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Evaluating the strategic design parameters of airports in Thailand to meet service expectations of Low-Cost Airlines using the Fuzzy-based QFD method

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Abstract:

The proliferation of Low-Cost Airlines (LCA) has phenomenally increased across the globe bringing a paradigm shift in the business model of airports specifically integrating the requirements of LCA. The current study attempts to evaluate the strategic design parameters of the airport integrating the requirements of LCA. The Fuzzy based Quality Function Deployment (QFD) approach has been utilized to conduct a House of Quality analysis for the integration of the voice of LCA in the design characteristics of the airport. The findings of the study identify evaluated design parameters of the airport for integrating the LCA requirement. It has been observed that the studied airport has been fulfilling the LCA requirements. However, few minor improvements are expected especially with regard to airside facilities, aeronautical tariff and other criteria. The study demonstrates and signifies that the Fuzzy based QFD method is a promising and pragmatic decision-making tool for customer-oriented airport strategic planning.

Keywords: Low-Cost Airlines, Fuzzy-QFD, Airport Planning, Airport Strategic Design Parameter

1. Introduction:

The aviation industry has been revolutionized by the ascendency of the Low-Cost Airline (LCA). The market share of LCA has grown unprecedentedly across the globe expanding in Europe, Oceania, South America, Asia and Australia. The rise of the LCA has make it necessary for the aviation industry to adapt and accommodate their specific needs. During the initial rise of the LCA, many secondary airports emerged to satisfy their specific needs for simple, affordable and uncongested facilities leading to the emergence of the 'Low-Cost Airport' whereas the primary airport was specifically dedicated to the legacy airlines. As the LCA became mature they began to operate from larger airports and at the same time, legacy airlines modified their business model and operational strategies to reduce cost as a response to increased competition from LCA while operating from larger airports. This led the primary airports to address the need of both legacy and low-cost carriers (De Neufville, 2008). Hence, the current situation, both low cost and primary airports need to integrate the requirements of LCA into their service offerings.

Southwest Airlines initiated the LCA model in 1970 and became one of the most successful business models in the airline industry, earning consecutive profits for 45 years as of 2017 and bringing unparalleled offerings to passengers and the economy as a whole (Anon., 2018). The first LCA in Thailand, One Two Go, owned by Oriental Thai airlines started its operations in December 2003 (Charoensettasilp, 2013). Thai Air Asia, jointly owned by Air Asia (Malaysia) and Shin Corp (Thailand), as the second LCA in Thailand in February 2004. Later Solar Air and Happy Air joined as LCA in Thailand. Nok Air, a subsidiary of Thai Airways International, began operating as a LCA in July 2004 (Pandey, 2016). Later in 2009, Thai Smile, a second subsidiary of Thai Airways

International, started its operations as a LCA (Qin, 2012). LCA in Thailand contribute 47% of total passenger traffic in 2017 at the six major Airports of Thailand (AOT) airports (CAPA, 2018). The LCA have tripled in terms of available seat kilometer (ASK) offering on Thailand domestic routes in the period 2014-2017 (CAPA, 2018).

Eventually, the increasing traffic of LCA made it necessary for airports to have an understanding of their specific needs and to integrate them into their design parameters. The specific understanding of the actual requirements of LCA would help the airport operators to render the customized service to the growing market segment of LCA in the air transport industry. This paper aims to evaluate the strategic design parameters of the Low-Cost airport in Thailand and whether they meet the service expectations of Low-Cost Airlines. The study utilizes the Fuzzy Multi-Criteria Decision Making Method (MCDM) to evaluate how well the service needs of LCA have met the expectations of LCA. Fuzzy-Quality of Function Deployment (QFD) has been employed to integrate the expectations of LCA into the technical design parameters of the studied airport rendering an evaluated design parameter of the studied airport.

The article is subsequently presented in the following sections. A brief of review of literature has been presented in section two, followed by adopted methods in section 3, findings with discussion in section 4 and finally concluded in section 5.

2. Literature Review:

2.1. Requirements of LCA from the airport:

The decision making process of airport selection for full service carriers differs from LCA as to airport charges and capacity (Berechman & de Wit, 1996). The choice factor of airport by airlines is also dependent on the airport service quality (Adler & Berechman, 2001). Apart from airport service quality other requirements of airlines encompass airport charges and night curfews (Gardiner, et al., 2005). Barrett (2004) has conducted a comprehensive study to gauge the requirements of LCA of airports and identified seven factors for airports that are attractive for LCA, namely, low airport charges, quick turnaround time, single story airport terminal, quick check-in, good catering and shopping at the airport, good facilities for ground transport, and no executive/business lounge. Another significant contribution comes from the study of Warnock-Smith & Potter (2005) in which eight LCA were surveyed in Europe revealing the differences in the airport choice factor of LCA, with the core requirement being low-cost services for all facilities. Gillen & Morrison (2003) also stressed the different requirements of LCA which prompted the airport managers to tailor their strategies to suit their needs. Gillen & Lall (2004) endorsed the existence of competition among airports facilitating LCA requirements in their service offerings and concluded that airports should have LCA oriented strategy. Francis, et al. (2003) contended that airports attract LCA on the basis of hub route offerings that emphasize the aeronautical revenue as primary. Conversely, Barrett (2004) contended that as the secondary airport is located away from the urban area, car rentals from the airport are increased. Therefore, non-aeronautical revenue increases which is compensated by a decrease in aeronautical charges levied to LCA. Lawton & Solomko (2005) identified that efficient operating conditions at the airport is the most required expectation of LCA. This is critical for decreasing of turnaround time and results in a higher aircraft utilization rate. Lu & Mao (2015) stated that the passengers of secondary airports are willing to endure inconvenient airport locations in exchange for a lower tariffs. Dziedzic & Warnock-Smith, (2016) identified the 15 airport choice factors of LCA of which the fundamental factors are related to quick and efficient turnaround facilities, convenient slot time and good aeronautical discount. Chang, et al. (2008) modeled a framework on the requirements of LCA from airports and contended that airport charges, operations hours, surface transport, terminal floor area, navigational aid and estimated demand for the destination were pertinent factors. The LCA seek to optimize their profitability by choosing an appropriate network of their routes which then leads them to choose an appropriate airport for operations (Graham, 2013).

The development of secondary airports catalyzed the growth of LCA in the US and European markets (ELFAA , 2004). Graham (2013) reviewed the academic literature pertaining to the relationship between airports and the development of LCA and concluded that the literature is inconclusive about the overall impact of LCA on airports. However, Graham (2013) identified that the LCA's choice of airport is determined by its business model. There are a few studies conducted to identify the requirements of LCA from airports; however the requirements of LCA in the Thailand context has not yet been explored and verified.

Table 1: LCA requirements from the airport

Factors	Authors
Access to airport	Warnock-Smith & Porter (2005), Chang et al. (2008), Dziedzic & Warnock-Smith (2016)
Airport Location	Graham (2013), Gillen and Lall (2004), Warnock-Smith & Porter (2005)
Labor Cost	Adler & Berechmen (2001)
Airport or Terminal Capacity	Neufville (2008), Berechman & De Wit (1996), Graham (2013), Dziedzic & Warnock-Smith (2016)
Simple Terminal Design	Barret (2004), Neufville (2008), Graham (2013), Dziedzic & Warnock-Smith (2016)
Quick Check-in Procedure	Barret (2004), Neufville (2008), Graham (2013), Dziedzic & Warnock-Smith (2016)
Passenger Demand	Neufville (2008), Berechman& De Wit (1996), Graham (2013), Dziedzic & Warnock-Smith (2016), Gillen and Lall (2004), Warnock-Smith & Porter (2005)
Airport Charges	Neufville (2008), Berechman& De Wit (1996), Graham (2013), Dziedzic & Warnock-Smith (2016), Gillen and Lall (2004), Warnock-Smith & Porter (2005)
Airlines Competition	Graham (2013), Gillen and Lall (2004), Warnock-Smith & Porter (2005)
Transport Connection	Graham (2013), Warnock-Smith & Porter (2005)
Slot times	Berechman& De Wit (1996), Gillen and Lall (2004), Warnock-Smith & Porter (2005), Graham (2013), Dziedzic & Warnock-Smith (2016)
Turnaround time	Neufville (2008), Berechman& De Wit (1996), Graham (2013), Dziedzic & Warnock-Smith (2016), Gillen and Lall (2004), Warnock-Smith & Porter (2005)
Overall Experience	Dziedzic & Warnock-Smith (2016), Warnock-Smith & Porter (2005)
Ancilliary Revenue	Francis et al. (2013), Barret (2004), Neufville (2008), Graham (2013), Dziedzic & Warnock-Smith (2016)
Privatization	Dziedzic & Warnock-Smith (2016), Warnock-Smith & Porter (2005)
Expansion plans	Warnock-Smith & Porter (2005), Neufville (2008)
Environment restriction	Graham (2013), Warnock-Smith & Porter (2005)
Cost conscious airport management	Dziedzic & Warnock-Smith (2016), Warnock-Smith & Porter (2005)
Airside facilities and equipments	Chang et al. (2008), Singh (2015)
Airport competition	Graham (2013), Warnock-Smith & Porter (2005), Neufville (2008), Barret (2004)
Maintenance Facilities	Graham (2013), Warnock-Smith & Porter (2005)
Reliable Air Traffic Control	Adler & Berechmen (2001), Chang et al. (2008), Singh (2015)
Network Strategy	Graham (2013)

2.2. Design and characteristics of Low-Cost Airport

The ascendency of LCA caused the development of airports to specifically meet the requirements of low-cost airlines (De Neufville, 2008). De Neufville (2008) explored how facilities and infrastructure are developed at Low Cost Airports and identified the characteristics that lead to operational efficiency and minimum frills. The strategy of LCA and low cost airports are developed in parallel and aligned to one another (Pandey, et al., 2018). The features of the Low-cost airports encompass simple design, avoiding the grandiose building; the terminal building with less space per person, emphasizing higher utilization and productivity for every resource deployed in the airport; limiting retail and commercial space because operating retail area is expensive and cumbersome (De Neufville, 2008). The low-cost terminal is designed with a simplified infrastructure and efficient services. The terminal of the Low cost airport is developed with low capital investment offering limited facilities (Sabar, 2009). Sabar (2009) identifies two types of terminal for low cost airports, converted and newly-built. The typical characteristics of the low cost terminal encompass basic terminal facilities, avoidance of jet bridges, limited retail and catering, single story terminal, no executive or business lounges, road services & coach services only to nearest cities and short taxiing distances to and from terminal building. The low-cost terminal targets the LCA segment of traffic however it has been criticized for duplicating the resources which are mandatory irrespective of the market focus (Njoya & Niemeier, 2011). Also, it cannibalizes the traffic from other terminals and lacks the ability to expand (Blackman, 2011); (Toh, 2013). The efficiency of the low-cost terminal is more dependent on its location rather than its configuration. The location with respect to runways affects the aircraft taxiing distance while simple terminal configuration helps to minimize the passenger walking distance (Hanaoka & Saraswati, 2011). The Low-cost airports are characterized by a simplified terminal building, limited and minimal check-in facilities, extensive use of self-service check-in kiosks, luxury lounges are eliminated, limited seating in the departure area and one or two conveyor belt in the arrival area (Hanaoka & Saraswati, 2011).

Kalakou & Macario (2013) concluded that low cost airports do not emphasize retail however contended that airside and other facilities remain the same. On the contrary, the European Low Fare Airline Association (2004) contended that Low-Cost Airports focus more on non-aeronautical revenue by increasing the terminal shopping area. It was contended that the nature of traffic has a strong influence on the airport business model. Further, more rise of LCA enabled the development of secondary airports in the USA and Europe providing 'low-cost efficient facilities' which increased the competition between airports offering LCA oriented services (ELFAA , 2004). However, the specific features of the low-cost facilities of the secondary airports were not in the study, pointing towards the scope of the future investigation.

Singh et al. (2015) have contended that low cost airports emphasize the strategy of maintaining the quality and efficiency of service offerings. The airport is developed with aim of enabling LCA to exercise their business model easily. Generally, the airport facilitates the handling of narrow body 20/40/80 seater aircraft depending on traffic forecasts. Initially, the airports start operation on the basis of VOR only without Night Operations facilities. The airports can have a Runway Length of 1400-1700m with 2 parking bays (Singh, et al., 2015).

Graham (2013) contends that Low-cost airports provide LCA with quick turnaround time, convenient slot time, speedy facilitation, low aeronautical charges and another user cost. The low cost airports have small airport size and encompass larger catchment areas. Dziedzic & Warnock-Smith (2016) contend that the primary feature of low-cost airports encompasses levying low cost to its users, higher catchment area, quick and efficient airport operations, proximity to the primary city and convenient slot availability.

Despite the increasing dominance of LCA in the aviation market, there is a dearth of research pertaining to the evaluation of design characteristics of airports integrating the requirement of LCA. Since most of the literature reviewed contends that low-cost airport development should mirror the strategies being practiced by LCA and other key stakeholders in the prevailing market. There is a lack of academic literature pertaining to LCA's requirement from airport in Thailand, hence the current study would address the existing gap in the literature.

Table 2: Design Characteristics of Low Cost Airports

Factors	Authors
Terminal Building	De Neufville (2008), Hanaoka & Saraswati (2011), Sabar (2009)
Gates	Sabar (2009)
Shared lounge	De Neufville (2008), Hanaoka & Saraswati (2011), Sabar (2009)
Surface transport connectivity	De Neufville (2008), Graham (2013), Sabar (2009)
Size of Investment	Graham (2013), Dziedzic & Warnock-Smith (2016)
Commercial Facilities	Kalakou & Macario (2013), ELFAA (2004),

2.3. Evaluation model: Integration of Airline Expectation with the Airport's strategic design parameter

2.3.1. Quality Function Deployment-The House of Quality Analysis

Quality Function Deployment (QFD) has been regarded as an effective tool for quality planning, continuous product improvement and decision making (Chan & Wu, 2002). Propounded in 1966 by Yoji Akao in Japan, QFD turned out to be a systematic framework to convert customer requests into design or engineering characteristics (Zhang & Chin, 2005). QFD facilitates a structured, systematic and pragmatic decision-making process with appropriate adoption and implementation (Yang, et al., 2003). QFD is an integrated set of tools to recode user requirements, engineering characteristics that satisfy these user requirements and tradeoffs that might be necessary for the engineering characteristics (Kayapina & Erginel, 2017). The integration of QFD in order to design impressive qualities for airport services is done by translating airport customer services into regular service planning. QFD is a useful tool for managerial staff in airport planning by recognizing, prioritizing and integrating customer need into its blueprint (Bulut, et al., 2016). As such, QFD found its applicability in the service industry as well, especially in the airport domain. The integration of QFD in order to design impressive qualities for airport service is done by translating customer perspective into regular service planning (Lee, et al., 2015). The application of QFD to airport services unveils customer needs, therefore tuning in on vital services and meeting customer satisfaction (Bulut, et al., 2016). Existing QFD has several limitations such as long implementation time and subjective decision making error. The opinion of customers presented in terms of numeric crisp value turned out to be imprecise and a vague measurement ((Pandey, 2016).

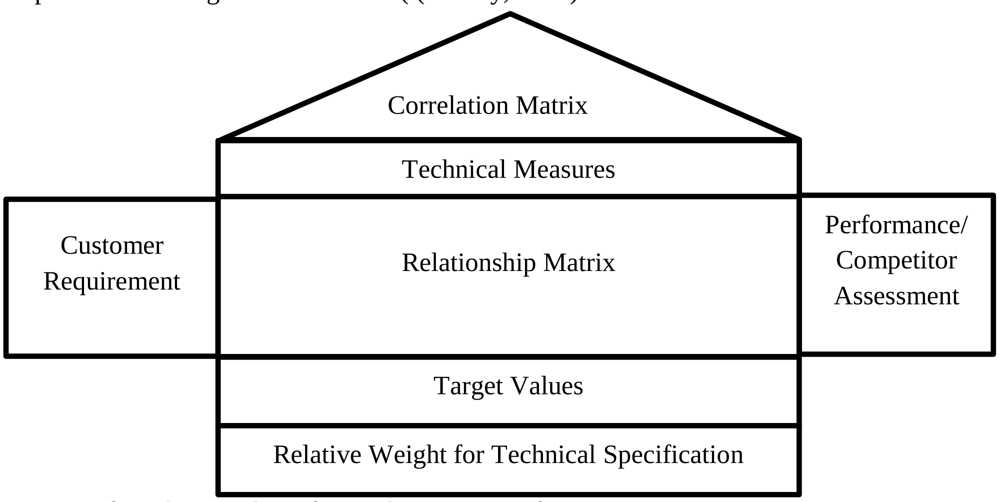

Figure 1: House of Quality Analysis for implementation of QFD

Hauser & Clausing (1988) have given the steps for conducting the HoQ analysis for implementation of QFD which has been represented in figure and explained below:

Step 1: Customer Requirements (What's): Identify the customer requirement. It can be done with consultation of customers.
Step 2: Technical Measures (How's): Establish the technical measures to meet the customer requirement by expert consultations.
Step 3: Relationship Matrix (Combination of What and How): Frame the relationship matrix between customer requirement and technical specification.
Step 4: Correlation Matrix: Measure the intra-relationship matrix between the technical specifications.
Step 5: Relative weight: The relative weight of technical specification is calculated by normalization of sum of product of weight of customer requirement and relationship value.
Step 6: Targets: The targets of project is decided by expert group on the basis of relative weight of technical specification.

2.3.2. The Fuzzy MCDM Approach

The theory of Fuzzy set was propounded by Zadeh (1973) with purpose to measure the human subjective issue accurately. The often imprecise results of the preferences expressed by respondents in terms of exact numerical value can be improved (Zadeh, 1973 ; Bellman & Zadeh, 1970; Zadeh, 1975; Hwang & Yoon, 1981; Liang & Wang, 1991; Hsu & Chen, 1997; Chiadamrong, 1999; Chien & Tsaia, 2000; Chen, 2001; Enrique, 2004). The fuzzy set theory renders a strict mathematical framework in which the complex conceptual phenomena can be precisely measured (Zimmermann, 2001). Many studies have been conducted to produce the mathematical model based on the Fuzzy MCDM method with wide application in decision making tool (Fodor & Roubens, 1994; Altrock, 1995). A fuzzy set is defined as a function of overlapping boundaries of the membership function (Mathworks, 2012). The Membership function depicts the curve explaining how each point in the input space is linked to membership value (Mathworks, 2012). The linguistic variables can be quantified by fuzzy numbers utilizing the appropriate membership function (Pandey, et al., 2018).

The wide application of Fuzzy MCDM to study the phenomena has led to the development of varied MCDM methods such as AHP (Saaty, 2008); TOPSIS (Hwang & Yoon, 1981); VIKOR (Opricovic, 1998; Opricovic & Tzeng, 2004) PROMTHEE ((Brans & Vincke, 1985) etc.. Specifically in the area of measurement of Service quality some studies utilized a deterministic; approach of MCDM (Chen & Tzeng, 2004; Correia et al., 2008; Liou et al. 2011). While other have taken into account the imprecise numeric values of decision data (Liang, 1999 ; Chen, 2000); (Ding & Liang, 2005; Iraj et al., 2008; Wang, et al., 2009).

As subjective evaluation is difficult to express in number, there is the existence of uncertainty (fuzziness), hence the use of the Fuzzy theory approach can be more realistic in assessing subjective issues which can be expressed in the linguistic term (Pandey, 2016). Fernandes & Pacheco (2010) utilized the Fuzzy Based alpha cut concept for evaluation of airport service quality of six airports in Brazil rendering the evaluated strategic framework for management of the airports. Lupo (2015) utilized Fuzzy based ELECTRE III method for evaluation of airport service quality, however the outranking approach of the ELECTRE method is not able to directly gauge and verify the strength and weaknesses of alternatives (Velasquez, Mark & Patrick, 2013; Konidari & Mavrakis, 2007). Also, the process and outcomes of ELECTRE method are complex and difficult to employ (Velasquez, Mark & Patrick, 2013). Chien-Chang (2012) utilized Fuzzy MCDM method to measure the service quality of two airports in Taiwan rendering a strategic solution to improve the service quality performance of these airports by employing a fuzzy MCDM method in which the service quality performance is fuzzified using a graded mean integration approach and defuzzified using the Inverse Arithmetic representation method. Liou et al. (2011) proposed hybrid fuzzy ANP model to select the strategic partners and considered the various criteria like marketing, product/service, computer systems, equipment servicing and logistics along with different sub-criteria. Liou, James J.H., Tzengb, G.H., Chang, H.-C. (2013) utilizes the evaluation model with the Fuzzy DEMANEAL and AHP method for measurement of airline safety. Büyüközkan et al.(2008) demonstrated the evaluation model for e-logistics-based strategic alliance partners using Fuzzy AHP and TOPSIS. Kannan et al. (2009) developed evaluation models based on Fuzzy ISM and Fuzzy TOPSIS for selection of third-party reverse logistics providers.

Since the implementation of QFD involves subjective assessment by expert team and customer, hence, the use of fuzzy approach based QFD will result in precise measurement of the priorities and targets.

2.3.3. Fuzzy QFD Model:

The Fuzzy QFD based model has been utilized in varied context for evaluation and selection of priorities. It has been used in supply chain industry since 2000 (Sohn & Choi, 2001). It has been used for supplier selection (Bevilacqua, Ciarapica and Giachetta, 2006), strategic selection (Bottanni & Rizi, 2006), licensor selection (Wang, Juan, Wang & Li, 2012) manufacturing strategy and development (Jia & Bai, 2011), market segments evaluation and selection (Dat, Phuong, Kao, Chou & Nghia, 2015). Fuzzy QFD has demonstrated good performance in handling problems regarding human expressions, selections or decisions in different industries (Lee, Ru, Yeung, Choy & Ip, 2015). There are only few studies based on Fuzzy QFD method in the context of aviation studies. Liang, et al. (2005) developed a Fuzzy QFD model to improve an airport cargo service by designing a correlation matrix between service offerings and customer expectations. Bulut, et al. (2016) evaluated the service quality of the Kansai airport terminal, prioritized the requirements of airport terminal using Fuzzy Analytic Hierarchical Process (AHP) and designed multi-layer QFD to integrate the requirements of the airlines. Although QFD is a popular planning tool, it is evident from literature review that there is a dearth of research developing a model for evaluation of the strategic design parameter of airports integrating the requirements of low-cost airlines. *From the review of literature it is found that there are only a few application of Fuzzy QFD model in context of aviation industry. There is absence of Fuzzy QFD based model for strategic decision making of airport design integrating the LCA needs.*

3. Methods:

3.1. Research Process

The current study adopts one of the QFD tools, House of Quality (HoQ) analysis, to evaluate the strategic design parameter of the airport with the objective to integrate LCA requirements. The research process utilized for implementation of the fuzzy QFD model are described below:

Step 1: Identify LCA requirements and related technical requirements (strategic design parameter) of the airport that influence the performance and satisfaction of service.
Step 2: Understand current satisfaction levels and the importance of the LCA requirements by utilizing fuzzy linguistic variables and fuzzy weighted averages.
Step 3: Establish the intra correlation between strategic design parameter of the airport
Step 4: Employ Fuzzy linguistic variables for correlating the LCA requirements relating to the technical requirement (strategic design parameters) and obtain evaluated strategic design parameters using fuzzy weighted averages.

3.2. Sampling Framework and Data Collection:

The step 1 of the research process requires to determine the weight and performance scores of the LCA requirements from the airport. The requirements of LCA from the airport are explored from an extensive review of literature resulting in the identification of the analytical hierarchical structure indicated in Figure 2. There are 20 variables depicting the needs of LCA from the airport. These variables covers dimensions, airport accessibility, ramp operation conditions, flight infrastructure management, passenger traffic operations conditions and airport's promotion policies. Based on the identified dimensions and variables, a questionnaire-based survey is designed to collect LCA perceptions regarding current satisfaction levels and the importance of each requirement. The LCA's perception for the current performance of each requirement is gauged using the linguistic variable scale which is labeled as 'very poor', 'poor', fair, good and very good and their respective rating are indicated in Table 1. The importance of each requirement is gauged using the linguistic variable scale which is labeled as 'Not at all important', 'slightly important', 'moderately important', 'very important' and 'extremely important' and their respective rating are indicated in Table 2. The Purposive sampling method was utilized to collect data from 100 senior executives employed with all 14 LCA operating from Don Mueang airport in Thailand. As we have to identify the requirements of LCA from airport, the purposive sampling method helps to choose the particular characteristics of a population that are of interest i.e. executives of LCA, which will best enable to answer the research questions (Etikan, Musa and Alkassim, 2016). Ten executives of each LCA were approached, out of which 100 responses were obtained which includes representation of all 14 LCA operating from the airport. Hinkins (1995) states that sample size of the exploratory study should be at least four times of the number of variables. As there are 20 variables for the current objectives; hence the sample size of at least 80 will be adequate to conduct the study.

Table 3: Linguistic variables to gauge performance score of LCA's requirement

Poor	(0.0, 1.0, 2.0)
Fair	(1.0, 2.0, 3.0)
Good	(2.0, 3.0, 4.0)
Very Good	(3.0, 4.0, 5.0)
Excellent	(4.5, 5.0, 5.0)

Table 4: Linguistic variables to gauge importance score of LCA's requirement

Not at all important	(0.0, 1.0, 2.0)
Slightly Important	(1.0, 2.0, 3.0)
Moderately Important	(2.0, 3.0, 4.0)
Very Important	(3.0, 4.0, 5.0)
Extremely Important	(4.5, 5.0, 5.0)

3.3. Fuzzy method for determining the weight and performance score of LCA requirement

The positive triangular fuzzy numbers were employed to measure the weight and performance scores of LCA requirement and has been depicted in Table 1 & 2. The previous literature has already established the basic arithmetic operations on fuzzy numbers. If A1= (l1, m1, u1) and A2 = (l2, m2, u2) are representing two distinct triangular fuzzy numbers (TFN) then their algebraic multiplication operations can be expressed by equation 1.

$$\mathrm{A1} \otimes \mathrm{A2} = (\mathrm{l1}, \mathrm{m1}, \mathrm{u1}) \otimes (\mathrm{l2}, \mathrm{m2}, \mathrm{u2}) = (\mathrm{l1l2}, \mathrm{m1m2}, \mathrm{u1u2}) \qquad \text{Equation 1.}$$

The graded mean integration method is utilized to transform TFN into a crisp number For example a TFN Y_1= (c_1,a_1,b_1) can be represented as a crisp value utilizing Equation 2. The same representation is employed on all the criteria for both performance and weight scores, which were obtained from LCA executives respectively.

$$\mathrm{P(Y1)} = \frac{1}{6}(\mathrm{c1} + 4\mathrm{a1} + \mathrm{b1}) \qquad \text{Equation 2.}$$

After that, the importance weighting of the LCA requirements are being assessed by a sample of q respondents based on their experience. The q_j respondent gives weighting for the i^{th} LCA requirement. By employing equation 3 the normalized weight of each LCA criteria is obtained which will be later utilized in HoQ analysis.

$$\mathrm{Wi} = \frac{\sum_{j=1}^{q} wij}{q} \qquad \text{Equation 3.}$$

The current service performance for each criterion is calculated utilizing equation 4 and shown as performance score in House of Quality analysis

$$\mathrm{Pi} = \frac{\sum_{j=1}^{q} wij * pij}{q} \qquad \text{Equation 4.}$$

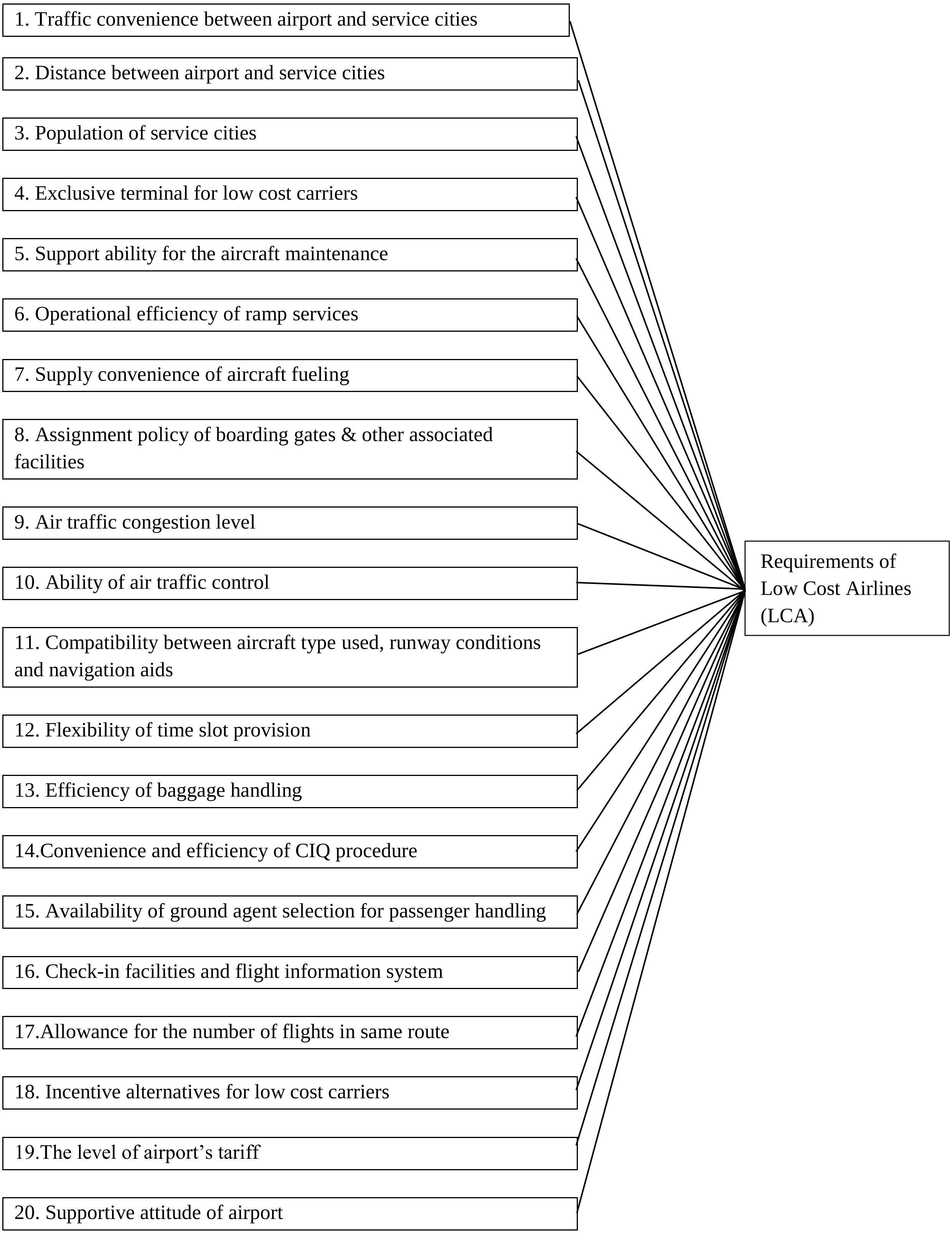

Figure 2: Analytical Hierarchical Structure of LCA Requirement

3.4. Fuzzy method for correlating LCA requirement to airport design characteristics and obtaining the target

The step 3 of the research process requires to establish the intra-correlation between airport design characteristics. The opinion of expert team have been utilized using the linguistic variables shown in table 3. The degree of association for each requirement is gauged using the linguistic variable scale labeled as ‘Not at all related’, ‘slightly related’, ‘moderately related’, ‘highly related’ and ‘extremely related’ and their respective ratings are indicated in Table 5. The expert team constituted of ten senior executives of the Airport of Thailand who were directly contributing to airport strategic planning and Airport operations. A semi-structured interview method has been utilized to obtain the responses which achieved saturation at 10 responses. The purposive judgement sampling method was employed to choose the respondent. Purposive sampling is fruitful to find the right respondents that provide advantageous information (Etikan, Musa and Alkassim, 2016).

The step 4 of the research process utilizes the same sampling strategy as employed for step 3. The expert team ten senior executives of the Airport of Thailand were interviewed for correlating the airport design characteristics to LCA requirement. The six airport design characteristics identified from the review of literature as summarized in table 2 has been utilized to examine the strength of the contribution of the jth airport design characteristics on the i^{th} LCA requirement. Each member of expert team have assigned the degree of correlation for the airport design characteristics to LCA requirement. The degree of association for each requirement is gauged using the linguistic variable scale labeled as ‘Not at all related’, ‘slightly related’, ‘moderately related’, ‘highly related’ and ‘extremely related’ and their respective ratings are indicated in Table 3. The saturation level of responses was obtained at 10. The average of correlation of airport design characteristics to LCA requirement is obtained from the equation 5 where c_{ij} is the correlation assigned by l^{th} respondent. The step 4 of research process gives the relationship matrix of House of Quality analysis.

Table 5: Linguistic variables for degree of association between airport strategic design parameter and LCA’s requirement

Not at all related	(0.0, 1.0, 2.0)
Slightly related	(1.0, 2.0, 3.0)
Moderately related	(2.0, 3.0, 4.0)
Highly related	(3.0, 4.0, 5.0)
Extremely related	(4.5, 5.0, 5.0)

The priority score (target) for each of the strategic design parameters (Design Characteristics) of the airport is obtained by utilizing the fuzzy weighted aggregation method indicated in equation 6 which is the average of the sum of the products of the correlation of technical requirements to LCA requirement (C_{ij}) and weights of LCA requirement (W_i). N is the total number of LCA requirements from the airport. The weight scores of the strategic design parameter is further normalized to obtain the relative weight of strategic design parameter.

$$\text{Cij} = \frac{\sum_{l=1}^{m} cijl}{m} \qquad \text{Equation 5.}$$

$$\text{WC} = \frac{1}{N}\sum_{i=1}^{N} Wi \otimes Cij \qquad \text{Equation 6.}$$

The setting of a goal is the crucial step in QFD. The goal is compared with the performance score for respective expectations of LCA. In the current study, the weight or importance score rendered by LCA for each criterion has been taken as a goal and has been compared with the performance score to obtain an improvement ratio (IR) as indicated in equation 7. If the IR is greater than or equal to 1 it means that the alternative is performing well on the given criterion.

$$Improvement\ Ratio = \frac{Performance\ Score}{Importance\ Score} \qquad \text{Equation 7.}$$

4. Results and Discussions

Based on the Fuzzy QFD approach, the House of Quality (HoQ) analysis in table 6 reveals the evaluated strategic design parameters of Don Mueang airport in Thailand. The importance and current performance scores on LCA requirements i.e. Voice of customer, has been presented in the table 6. The roof of HoQ analysis i.e. the intra-relationship between the technical requirements has been indicated in table 7. Table 6 also exhibits the relationship matrix showing the degree of relationship for each LCA requirement (Voice of Customer) to respective strategic design parameter of the airport (Voice of Engineer). The relative priorities of strategic design parameter of airport (Voice of Engineer) has been presented as final outcome of the HoQ analysis.

The relative priorities of the six strategic design parameters (technical requirements) of the airport have been evaluated and ranked. It is observed that terminal structure is the most important parameter with 20.4% of relative weight. The high weight of terminal structure signifies the need of keeping the capital expenditure low and maintaining high efficiency. The 'size of investment' is ranked second with weight of 19.3%. It shows that the low-cost airport must keep the size of investment low resulting in lower levy from its users and must strengthen the business model of Low Cost Airlines in line with findings of Graham and Dennis (2007). The parameter 'Number of Gates' has been ranked third with a weight of 18.4%. High weight of the parameter indicates that the utilization should be maintained with high operational efficiency. 'Commercial Facility' has attained the weight of 15.4% with fourth rank. The low cost airport may explore the revenue generation from non-aeronautical sources and the trade-off with a low levy of aeronautical revenue as contended by Graham and Dennis (2007). However, the commercial facility should be designed in tune with the passenger's expectations. The parameter 'Mass Rapid Transit System' (MRTS) has attained fifth rank with weight of 13.9%. The passengers of low cost airlines prefer economical and fast connectivity between the airport and the connecting city as also endorsed by Ryan and Birks (2005). Therefore, MRTS can be provided at low cost airports, it will result in economical transport in terms of cost and travel time. The 'shared lounge' has obtained sixth rank with weight of 12.5%. The low cost airport aims to offer a delightful user experience but at the same time luxurious lounges may be capital intensive. Hence the sharing of lounges of low cost airlines trade-off the interests as also contended by Hanoaka and Saraswati (2011).

The average improvement ratio for Don Mueang airport is 0.97 suggesting minor improvements for the criteria indicated in the table with an improvement ratio less than 1. It is identified that Don Mueang airport requires improvement for the following criteria; traffic convenience between airport and service cities, support for the aircraft maintenance, operational efficiency of ramp service, supply convenience of aircraft fueling, air traffic congestion, ability of air traffic control, flexibility of time slot provisions, efficiency of baggage handling, check-in facilities and flight information system, allowance for the number of flights in same routes, Incentive alternatives for LCA, the level of airport's tariff and supportive attitude of airport. For all of the stated criteria it is noted that small improvement is required to meet the user's expectation.

It is observed that many of the improvement criteria are related to airside. With regard to the observed dissatisfaction of airlines due to saturated capacity of ramp services at the Don Mueang airport, the airport under development phase 3 has planned to construct 12 contact parking bays and 4 remote bays for aircraft code A or B and 32 for aircraft code C under development phase 3 (AOT, 2018). As observed, the low cost airlines are dissatisfied with the 'air traffic congestion level' and 'ability of air traffic control' for which the airport plans to enhance its airport handling capacity to 50 flights per hour (AOT, 2018).

The level of airport's tariff is the least performing criteria with IR of 0.81 necessitating the airport operator to incentivize the operating tariff of the airport and thereby fulfilling the expectations of LCA. 'Supportive attitude of the airport' is the second least performing criteria with IR of 0.93 for which the airport operator has to deeply investigate the underlying issues and addressing the concerns of the key stakeholders. The low cost airlines have been requesting the AOT to reduce the airport charges, stating that the charges are double the charges being levied by the low cost terminal of Kuala Lumpur International Airport (Bangkok Post 2015). Still AOT has been unable to meet their demand as the airport has already achieved full capacity and reducing the airport charges conflicts with shareholder's interests (Bangkok Post, 2015). Hence the AOT needs to manage the perceived benefit of the low cost airlines by alleviating their dissatisfaction with the airport charges.

The criteria which are performing well pertaining to LCAs' expectations at Don Mueang airport are traffic convenience between airport and service cities, distance between airport and service cities, population of service cities, exclusive terminal for LCA, assignment policy of boarding gates and other associated facilities, compatibility between aircraft type used, runway condition & navigational aids, convenience and efficiency of CIQ procedure, availability of ground agents selection and passenger handling.

Table 6: Fuzzy QFD HoQ Analysis for airport services to LCA in Thailand

Technical Criteria / Customer Requirements	**Importance Rating**	Terminal Structure	Mass Rapid Transit System	Commercial Facility	Number of Gates	Shared Lounge	Size of Investment	Current Performance Score	Improvement Ratio
1. Traffic convenience between airport and service cities	4.66	3.90	4.66	3.00	3.65	3.89	3.78	4.27	0.92
2. Distance between airport and service cities	4.28	4.00	4.40	3.52	4.00	3.19	3.65	4.30	1.00
3. Population of service cities	4.50	4.50	4.20	3.60	4.10	3.50	3.55	4.66	1.04
4. Exclusive terminal for low cost carriers	3.89	4.80	4.50	4.20	4.50	4.33	4.50	4.24	1.09
5. Support ability for the aircraft maintenance	3.85	4.00	2.33	2.50	3.66	1.20	4.00	3.70	0.96
6. Operational efficiency of ramp services	4.23	4.20	2.33	2.60	3.41	1.33	4.50	3.97	0.94
7. Supply convenience of aircraft fueling	4.04	4.25	1.83	2.55	3.44	1.33	3.88	3.81	0.94
8. Assignment policy of boarding gates & other associated facilities	4.04	4.10	2.50	2.70	4.66	1.75	3.90	4.20	1.04
9. Air traffic congestion level	4.11	3.90	1.83	2.70	3.93	1.66	3.70	3.92	0.95
10. Ability of air traffic control	3.97	4.40	1.80	2.75	3.98	1.83	3.66	3.86	0.97
11. Compatibility between used aircraft type, runway conditions and navigation aids	4.10	4.15	1.60	2.80	2.89	1.66	4.00	4.31	1.05
12. Flexibility of time slot provision	4.09	4.25	1.83	2.87	4.25	1.33	4.20	3.88	0.95
13. Efficiency of baggage handling	4.19	4.80	1.96	3.00	3.78	2.33	4.50	3.97	0.95
14. Convenience and efficiency of CIQ procedure	4.06	4.85	2.33	3.54	4.33	3.33	4.50	4.13	1.02
15. Availability of ground agent selection for passenger handling	4.04	3.00	1.73	2.70	3.10	1.92	3.79	4.04	1.00
16. Check-in facilities and flight information system	4.06	4.20	2.20	3.52	2.90	3.00	3.30	3.87	0.95
17. Allowance for the number of flights in same route	3.99	3.50	2.33	3.00	2.80	2.33	4.00	3.88	0.97
18. Incentive alternatives for low cost carriers	4.11	4.33	4.08	4.00	4.20	3.33	3.60	3.94	0.96
19. The level of airport's tariff	4.23	4.92	4.20	4.25	4.27	4.20	4.50	3.43	0.81
20. Supportive attitude of airport	4.18	4.70	4.50	4.10	4.33	4.20	4.50	3.87	0.93
SoP Raw Score		350.22	238.24	264.31	314.80	214.93	330.32		
Relative %		**20.4%**	**13.9%**	**15.4%**	**18.4%**	**12.5%**	**19.3%**		

Table 7: The intra-relationship between variables of airport design characteristics

	Terminal Structure	Mass Rapid Transit System	Commercial Facilities	Number of Gates	Shared Lounge Room	Size of Investment
Terminal Structure	X	1.5	3.5	3.5	3.5	4.66
Mass Rapid Transit System	1.5	X	1.5	1.5	0.5	1.5
Commercial Facilities	3.5	1.5	X	2.5	1.5	2.5
Number of Gates	3.5	1.5	2.5	X	2.5	2.5
Shared Lounge Room	3.5	0.5	1.5		X	3.5
Size of Investment	4.66	1.5	2.5	2.5	3.5	X

5. Conclusion:

This paper demonstrates that the fuzzy QFD House of quality approach is a simple, promising and pragmatic tool for evaluating the strategic design parameter of the airport, integrating the requirements of LCA. The HoQ analysis furnishes the evaluated strategic design parameter (technical criteria) of the airport. It also furnishes the managerial implications for the improvement of Don Mueang airport so as to meet the LCA's expectations.

It has been observed that Don Mueang airport requires minor improvements especially pertaining to airside facilities. The least performing criteria is 'The level of airport tariff'. The second least is the 'supportive attitude of the airport. This suggests that the airport operator needs to incentivize the operating tariff of LCA at Don Mueang airport and to fulfill the expectations of LCA.

Theoretically, the paper contributes by developing and demonstrating the application of the Fuzzy based QFD house of quality model for evaluating the strategic design parameter of airports through integrating the need of LCA. The application of the fuzzy based approach in the above model helps to counter the imprecision involved in the measurement of the human judgment in the decision process.

The study undertakes a single trial study with the observations specific to Don Mueang airport in Thailand. This is not adequate to generalize and then utilize the findings for the low-cost airport development. However, the study serves as a guideline to utilize the fuzzy-based QFD model in a similar decision-making process.

As to contribution to future research in this domain, more strategic design parameters should be included in the construct for evaluation. Also, the current study undertakes only a single alternative to evaluate the parameters be increased to better generalize the results. Since LCA perception is subjective and context-dependent, testing of the suitability of the measuring scale may give more precise results.

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