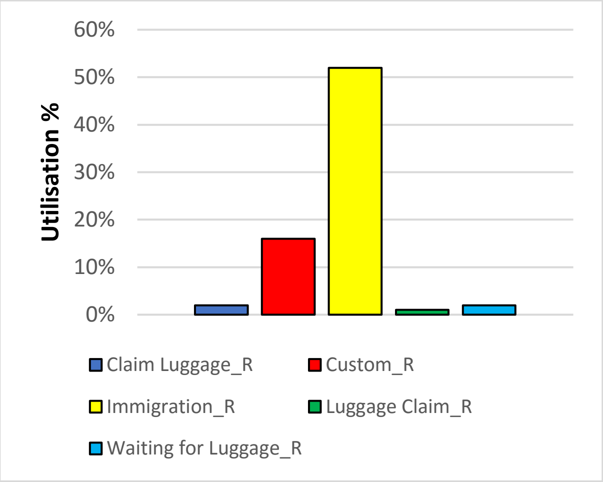

Figure 12: Arrival present state: utilisation schedule

In Figure 13, the total number seized is always 72; this is because the total number of passengers for this model was 72 passengers and 72 pieces of luggage. Total number seized in luggage claim process simulation was 144 because this is a combined process of passengers and luggage. However, the luggage claim resources shown in figure 13 recorded as 115 which indicate long queue for luggage claim.

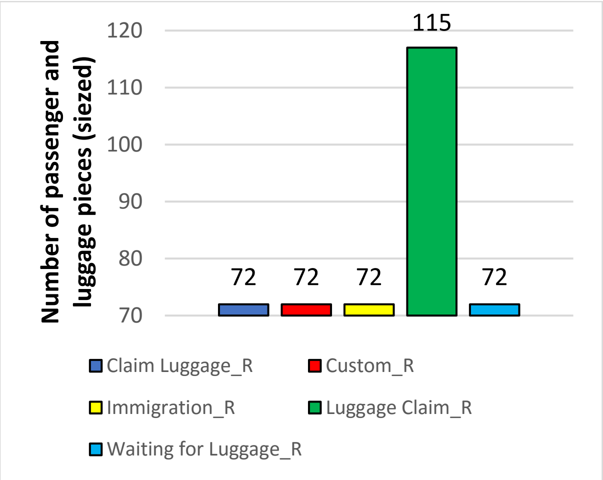

Figure 13: Arrival present state: total number seized

In Figure 14, the future state utilisation increases significantly in all aspects of the process—for example, the luggage claim control centre is 20 per cent, where the present state was less than one per cent. The robot used for loading and unloading the luggage is between 33 per cent and 44 per cent, as the number of robots is reduced, increasing the time of loading, but the overall utilisation increases. It is also noted that immigration in the present state is similar to the future state; however, the overall utilisation in immigration increases slightly from 53 per cent to 57 per cent. This can be regarded as the free path of the passengers in the downstream of the process.

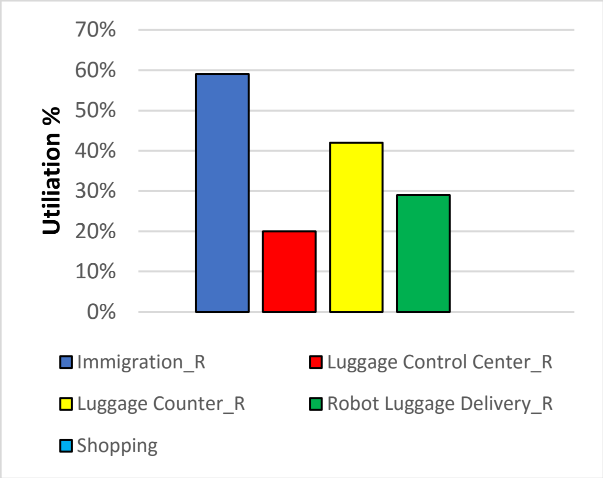

Figure 14: Arrival future state: utilisation schedule

The free path created was the duty-free area, where no queue was required. The passengers can wait in that area until they receive notification from the wide screen noting their ticket details for luggage collection.

In Figure 15, the total number seized was 72 and it was constant for all the processes; this indicates a smooth flow from the start of one process to the end.

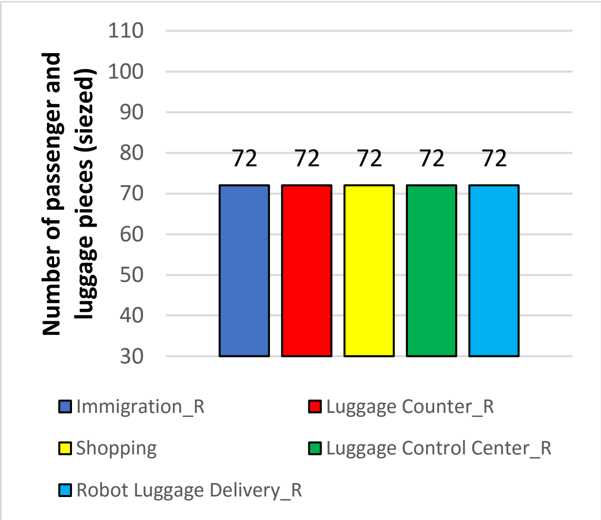

Figure 15: Arrival future state: total number seized

In Table 1, the total time for the 71 arrival passengers at the present state completed in 63 minutes (one passenger is rejected by security): the first passenger to exit the airport was recorded at 32 minutes. The throughput was 71 or 72 in 65 minutes. In the future state, the throughput was 72 in 41 minutes; the first passenger to exit the airport was recorded at 18.5 minutes. The queue time for the present state was 34.5 minutes as a maximum, and 17.25 minute as an average for the immigration process. The future state showed an improvement, as the queue time was reduced to 26.5 minutes maximum and 3.2 minutes average. The maximum queue number was recorded as 54 and 62 for the present and future states respectively. This is due to the fact that in the future state the waiting time and the arrangement of waiting seats or shopping was foreseen.

Table 1: Passenger Exit Airport and Immigration Queue Time

Simulation for Arrival	**Present State**	**Future State**
Total Passenger	72	72
Number of Passenger exit airport	71	72
Time of First passenger exit airport	21 min	18.5 min
Time of all passenger exit airport	63 min	41 min
Immigration Max queue time	34.5 min	26.5 min
Immigration average queue time	17.25 min	3.2 min

The results in the arrivals at the present state and future state can be compared by the percentage of utilisation in various process. In present state, the percentage of utilisation of the immigration counter is 53 percent whereas in future state is 57 percent. In the present state, the utilisation of luggage claim is less than one percent and custom is 17 percent. In the future state, the percentage of luggage claim counter is 20 percent and the luggage checkout counter is 43 percent. The performance greatly enhanced because three robots are applied in the luggage claim system and two more in the loading area.

The reduced capital requirement shows no change in the present state. However, in the future state, the speeding up of the luggage handling process by the automation of the luggage system, and the increase in utilisation overall, combined the two processes of luggage claim and security into one process. This reduces the cost and the space and increases the space for duty-free shopping.

In summary, the case study proved that, with the help of the proposed best practice approach, any idea can be examined and tested. The results obtained from the models were satisfactory considering the minimum data provided for this project.

8. CONCULUSIONS & RECOMMENDATIONS

The following ideas were generated and examined in this paper.

1) Replacing the conveyor belt in the luggage claim area at the arrival hall in an airport. This can be done by moving part of it or most of it away from the visibility of the customer upstream in order to have better control. This is called the material decoupling point in supply chain management (Olhager, 2012), and extends the information decoupling point downstream to the customers/passengers to deliver accurate information about their luggage arrivals. This will lead to customer satisfaction and will shorten the time and the distance between the passengers and the aircraft.

2) Using check-in counters as checkout counters, by applying the reverse flow path of luggage—what can be sent to the aircraft can be received in the same way. This needs a storage buffer for the luggage and can be designed to store the luggage temporarily. Once the passenger arrives in the arrival hall, he or she will approach a calling point for luggage—a push button that will send a signal to the computer, calling for the luggage to be unloaded from the storage shelves. The storage unit will be equipped with robot arms that will be able to upload and download the luggage to the shelves and identify the luggage location through a sophisticated intelligent system such as **r**adio frequency identification (RFID). The storage unit will be able to read and identify the luggage and will be triggered by the kanban system. The kanban system is based on a pull command from the passenger: once the luggage is called, the kanban card will be created and sent to the computer system for the luggage unit to unload the called luggage.

3) Once the passenger arrives at the airport, the flow path can be redesigned in order for the passenger to wait for the luggage while visiting the duty-free shopping areas. A liquid-crystal display in the form of LCD screens can be located in many areas displaying information about the flight and the luggage arrival status and general information guidelines.

4) In order to avoid delays at take-off because of passengers not showing up in the boarding area, there should be zones for uploading luggage according to the availability of the passengers to avoid unloading the luggage of a passenger who did not show up in the boarding hall. Adopting a 'last in, first out' policy should not reward the late attendance of passengers.

5) Incremental change is always the safest approach in adopting a process improvement. The introduction of the checkout counters can be implemented parallel to the conveyor belt arrangement to ensure a smooth change and to allow for any corrections needed during the implementation process.

6) Bringing the airport to the city means that passenger will not need to perform the check-in or drop-in luggage process once he has decided to travel. Airport branch counters for specific airlines, for example, can handle partial loads that stress the entire system in the airport. This is already implemented: for example, check-in can be done through the internet, and drop-in luggage in the present practice of some of airlines is one or two days before departure. The passenger can go to any branch and drop his luggage after security checks. However, in the

authors' opinion, the system has not yet been proved. The airport can also be brought to the city by extended and express transport between the airport and the city, as at Heathrow Airport, where express trains can transport the passengers from central London to the airport terminal in ten minutes. Another way of extending the airport to the city is to bring life to the airport by extending buildings to be used for general exhibitions, as implemented in Dubai Airport, where most of the biggest exhibitions are conducted on the airport premises. Expanding the areas shared by the public and the passengers at the check-in counters—circulation areas in BAA's terminology (Edwards, 1998)—can be useful and the same system can be carefully implemented in the arrival process. However, for security reasons, it may not be practical to allow a mixture of arriving passengers and the general public before the customs point.

7) Door-to-door delivery service. Many passengers—especially those who are returning to their homes—would like to avail themselves of this kind of service. This would shorten their arrival process time and reduce the load in the airport arrival section. A door-to-door service is available in some countries like the United States, which ensures the delivery of luggage on a next-day basis, or within 48 hours.

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