Using Lean Six-Sigma in the Improvement of Service Quality at Aviation Industry: Case Study at the Departure Area in KKIA

T. M. Al Muhareb, J. Graham-Jones

Abstract—The service quality is a significant element in aviation industry especially in the international airports. Through this paper, the researchers built a model based on Lean six sigma methodologies and applied it in the departure area at KKIA (King Khalid International Airport) in order to assess it. This model characterized with many special features that can become over the cultural differences in aviation industry since it is considered the most critical circumstance in this field. Applying the model of this study is depending on following the DMAIC procedure systemized in lean thinking aspects. This model of Lean-six-sigma as a managerial procedure is mostly focused on the change management culture that requires high level of planning, organizing, modifying, and controlling in order to benefit from strengths as well as revoke weaknesses.

Keywords—Lean-six-sigma, Service quality, Aviation industry, KKIA (King Khalid International Airport), SERVQUAL.

I. INTRODUCTION

AS a managerial procedure of continues improvement(CI), lean-six-sigma is considered a process that can improve services or products continuously in order to achieve high product/service quality, competitive costs and reduced delivery times, leading to the satisfaction of customers [1]. The aviation industry nowadays requires continuous improvement to raise the levels of customers' satisfaction. This satisfaction can be achieved through many managerial procedures (such as lean-six-sigma procedures), in order to ensure the business's viability. Airports are complex organizations whose areas of comparative advantages and efficiency hinge on elements that the airport management is more likely to control and on applying the lean six-sigma philosophy in such areas. This will ideally result in the optimization of resources, efficiency in performance and the continuous gradual reduction of all forms of waste [2].

This research considers the application and possible implementation of lean six-sigma in the aviation sector, with specific consideration of King Khalid International Airport

T. M. Al muhareb worked at King Khalid International Airport (KKIA) in Saudi Arabia, and he is with the Department of Mechanical and Marine Engineering, School of Marine Science and Engineering (Faculty of Science & Environment) Plymouth University, Devon, PL4 8AA UK (phone: +447527867772; fax: +44 (0)1752 586101; e-mail: muhareb40@ gmail.com).

J. Graham-Jones, Associate Professor, is with the Department of Mechanical and Marine Engineering, School of Marine Science and Engineering (Faculty of Science & Environment) Plymouth University, Devon, PL4 8AA, UK (phone: +441752586176; fax: +44 (0)1752 586101; e-mail: jasper.graham-jones@plymouth.ac.uk).

(KKIA) as a case study. KKIA in Riyadh is one of the three main international airports in the Kingdom of Saudi Arabia (KSA). Since 1983, when it was opened, it has been the gateway to the capital of the kingdom, Riyadh. The airport is located approximately 25 kilometers away from Riyadh's city centre [3].

II. PROBLEM STATEMENT

KKIA in general and the departure hall in particular suffer from an insufficient applied quality management system. A more robust system would contribute to the identification of problems and solutions and provide a database to measure and monitor the provided quality of service and the extent of development. There is also a lack of a scientific method and modern management to determine the level of maturity in the provided quality of service. These gaps have been revealed from the analysis of the managerial procedures followed at KKIA.

This study focused on improving the quality management in the departure area at KKIA in detail, as well as creating a design of managerial model based on lean-six-sigma methodologies. The fact that KKIA operates in a vital sector is important, particularly as there are many services and businesses that operate under its care. Considerable attention has been paid to KKIA's levels of service quality, especially in the departure hall. Hence, this study focused on the improvement of the service quality in the departure area at KKIA through the use of a quality management model based on lean-six-sigma methodologies.

III. METHODOLOGICAL APPROACH

This study will use a kind of descriptive analytical methods of the case study, and evaluate the level of services LOS provided within the departure hall at King Khalid International Airport, in order to achieve the desired results of the study.

The quantitative and qualitative approaches were used to measure customers' satisfaction through the steps of implementing the lean-six-sigma procedures at the airport management. A questionnaire that is based on the SERVQUAL model was distributed among the passengers in the departure area at KKIA to assess the level of service LOS and their satisfaction. In addition to that, some interviews were conducted with managers and managerial employees in the departure area at KKIA.

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This study mainly follows the DMAIC (Define, Measure, Analyze, Improve and Control) methodology [4] by the use of different DMAIC tools. After the services had been improved, the satisfaction of customers was the main concern in the collection of data through questionnaires based on the SERVQUAL model [5]. The SERVQUAL model uses five specific criteria that recognize and evaluate the quality of service rendered. Questions were drawn from these five criteria, which can be seen as identifying the gaps between existing perceptions and expectations in terms of quality. These criteria can be viewed in relation to KKIA as follows:

- *Tangibles*: related to physical facilities, equipment and personnel.
- *Reliability*: related to the ability of personnel to perform the service accurately and dependably.
- *Responsiveness*: related to the eagerness and willingness of staff to help customers and provide prompt service.
- *Empathy*: related to the caring level that is shown by staff and the amount of individualized attention given.
- *Assurance*: related to the ability to inspire trust and confidence with courtesy due to good knowledge of the job and the needs of customers.

Those variables are used in defining the gaps of SERVQUAL model that describe the level of service quality; those gaps are as the following:

Gap 1: This gap was between passengers' expectations and the management's perception of these expectations. This gap represents the airport management's inability to determine the needs and desires of passengers. For example, the airport management expects the passengers to want better restaurants and coffee shops, but the passengers want reduced waiting times at queues in the check-in area, the passport area and the security inspection area.

Gap 2: This gap was between the management's perception of passengers' expectations and the planned level of services in the airport. This could be due to reasons such as limited financial resources or misunderstanding the basics of quality in an airport.

Gap 3: This gap was between service quality specifications and service delivery. Rules and guidelines are not translated into practice by employees. This could be a result of low-quality training and developmental strategies for the communication skills of the employees. The employees may need further training in understanding service concepts, listening to customers and completing services quickly.

Gap 4: This gap was between service delivery and communications with passengers. The promises made to passengers do not match the service delivery. For example, the agreement between the customer and the airport management is that the customer will not have to wait a long time at check-in, passport scanning and security inspection. However, when the customer arrives at the airport, the opposite can be found, without prior agreement between the parties.

Gap 5: This gap was between passengers' expectations and perceptions of services in the airport .This results from the differences between the passengers' expected level of services and the actual level they faced.

IV. RESEARCH DESIGN

The research design is illustrated in the following points based on DMAIC procedure:

A. Defining the Problem at the Departure Area in KKIA

Defining the main aims, objectives, and questions of the study by collecting some data about the status of the departure area at KKIA from different sources; this step will use each of the following tools: Observations, Voice of Customer (VOC), Critical-To-Quality Tree (CTQ tree), Value Stream Mapping (VSM), Strengthens, Weaknesses, Opportunities, and Threats (SWOT) analysis, Suppliers, Input, Output, Process, and Customers (SIPOC) process map, and Problem and Goal Statement.

B. Measuring the Service Quality in KKIA

According to the problem that has been defined in the previous step, this step will measure and collect data to determine the current level of maturity in the departure area at KKIA by the use of the following tools: Value Stream Mapping (VSM), Critical-To-Quality (CTQ): by the use of SERVQUAL questionnaires, and Conducting Interviews

C. Analyzing Problems of Departure Area in KKIA

This step will analyze the collected data by the previous step by different tools and methods as the followings: Sort, Set in order, Shine, Standardize and Sustain (5S) strategy, Statistical Analysis of SERVQUAL results, Interviews Analysis, and Cause and Effect Diagram.

D. Improving Quality at the Departure Area in KKIA

According to the defined problems and suggested solutions and procedures for the departure area at KKIA, this step will apply them and measure their influence on the level of maturity by the use of the following tools: Changing the Layout of Departure area, Queuing Theory, Increasing the number of self-service check-in kiosks, 5S (Sort, Set in order, Shine, Standardize and Sustain) strategy, SERVQUAL and statistical analysis, and VSM after modifying the departure area at KKIA.

E. Control Improvements in the Departure Area at KKIA

This step includes a suggestion of a three-year plan for other improvements in the departure area at KKIA in order to increase the level of maturity. The tools that will be used for this step is: Kaizen theory, Failure Mode and Effects Analysis (FMEA), Control plan.

V. SYSTEM THINKING

There are many goals and aims of applying lean management in any institution, such as producing needed amounts of products and services, continuous improvement for the whole institution and time management of process flows [6].

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Applying the lean-six-sigma management strategy in the departure area at KKIA was mainly done to achieve the main goals of wise management. Starting with the first aim of the lean six-sigma approach (producing only the needed amounts of products and services), this goal involves waste management. This aim could aid in decreasing the required waiting times at the different stages in KKIA, since wasting time influences customers' attitudes and satisfaction.

The next aim of lean management is continuous improvement. From a managerial perspective, continuous improvement is an important process that ensures the success of any kind of management procedure. Continuous improvement requires continuous observation of plans after the implementation of managerial views, in order to modify any problems and to encourage successful aspects. Continuous improvement is a necessary process that ensures the success of the lean six-sigma managerial procedure [6], [7]. In KKIA, this aim of continuous improvement could be achieved after applying the required changes through the airport areas, in order to maintain the success of this managerial process.

The final aim of lean six-sigma management [6] is the time management of process flows. This aim is very significant in KKIA since the long waiting times cause very big problems that face every individual in the airport.

DMAIC (define, measure, analyze, improve, and control) methodology refers to the most significant processes in lean six-sigma management [8]. These processes were implemented at KKIA as explained in the following sub sections.

A. Define

Within this process, the problem that needs to be solved is identified, including its variables, purposes and scopes. Through this step, the manager can highlight the main problem and understand its concerns.

B. Measure

This process requires the manager to find suitable methods by which to collect the required data in order to measure the real variables and effects of the problem that is defined in the previous step.

C. Analyze

Within this process, the manager must select a suitable data analysis tool for the collected data in the previous step in order to analyze them and determine the problem size in addition to find the most suitable solutions. This step provides the results required to calculate the real size of the problem.

D. Improve

According to the results of the previous process, this step aims to improve the systems that are related to the problem in order to apply the most effective solution. Following this, the "measure" and "analyze" processes must be repeated in order to ensure that the "improve" process achieves its aims; otherwise, this process has to be repeated until the most effective solution is found.

E. Control

This process involves quality assurance, which requires observation from the manager regarding the flow of the final plan, in order to ensure that quality has increased from implementation to the end of the project.

VI. CULTURE VARIABLES IMPACT IN SAUDI CULTURE

Culture in its basic essence may be outlined as a system of values and norms that are jointly shared between groups of individuals. These shared ideas form a foundation for the lifestyles of specific groups. For international companies, two or more cultures require focus at the national and structural levels. Culture influences all aspects of a manager's job, including social control design and management choices. Culture also affects negotiations [9].

The functions of managers (as the functions are people oriented) are influenced by culture. As an example, if a culture places stress on individuals being unequal in physical and intellectual capabilities, then (in line with [10]) there is a high power distance. In essence, a large gap in power between superiors and their subordinates can be expected in the present study's context of the KSA. Another necessary facet of how culture affects business management is the degree to which people have collective ties with one another. Business in the KSA is littered with collectivist thinking, which dictates that relationships are more necessary than business dealings [11].

For international companies, it is typically understood that national culture may be a significant obstacle to increasing overall structural performance. Creating structural enhancements typically needs internal cultural amendments. In the KSA, where faith influences most (if not all) areas of life, it is difficult for managers to change certain aspects of the structural culture. The Saudis' preference for social control positions is reflected by standings and positions (within the remit of national culture) [12]. While there are several sides of culture that affect management effectiveness in the KSA, faith and scheme may have the most influence.

VII. RESEARCH MODEL

In general, quality improvement studies use different approaches based on the desired quality level. The six-sigma approach is one of the most accurate quality improvements procedures that might be applied in organizations. The minimum level of accepted quality in the six-sigma approach is 99.99966%, which is considered a very high level of quality. In this study, the six-sigma approach was selected to improve quality in the departure area by using the included tools within this approach and following the DMAIC methodology, in order to increase the average profits of this area in KKIA and to increase KKIA's market share without ignoring customer satisfaction. The six-sigma approach has customer satisfaction at its core; therefore, it could be considered very suitable to the aviation industry. The main aim of using the six-sigma approach in this study was to improve the level of quality in the departure area at KKIA by

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following lean principles; therefore, the main methodology was the lean six-sigma approach.

As it is mentioned in the previous section, this study follows many methodological approaches and uses them to implement the lean six-sigma managerial approaches at the departure area at KKIA as a kind of quality management. The research design in this study follows the DMAIC five steps: Define, Measure, Analyze, Improve, and Control. And through implementing this design the researcher use many tools that follow the following methodologies: descriptive, analytical, quantitative, or qualitative approach.

The lean thinking will also be applied through implementing six-sigma approach in order to manage quality by eliminating waste and utilize the possible resources.

As a new implemented approach, lean-six-sigma procedure could not be applied in the departure area and KKIA without preparing a team who understand the main principles and philosophies of lean six-sigma procedure. Therefore, the airport managers start some training courses in order to get started into lean six-sigma implementation. This indicates that the lean six-sigma implementation in the departure area at KKIA is done by a team of professionals in this procedure. After that, the DMAIC steps were started to implement by this team. The researcher role in this implementation was in the decision making through the implementation of lean six-sigma in addition to applying some tools as a third part in this project. Therefore, this study is considered a descriptive and analytical one mainly.

Considering this study as a descriptive and analytical one for the current changes at KKIA, it requires a clear description of each step in the implementation of DMAIC procedure (six-sigma) at the departure area of KKIA.

As mentioned before in the research design, the following steps explain the model of this study:

A. Defining the Problem at the Departure Area in KKIA

The "Define" is the first step of DMAIC approach, which includes the definition and studying of the current status at KKIA to define the most significant headlines for the whole work in this study. The "Define" includes the identification of the research significance in addition to its scope and the population who will be affected by the study [13]. In order to achieve the aims of this step in DMAIC, the following tools will be used:

1) Observations

This step can be achieved by a visit to the departure area at KKIA before implementing lean-six-sigma approach in order to observe the actual state of the departure area; for referencing, the researcher can take some photos that explain the status of the airport.

2) Voice of Customer (VOC)

One of the main aims of using DMAIC approach is in the achievement of customers' satisfaction. From this point, reaching to the customers' satisfaction is linked with implementing their requirements in the organization and letting them find the desired products or services as they expected and better. Nevertheless, the improvement of services in the departure area at KKIA requires an understanding to each requirement of customers [13].

3) Critical-To-Quality Tree (CTQ tree)

CTQ, in general, is used within lean six-sigma methodology for defining the most significant features of quality that should be available to gain customers' satisfaction by transforming the Voice of the Customers (VOC) into measurable features and specifications. For that, this method has been used in this study. CTQ is achieved by three steps as followings: (a) Identifying the customers' requirements; (b) Defining the factors that influence customers and their requirements; (c) Transforming the influential factors into critical-to-quality standards [13].

4) Value Stream Mapping (VSM)

The value stream mapping is used in this step in order to map the whole processes that face passengers from their first step into the airport until they reach to their plan. This mapping can aid in defining all the processes and determining their values. However, based on this analysis, all the processes will be divided into two categories: value-added processes and non-value-added ones [13].

The aim of using this tool is in the focusing on utilizing the value-added processes and removing the non-value-added ones by considering them as a waste of available resources. For sure, these processes are analyzed according to the pre-determined CTQs in CTQ tree for the achievement of customers' satisfaction.

5) Strengthens, Weaknesses, Opportunities, and Threats (SWOT) analysis

SWOT analysis is used in the define step of the problem in the departure area of KKIA as a lean thinking procedure. KKIA has a higher population base, is an iconic inbound tourism destination and has a strategic geographic location (i.e. it has hub potential). Therefore, it is so significance to analyze its strengths, weaknesses, opportunities and threats that are required for KKIA to reach the aimed level of service LOS. It is worth to note here that all of SWOT analysis points are concluded from some interviews with the managers and leaders at the departure area in KKIA.

6) Suppliers, Input, Output, Process, and Customers (SIPOC) Process Map

The SIPOC process map is another tool that used in quality management studies which determined mainly the inputs and outputs of each process to understand the entire details of that process [13]. Through KKIA, many processes are found in the departure area at KKIA by the use of VSM in its first step in DMAIC process. The SIPOC is used only in the "Define" step of DMAIC to determine the inputs and outputs of each process. Usually, the SIPOC is used in tabulated form to show the process map for the processes in the departure area at KKIA.

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7) Problem and Goal Statement

The main aim of "Define" step in DMAIC procedure is the identification of problem statement. Based on the used tools through this step, the problems in the departure area should be clear and determined.

B. Measuring the Service Quality in KKIA

As well as "Define" step in DMAIC, "Measure" has its own tools that could continue the work to achieve the required aims in the departure area at KKIA. Through this step, the following tools will be used for this step:

1) Value Stream Mapping (VSM)

The first stage of value stream mapping shows that there are four processes influence the customers' satisfaction in the departure area at KKIA and those processes are valued ones. The waiting time that is required for each one of those steps and the available spaces for each passenger should be measured by the researcher in different statuses in order to measure the average required time and then compare this with other airports in the next steps of DMAIC with other tools.

2) Critical-To-Quality (CTQ) (by the Use of SERVQUAL Questionnaires)

In the second stage of CTQ tree, the researcher measures the pre-defined CTQs from the different perspectives in the departure area at the KKIA by the use of SERVQUAL questionnaires. However, the SERVQUAL measures the CTQs from two aspects, perceptions and expectations in order to evaluate the actual status of these services in the departure area at KKIA.

3) Conducting Interviews

In order to be honest and collect as much as possible data, the interviews are used to collect qualitative data from the managers in the departure area at KKIA. Actually, the analysis of the collected data will be introduced in the next step, "Analyze" step, but the conducting of the interviews is considered a part of the "Measure" step. However, the interviews results can support the SWOT analysis results since they are revolving around the same concepts and aims.

C. Analyzing Problems of Departure Area in KKIA

As mentioned before, the main aim of this step is to analyze the measured problems that have appeared in the previous steps and suggest some solutions to resolve them. For that, the following tools have been selected to be used in this step:

1) Sort, Set in Order, Shine, Standardize, and Sustain (5S) Strategy:

According to 5S tool, the improvements in the departure area at KKIA have to be achieved in the following manner: Sort, Set in order, Shine, Standardize, and Sustain. Starting by the "Sort" process, it can be achieved by sorting and identifying the factors influencing the process or operation. The next step in the 5S strategy is "Set in place" [13]; this is achieved by suggesting the best fitted and appropriate improvements in its proper place. By reaching this step, the 5S

tool role is finished in the "Analyze" step of DMAIC, and the other steps will be done in the "Improve" step.

2) Statistical Analysis

This tool is applied on the collected data from the SERVQUAL questionnaires that achieved in the previous DMAIC step, the "Measure" step. This part will include a test for the following hypothesis based on the collected data; "$H1_0$: There is no statistically significant difference at ($\alpha \leq 0.05$) between expected dimensions and perceived dimensions for the service offered in King Khalid International Airport (KKIA)".

3) Interviews analysis

This part will discuss the responses of managers in the interviews with the researcher, find relationships, themes and patterns of the responses, summarize the results, and derive the main points correlated to the quality of services in the departure area at KKIA.

4) Cause and Effect Diagram

The cause and effect diagram is a graphical illustration of the relationship between the factors and the required goals [13]. Through this study, the cause and effect diagram is used for determining the factors within the departure area at KKIA and its positive and negative influences on the maturity level of the departure area at KKIA. This will aid in determining the root causes of the problems in the departure area in addition to focus on the positive influencing factors.

D. Improving Quality at the Departure Area in KKIA

Through this step some solutions of the problems that found in the previous steps will be done and applied through the departure area and then their efficiency and effectiveness will be measured. The following tools are used to achieve the aim of this step which is improving quality level at the departure area in KKIA:

1) Changing the Architecture of Departure Area

Some problems may require changing the layout of the departure area in order to solve the problems that appears from VSM in the previous step of DMAIC.

2) Queuing Theory

Queuing theory can solve the space problem by reorganizing the order of passengers in waiting lines, where queuing reorders the straight lines into zigzagging ones [13].

In the departure area at KKIA, the queuing theory is used in order to use the available area and arranging crowds in front of any boarder.

3) Increasing the Number of check-in Services in the Departure Area:

The self-service check-in kiosks in the area characterize with many features make it better than traditional terminals; where electronic terminals needn't any employee, can work 24 hour by 7 days, and can achieve the required transactions quickly and accurately. In the other hand, in Saudi cultures, there are still some people who cannot deal easily with

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electronic instruments or suffered from technophobia and cannot deal easily with self-service check-in kiosks and prefer traditional ones. Also, self-service check-in kiosks might down and then traditional terminals are needed. However, as a conclusion, both traditional and electronic terminals are required in the aviation industry for the check in area.

4) 5S

According to the previous step of DMAIC, the 5S strategy is divided into the "Analyze" and "Improve". As mentioned before, 5S strategy consists of five main steps; Sort, Set in order, Shine, Standardize and Sustain. The first two steps have been done in the "Analyze" step of DMAIC; and here, the rest steps will be applied.

For the Shine step, it is realized by performing the improvements in the departure area at KKIA with the best quality and standards.

The next S is the *Standardize* which is achieved by sorting, setting in place and shining of the improvements continuously. It is done by making the audits for the running processes and the developments carried out and hence being able to find the defects in the improvements when comparing with the standards and try to standardize the process and improve it; this is referred to the sustainability and continuous development.

Finally, "Sustain" is the sustainability of the improvements in the airport which is necessary for the continuous economic growth and avoidance of the recession after being developed and enhanced. All of the stated and implemented practices and strategies are maintained by creating a culture with shared set of values [13].

5) SERVQUAL and Statistical Analysis

In order to ensure the developments in the departure area at KKIA, the service quality should be measured after modifying the area by using the SERVQUAL questionnaire and analyze it statistically.

6) VSM after Modifying the Departure Area at KKIA

Also, VSM after changing should be done in order to ensure the enhancements in time and available area for each passenger in the departure area at KKIA.

E. Control Improvements in the Departure Area at KKIA

The control of the change and the development is achieved by the continuous review of the achieved changes in the departure area at KKIA which makes the mind diagram required to understand and review the practices carried out, the regular audits of the actions taken and the standards followed along with the continuous monitoring and assessment [13].

Moreover, the control is achieved by making the culture understanding the importance of the change and hence working to develop the processes and further working to control and sustain the developments; this is achieved by the proper understand of the culture and its needs and the successful management of change.

Only some tools is described through this thesis for "Control" phase; which are:

1) Kaizen Theory

Kaizen is a Japanese word that means: Change to Good [14]. The Kaizen philosophy consists of many organization's constituents. Some of the used tools in different steps of DMAIC implementation at the departure area of KKIA are used as a constituent of Kaizen philosophy such as 5S strategy. However, it is worth to note here that the aim of using Kaizen philosophy in the departure area at KKIA is to keep up improvements and change it to the best. Therefore, many strategies will be used to collect as much as possible recommendations and suggestions for improvements from employees, work-staffs, managers, and passengers of the departure area at KKIA.

2) Failure Mode and Effects Analysis (FMEA)

The Failure Mode and Effect Analysis (FMEA) is a very effective tool) to find quick solutions by expecting the possible failures in any process or service before its occurring [13]. In the departure area at KKIA, this tool should be used in KKIA to control the services in the airport by tracking them and expecting the possible failures. This tool of control will aid in keeping the modification up by tracking all the processes in the departure area at KKIA and treating any failure immediately

3) Suggesting a Control Plan

The control plan is a strategy that can put down the main plans of the next three years at the departure area in KKIA. Here, the researcher will suggest some plans and points to be done in the airport in the next three years.

VIII. PROPOSED RESULTS

The following are the proposed results of applying the explained model in this study on the departure area at KKIA:

- Decreasing waiting times and increasing available spaces of each passenger.
- Improving the level of services LOS in the departure area at KKIA.
- Rising up the passengers' satisfactions and revoke of all the gaps that could appear in services quality.
- Using the sustainable and continuous improvements CI procedure in the departure area at KKIA more effectively.

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