

Criteria for C-Check Maintenance Service Provider Selection

Chark Tingsabhat^{*1}, Wichitra Chamlongrath², Chote Limsintaropas³

¹Faculty of Business Administration, Thai-Nichi Institute of Technology, Bangkok, Thailand

²Faculty of Management Science, Pibulsongkram Rajabhat University, Phitsanulok, Thailand

³Fleet Technical Manager of NokScoot Airlines, Bangkok, Thailand

¹ctingsabhat@gmail.com

²jee.wichitra@gmail.com

³choatlim@gmail.com

*Corresponding Author

Abstract— The objective of this paper was to determine the criteria for selection of C-Check maintenance service provider for a Thai-Singaporean low cost airline. To identify the significant criteria, the documentary studies from reviewing ten related researches in scholarly literatures were conducted and then developed the semi-structure interview guide. Based on results of the interviews of four key informants, who are the top managerial level officers of the airline company, from the competing values of roles and responsibilities, the supplier selection criteria were examined and scored by using the weighted factor rating method. The results revealed 4 significant criteria being used as a framework for the C-Check maintenance service provider selection; these are quality, cost, delivery and compatibility. However, the result confirmed that quality is a must for C-Check maintenance in compliance with the restriction of the aviation industry. The proposed framework can help the airline select the suitable service provider for the aircrafts C-Check maintenance to enhance its competitiveness.

Keywords— Aviation industry, maintenance supplier selection, factor rating method, C-check criteria, MRO

1. Introduction

Aviation industry is nowadays full of competition in the global market. From the industry analysis using Porter's five competitive forces model, four out of five forces are considered as high to very high, resulting airlines face many challenges from all directions and have to struggle to remain in business [1]. In 2015, The International Civil Aviation Organization (ICAO) audited Thai Department of Civil Aviation (Thai DCA) as part of ICAO's Universal Oversight Audit Programmed (USOAP). ICAO is responsible for standardizing aviation safety, which the members including Thai DCA are subject to doing the regular audits. The outcome was ICAO

downgraded Thai DCA from Category 1 to Category 2 due to the findings found during the evaluation had a significant impact on the safety matter. Many civil aviation authorities among various countries such as Japan and Korea refused to issue a license for Thai new operators and would not extend the expired license unless ICAO promotes Thai DCA to Category 1. Since Japan and Korea are considered as one of the biggest air transportation markets for Thailand. Such situation affected Thai operators to struggle for their existence.

In order to survive and compete with other airlines, a Thai-Singaporean low cost airline must manage its costs and service quality efficiently. One of the best way is to focus on procurement activities. Procuring process includes but not limits to airplanes buy or lease, air to ground data transferring services, maintenance services and ground handling services.

According to the study of airline cost structure [2], the fuel cost is the highest cost equaling to one third of total cost. This cost can be managed by financing activity such as hedging. The maintenance cost is considerably high as well. The low-cost carriers usually do not conduct the maintenance activities as its core function. Therefore, they outsource a variety of maintenance, repair and overhaul tasks through the company procurement processes to get parts or services at the lowest possible cost, within the appropriate time while maintaining the standard quality. In order to achieve the procurement goal, the effective supplier selection criteria are needed to be defined [3].

Maintenance is a must for the airline, providing the assurance of flight safety, reliability, and

airworthiness. Moreover, there are rules and regulations for the airline to comply with regarding to the maintenance, such as holding an operating certificate (OC), passing the airline operator certificate requirements (AOCR) including the maintenance requirements which specify for the maintenance program applicable to a specific aircraft model. It is the airline's responsibility to maintain aircraft in accordance with the approved maintenance program.

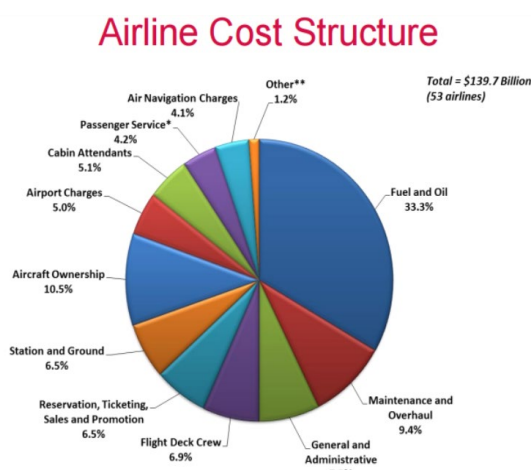


Figure 1. Airline cost structure

Source: [2]

C-check is a scheduled aircraft maintenance in order to keep the aircraft in a continuing airworthiness condition. It is usually performed every 1-3 years depending on its maintenance program. The C-Check cost varies depending on the aircraft type and maintenance program. For Boeing 737NG, average cost for the C-Check varies from USD 222,000 to 272,000 [4]. There are also the hidden costs such as the cost of delay. If the C-check turnaround time is planned for 14 days but the actual turnaround time takes longer, then the airline may worst end up canceling all planned flights. Therefore, it is critical to have a set of selection criteria for choosing the appropriate service provider than considering only the price quote.

The objective of this paper is to identify supplier selection criteria for the C-Check maintenance service provider and rank the significant criteria by weighted factor rating method. Finally, results from this research are used to formulate an evaluation approach for selecting the suitable service provider

for the aircrafts C-Check maintenance to enhance the airline's competitiveness.

2. Literature review

2.1 Aircraft maintenance checks

The aviation is a highly regulated industry. Commercial operators are required to comply with the continuous inspection programs established by the aviation authorities; such as the Federal Aviation Administration (FAA) regulates in the United State, while European countries are administered by the European Aviation Safety Agency (EASA). Each airline is required to develop its continuous airworthiness maintenance program (CAMP), which has to contain routine and detailed inspections of the aircraft, such as Boeing provides their customers the publication called "Maintenance Planning Data (MPD)" [5]. Boeing forms a group to develop the maintenance program by using the guidelines of the ATA Operator/Manufacturer Scheduled Maintenance Development (ATA MSG-3) [6]. The development of the maintenance program can be easily understand by the flow in Figure 2. Maintenance tasks listed in a maintenance program provide the schedules in terms of flight hour (FH), flight cycle (FC) and calendar day and month.

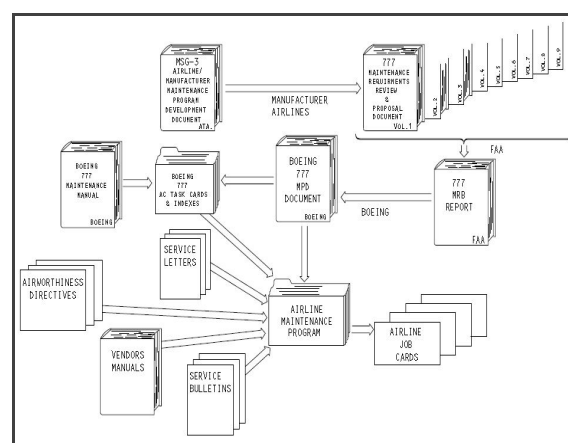


Figure 2. Maintenance program development

Source: [6]

Aircraft maintenance checks refer to the periodic inspections every commercial aircraft must go through after the completion of a specific number of flying hours or length of use time. Airlines and airworthiness authorities call the detailed

inspections as “checks”, comprising of A-, B-, C- and D-checks. A- and B-checks are lighter checks, while C- and D-checks are considered heavier checks [7].

C-check, an annually scheduled maintenance on an aircraft, is a preventive maintenance to keep the aircraft in a continuing airworthiness condition. C-check is performed by a maintenance, repair and overhaul (MRO) organization, approximately every 20-24 months of a specific number of actual flight hours (FH) or as defined by the manufacturer. This maintenance check is much more expensive than a B-check, requiring a large majority of the aircraft’s components to be inspected. During the C-check, most of airplane system and subsystems are dismantled. The aircraft is out of service, being leave in the maintenance site until the inspection completion. It is usually carried out in a hangar at a maintenance base. The time needed to complete such a check is at least 1-2 weeks and effort involved requires up to 6,000 man-hours [8]. Table 1 elucidates a typical maintenance checks for aircraft B777.

Table 1. Typical maintenance checks for aircraft B777

Source: [9]

| Check | Location | Description | Duration | Rate of Occurrence |
|-------|----------|--|--------------------|--------------------|
| A | at Gate | Routine light maintenance; engine inspection, services and lubrication of systems | ~10 hours | 600 FH |
| B | at Gate | Similar to A-check but with different tasks occurring between consecutive A-checks; torque tests, internal checks and flight control | ~10 hours to 1 day | n/a |
| C | Hangar | Structural inspection of airframe, opening access panels, routine and nonroutine maintenance, run-in test | ~3 days to 1 week | 18 MO / 6,000 FH |
| D | Hangar | Major structural inspection of airframe after paint, removal engines, landing gear and flaps removed, electronic & electrical equipment removed, hydraulic & pneumatic component removed | ~1month | 72 MO |

2.2 Selection criteria for maintenance supplier

Airlines have mainly concentrated on the supplier selection since suppliers are the input ends of resources, whose products and services directly affect the quality, delivery, customer satisfaction and other aspects contributing to the enterprise

competitiveness in the aviation industry. Buyers usually evaluate potential suppliers across multiple categories using their own selection criteria with assigned weights. A high technology buyer might emphasize a supplier’s process and technological capabilities or commitment to research and development. The selection process for a service provider will emphasize a different set of criteria depending on a specific aspect of the industry or a particular case such as the study on a comprehensive set of criteria for the textile and apparel industry [10] and the evaluation criteria for a mechanical manufacturing firm [11]. Most evaluations rate suppliers on three primary criteria; i.e. (1) cost or price, (2) quality, and (3) delivery [12].

Some researchers have identified criteria, and develop frameworks or models to evaluate suppliers in order to select the best alternative. Using grey target decision method, the supplier selection evaluation index for the aviation industry have developed, comprising of quality, cost, delivery, cooperation, competitiveness and service support [13]. Through the extensive reviews of literatures including the in-depth interviews with the decision makers of KLM Royal Dutch Airlines and processed with the funnel methodology, the supplier selection criteria were composed of cost/price, product quality, delivery, financial stability, corporate social responsibility, and assortment which defined that the supplier is able to supply a large number of products and volume, and buyer can minimize suppliers and lower administration cost [14]. While another research [15] studied the selection criteria based on literature reviews and discussions with the case company’s managers, and identified four dimensions of criteria; i.e. 1) compatibility 2) quality 3) cost and 4) risk. Each dimension was divided into several criteria to help avoid the pitfalls of classic outsourcing decisions where cost is considered as only the deciding factor.

Besides, the study on the attributes system of supplier selection based on entropy and TOPSIS including determining the subjective weights by REM has shown that the supplier selection factors for aviation enterprise were technology capabilities, management experience, facilities assurance, quality and airworthiness, and customer service [16]. Another proposed framework for monitoring and evaluating suppliers’ performance with a

subjective point of view and AHP method comprised five multiple criteria which were combined into one global variable for decision making [17], these are; cost, flexibility, quality, delivery, and variety. However, the research using fuzzy SWOT analysis and linear programming has defined the internal and external criteria categories [18]. Internal criteria such as unit cost, quality, percent of on-time delivery, and management are controllable by supplier, whilst external criteria, i.e.; mutual trust, location, and international communication are uncontrollable. Using the performance benchmarking method, it revealed that in the aviation industry the factors for supplier selection were cost, quality assurance, reliability, maintainability, lead-time to fulfill requirement, availability, and flexibility [19]-[20]. The study using AHP method for evaluating the maintenance and repair parts supplier adopted five criteria, comprising of cost, delivery, quality, flexibility, and service [21].

In the past, many organizations have tended to use quantifiable factors such as delivery and cost in selecting suppliers. Recently more companies have adopted relationships in evaluating their supplier performance [22]. Relational factors such as feeling of trust, openness of communication are difficult to quantify and required expert judgments. Criteria for performance assessment are cost, satisfaction of service, quality, and assurance of supply or on time delivery. It also reveals, from the survey, that airlines are not simply considering maintenance service in basis of lowest price, but rather overall operation [23], and the most important criteria is quality of work, being consistent with the finding of Lin, et al. [24] emphasizing that the quality and precision of workpieces is the critical importance. Other important criteria are short turn around time, range and capabilities, depth of experience, and the ability to assure highest aircraft utilization.

From the reviews of ten academic papers related to suppliers selection and decision making methods, it appeared that quality, cost and delivery were undoubtable chosen for supplier selection criteria due to the high frequencies from those research results. The following items are flexibility, service, compatibility and management respectively. Considering flexibility, service and compatibility, they are very close in term of practical. Regarding to the study on the criteria used to consider the external partners to obtain the

well-matched ones [25], they defined the compatibility dimension as the approach to capture value from the suppliers, to foster and maintain their participation and contribution for the smooth run of the activities. The compatibility then regards to culture and operational norms, or in relational dimension. In our research, service and flexibility are considered as sub-criteria of compatibility. On the matter of “management”, it reflects supplier’s organizational fit to enter into a close long-term relationship with the airline [14]. Actually management is the underlying principle and functional practices required in all supplier selection criteria [15],[19],[21]. Then it can be summarized that the framework for supplier selection composes of four main criteria which are quality, cost, delivery and compatibility, including their twelve sub-criteria as shown in Table 2 and Figure 3.

2.3 Supplier measurement decision

What is to measure and how to weight various performance criteria are the central to the design of supplier measurement. Some performance criteria are objective or quantitative, others are subjective or qualitative, as the metrics and methods used will be different between these two. Most of these variables lie within 3 categories, i.e. 1) delivery performance – assessing how well to satisfy the quantity and delivery due-date commitments; 2) quality performance – a critical component to evaluate a supplier’s performance against specified objectives, track trends and improvement rates; and 3) cost reduction – to track a real cost against the industry baseline or target price [12]. Although the qualitative factors are largely subjective, a buyer can assign a score or rating to each factor, so that a buyer can rank the suppliers performance by the percentage of total possible points earned.

Weighted factor rating is a procedure or technique to evaluate multiple alternatives based on a number of selected factors. It allows decision maker to include qualitative information and opinions, and quantitative information while providing a rational basis of comparison based on factor rating by establishing a value for each option that encompass all factors. Factor rating subjectively weights and ranks suppliers’ selection factors, the most popular method that is relatively simple to use. Factors are evaluated, rated and ranked, then a supplier is compared to others and

selected. The basic 6 steps to factor rating method are as follows [12],[26];

1. Develop a list of relevant factors
2. Assign a weight to each factor reflecting its relative importance to the supplier selection
3. Develop a rating scale for the factors (1 to 10 or 1 to 100 points)
4. Score each supplier on each factor based on the scale
5. Multiple the scores by the weights for each factor and total the weighted score for each supplier
6. Make a recommendation based on the maximum point score.

Table 2. Summary of criteria and sub-criteria from literatures

| Criteria/Sub-criteria | Description | Authors |
|------------------------------|--|-------------------------------|
| Quality | very important in aviation industry, failure may lead into severe incident | [13]-[23] |
| Knowledge and skills | Knowledge in terms of aircraft maintenance is insight of aircraft system to understand the maintenance instruction while skill is ability to transform knowledge into activities | [13],[15],[16],[22]-[23] |
| Conformance to specification | The airline industry is one of the highest regulated industry. The aircraft maintenance organization must comply with such regulation in order to run the business. | [13]-[14],[16]-[17],[19]-[23] |
| Reputation | what people opinion, good or bad experience with such service provider and share among industry | [13]-[14],[22],[23] |
| Cost | Expense of work task, being one of the critical problem areas reflecting to the price policy, due to the severe competition in the airline industry. | [13]-[15],[17],[23] |
| Price Stability | In aircraft maintenance service agreement usually mentioned the inclusive service price. However, the unexpected service will be charged and it may not be budgeted before, affecting the cash flow. | [13]-[14],[22] |
| Total Cost | Cost occurred for using resource to achieve C-check maintenance event. | [14]-[15],[19],[21],[23] |
| Payment Condition | How to pay service provider in term of credit term and amount to pay before and after complete service, including payment type such as flat rate or power by the hour. | [13],[15],[17],[21],[22] |
| Delivery | Supplier's ability to offer what its customers need at the right time with the right quantity, with right documentation, and within its guaranteed turn around time. | [13]-[14],[17],[23] |
| On-time Performance | The rate that service provider is able to release aircraft back to service within guaranteed turn around time. | [13]-[15],[17],[23] |
| Turn Around Time Guarantee | Service providers provide guaranteed turn around time depending on their capability and risk taking. | [14],[19],[23] |
| Compatibility | How well between service provider and customer working together and can rely on each other for survival. | [13]-[17],[19],[23] |
| Relationship | It includes shared risks and rewards, ensuring cooperation between the airline and ground service provider. | [13]-[15],[18],[21]-[23] |
| Service | The way service provider practice with customer. | [13]-[16],[19]-[23] |
| Mutual Trust | Both service provider and customer believes in each other to achieve mutual goal. | [14]-[15],[18],[21]-[22] |
| Flexibility | When dealing with abnormal situations, such as delays, unforeseen defect, incidents, etc. | [13]-[15],[17],[19]-[23] |

3. Research method

The following methodology is included for C-Check maintenance supplier selection:

1. Intensively reviewing ten academic papers related to suppliers' selection factors for the aviation industry to identify the critical criteria and sub-criteria as a framework for evaluating the suppliers.

2. Developing the semi-structured interview guide as a research instrument, which encompassed the list of 14 questions to be explored during the interview. Index of item-objective congruence (IOC) was used to verify the congruence of item objectives during research tool development. Three expert committees evaluated the content of the criteria in the interview guide to validate the congruence of items and research objective.

The average resulted IOC value of the whole interview guide equals to 0.92 (lowest 0.67 – highest 1.00). IOC per item were rated between 0.67-1.00, indicating that the experts agreed that all items are clearly measured the research objectives. The validity of the whole items values over 60% being acceptable, which is above the minimum standard requirement of 0.50 [27].

3. Conducting the in-depth interview with four top managerial level officers; these are Head of Engineering, Head of Flight Operation, Head of Finance, and Quality Assurance Manager of a Thai-Singaporean low cost airline company, from the competing value of roles and responsibilities, to explore their perspectives on the particular ideas by asking them about their experiences, and expectations related to the criteria, their thoughts about processes and outcomes, and about any changes they perceive in themselves as a result of the selection criteria, including their judgments on assigning the weights to these criteria and sub-criteria based on their relative importance. The factor weighting must cumulatively equal 100 percent. The assessment rating is multiplied by the weighting factor to calculate the contribution of each criterion to the overall assessment rating. Then an overall weighted average is calculated by adding together each of the individual results, and dividing by number of key informants.

4. Evaluating the weighted rating criteria towards three potential suppliers for C-Check

maintenance supplier selecting decision. Three suppliers are one MRO organization from Germany, the others from Taiwan and Malaysia.

5. Analyzing all interview data, soliciting feedback from the interviewees, then revising and disseminating findings [27].

4. Finding and Discussion

The research results were divided into 2 parts. First, the criteria framework for evaluating supplier. Second, the weights of criteria and sub-criteria of the framework including the factor rating evaluation for C-Check maintenance supplier selecting decision.

The result of the first part from the documentary studies appeared that the most frequently cited supplier selection criteria are quality, cost, delivery and compatibility. These significant criteria were defined and subcategorized into its sub-criteria as shown in Table 2 and combined in a framework for evaluating suppliers as in Figure 3.

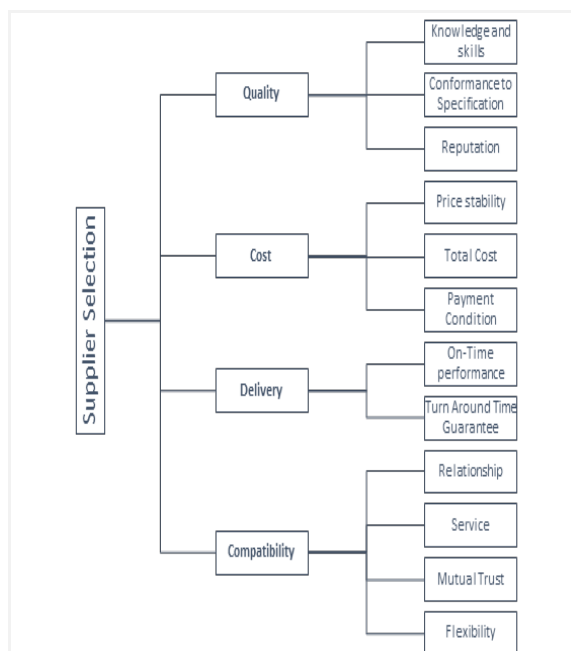


Figure 3. Criteria framework for evaluating supplier

In the second part, four key informants assigned the relative weight to each criterion and rating them. It revealed that the most important criteria for supplier evaluation is quality, which is 41.25%.

Cost, delivery, and compatibility are 30%, 20%, and 8.75% respectively. The overall result of their final weight contribution was exhibited in Table 3.

Table 3. Weights of criteria and sub-criteria from key informants

| Criteria/Sub-criteria | Key Informants' Weight Percentage | | | | Average (%) |
|---------------------------|-----------------------------------|-----------|-----------|-----------|--------------|
| | No.1 | No.2 | No.3 | No.4 | |
| Quality | 50 | 40 | 40 | 35 | 41.25 |
| Knowledge & Skills | 16.50 | 20.00 | 6.80 | 8.75 | 13.01 |
| Specification Conformance | 25.00 | 13.20 | 20.00 | 17.50 | 18.93 |
| Reputation | 8.50 | 6.80 | 13.20 | 8.75 | 9.31 |
| Cost | 30 | 20 | 40 | 30 | 30.00 |
| Price Stability | 5.10 | 3.40 | 13.20 | 7.50 | 7.30 |
| Total Cost | 15.00 | 10.00 | 20.00 | 15.00 | 15.00 |
| Payment Condition | 9.90 | 6.60 | 6.80 | 7.50 | 7.70 |
| Delivery | 10 | 30 | 10 | 30 | 20.00 |
| On Time Performance | 6.70 | 20.10 | 6.70 | 20.10 | 13.40 |
| TAT Guarantee | 3.30 | 9.90 | 3.30 | 9.90 | 6.60 |
| Compatibility | 10 | 10 | 10 | 5 | 8.75 |
| Relationship | 4.00 | 2.00 | 3.00 | 0.50 | 2.38 |
| Service | 2.00 | 4.00 | 2.00 | 1.00 | 2.25 |
| Mutual Trust | 1.00 | 3.00 | 4.00 | 1.50 | 2.38 |
| Flexibility | 3.00 | 1.00 | 1.00 | 2.00 | 1.75 |

When using factor rating technique to compare and select the best alternative from three MRO organizations, one from Germany, the others from Taiwan and Malaysia representing as company A, B and C, it showed that company B had the highest weighted score, 74.04 from 100, was the best supplier in term of high score values in most appraisal criteria except compatibility. While company A had greater outstanding in quality and delivery. For company C was considered as the poorest, acquiring the lowest weighted score, which could need the effective improvement in aspects of quality. The factor rating evaluation for C-Check maintenance supplier selection was shown in Table 4.

Table 4. Factor rating evaluation for C-check supplier selection

| Criteria | Weight | Score (1-100) | | | Weighted Score | | |
|----------------------|--------|---------------|-----|-----|----------------|-------|-------|
| | | A | B | C | A | B | C |
| Quality | | | | | | | |
| Knowledge & Skills | 13.01 | 80 | 60 | 40 | 10.41 | 7.81 | 5.20 |
| Spec. Conformance | 18.93 | 100 | 80 | 50 | 18.93 | 15.14 | 9.47 |
| Reputation | 9.31 | 90 | 50 | 30 | 8.38 | 4.66 | 2.79 |
| Cost | | | | | | | |
| Price Stability | 7.30 | 30 | 80 | 100 | 2.19 | 5.84 | 7.30 |
| Total Cost | 15.00 | 40 | 100 | 100 | 6.00 | 15.00 | 15.00 |
| Payment Condition | 7.70 | 20 | 80 | 100 | 1.54 | 6.16 | 7.70 |
| Delivery | | | | | | | |
| On Time Performance | 13.40 | 80 | 70 | 40 | 10.72 | 9.38 | 5.36 |
| TAT Guarantee | 6.60 | 80 | 70 | 60 | 5.28 | 4.62 | 3.96 |
| Compatibility | | | | | | | |
| Relationship | 2.38 | 80 | 50 | 100 | 1.90 | 1.19 | 2.38 |
| Service | 2.25 | 90 | 60 | 100 | 2.03 | 1.35 | 2.25 |
| Mutual Trust | 2.38 | 90 | 70 | 100 | 2.14 | 1.67 | 2.38 |
| Flexibility | 1.75 | 100 | 70 | 100 | 1.75 | 1.23 | 1.75 |
| Total Score | | | | | 71.27 | 74.04 | 65.54 |

5. Conclusion

From the academic paper reviews, the significant criteria for C-Check maintenance supplier evaluation and selection were quality, cost, delivery and compatibility, and combined into the framework as shown in Figure 3. In this paper, weighted factor rating is used for supplier selection, through the subjective evaluating of four key informants from the case airline company, due to the most popular method and relative simple to use. Based on the information gathered from the interview, the quality cannot be compromised, otherwise the operation could be at risk and consequently occurred higher cost, which is consistent with the results of the aforementioned studies [13]-[24]. The regulation compliance as to specification conformance is the most important. Knowledge and skills, and reputation can demonstrate the way the supplier works to strictly comply with the aviation regulations. Quality and cost need to be balanced since the total cost could impact airline's financial status. If the delay happened, it could affect airline's operation and revenue. Lastly, the good relationship between airline and suppliers, a sub-criterion of compatibility, is the foundation of the success,

affecting the service quality [25]. Flexibility is the outcome from strong relationship and mutual trust with the suppliers [14]-[15],[25]. This case study helps validate the criteria framework for selecting the C-Check maintenance service provider. The proposed framework is high practical value, and the suitable service provider for the aircrafts C-Check maintenance can enhance the airline's competitiveness.

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