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Reducing Cost Through Long Term Schedule Maintenance Planning in Aircraft Maintenance Industry

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Abstract:

From a wider perspective aircraft maintenance constitute two type of maintenance, one is scheduled maintenance and another one is un-schedule maintenance. To maintain aircraft in serviceable, airworthy and safe condition, it is necessary for an aircraft owner or operator to perform all schedule maintenance as advised by aircraft or equipment manufacturer or as per aircraft maintenance program approved by airworthiness regulatory authority of the country. To perform schedule maintenance for the fleet, it is very important to have a long-term schedule maintenance plan so that resource utilization can be maximized to achieve higher serviceability and flying availability for the aircraft. It helps organisation to wisely allocate its resources so that zero lost hours and minimum overlapped grounding of aircraft can be maintained. Reduced resource wastage and maximum availability of aircraft helps organization to maximize its revenue and profit share for stake holders.

Keywords: Long-Term Planning, Aircraft Maintenance, Aircrfat Maintenance Planning, Production Planning, Long-Term Schdeule Maintenance Planning, Aircraft Maintenance Cost, Aircraft Serviceability.

1. Introduction

The aircraft maintenance industry is a renowned industry in the aviation market. Due to its complex nature and sensitivity of work, it requires very specialized practices to be performed on aircraft and its components. Therefore, aircraft can be maintained with highest standard and specifications as prescribed by manufacture and airworthiness authorities of type certificate holder country. These safety standards are same around the world as per International Civil Aviation Organization (ICAO) convention which is agreed by all nation. These standards are must to be followed by aviation regulatory authority of each country to ensure aircraft and its components airworthiness and safety because it is directly related to passenger confidence in air travel and transportation. Due to its nature and complexity, aircraft maintenance cost is very expensive and need a massive planning in advance so that minimum maintenance cost can be achieved. To perform such specific job of planning, aircraft maintenance industry having a specific department known as aircraft maintenance planning. This department work solely to plan aircraft maintenance in such a way that least maintenance cost can be achieved

simultaneously quality and standard of the work can be maximized. This research paper is further describing about the techniques to reduce aircraft maintenance cost.

2. Background theory and literature review

The aviation industry creates enormous value for the world, calculated approximately 3.4 % percent of global GDP [2]. This is more than $2 trillion of GDP that's supported either directly or indirectly by aviation [2]. Over the most recent economic cycle, including some excellent years, airlines still lost nearly $20 billion in value for their shareholders [3]. The survival of an airline in such a highly competitive market environment is possible with strict cost management strategies and long-term planning. Further detailed statistics shows that globally airlines have spent $67.6B on maintenance of aircraft in aircraft maintenance and repair overhaul centres (MRO), it shows the amount is around 9.5% of total operational costs and can be rounded of to 10 % [1]. During the year of 2012, total cost of the aircraft maintenance was 80 billion US dollar, inclusive 60.7 billion US dollar spent on maintenance repair overhaul (MRO) market out of which 40% spent as maintenance cost for the engines [4]. Past 20 years trend shows that airlines ticket prices are declining on average by 2 % every year [5]. With the present market state in aviation industry, steadily rising costs of labour and material, together with lagging or level fare structures, are demanding even greater gains in productivity and utilisation of resources to maintain profit margins and adequate returns on investments [8]. Cost for the aircraft and its components maintenance vary with the age and with the passage of time it goes higher. For new aircraft, since it is under manufacturer's warranty the costs associated are comparatively low and rise steadily and levelling off as aircraft get around five year old [9]. For aircraft maintenance industry, organization to run in competitive market must have mission and vison for the organization. Upper level management formulates aircraft long-term maintenance strategies and it comprises of required resources and mode of selection for maintenance [12]. Long term planning has a time duration in years and mostly being planned from 02 to 05 years [11]. Long term goal set-up by upper management is further cascaded to down the line and aircraft maintenance planning teams ensures that maximised availability and serviceability of fleet can be achieved by effective long-term schedule maintenance planning and its execution. This can be achieved by effective long-term aircraft schedule maintenance planning in conjunction with maximum resource utilization and minimum ground time for aircraft. Aircraft maintenance is basically categorized in scheduled and unscheduled maintenance and it is further categorized as major maintenance, component replacement, line maintenance, defect rectification; life limited parts (LLPs), service bulletins (SBs), airworthiness directives (ADs) and modification (MODs) compliance. Among all different types of maintenance performed on aircraft, line maintenance and heavy maintenance constitutes major portion of maintenance requirements. Both of these maintenance requirements differ with each other due to usage of project based methodologies in heavy maintenance whereas line maintenance do not require such methodology [12]. Aircraft heavy maintenance also known as base major maintenance take significant amount of time to make it return to service. During such maintenance input complete strip down of aircraft structure performed with components maintenance, due to nature and severity of work it take significant amount of ground time and coordination among all engineers from different trades [12]. Such heavy or base maintenance are carried out inside hangar and this duration will be treated as un serviceable and widely known as the aircraft downtime [12]. It means that aircraft cannot be utilized for revenue generation during the downtime due aircraft maintenance activity [12]. Manufacturers for aircraft and its components publish

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Maintenance Planning Document (MPD) to support aircraft maintenance planning to retain serviceability and reliability of their product [9]. Such documents having list of the minimum required maintenance tasks, its frequency, ground time and procedures to perform on aircraft and its components [9]. Airlines CAMO department which also known as continuing airworthiness management organisation reviews aircraft and equipment manufacturer requirements, maintenance planning document (MPD), and supplementary inputs received from local airworthiness authorities and other support functions within airline to produce the operator Aircraft Maintenance Program (AMP) [11]. The real issue is not so much what maintenance is, but rather how is it organised and accomplished to meet the many constraints imposed upon it and how can it develop to meet the ever increasing challenges of the future [8]. These constraints are the planning and scheduling of aircraft maintenance so that required resources like qualified man power, tools, equipment, material and hangar space can be organised in most optimised way to minimum cost and zero lost hours. On top of this, overlapped grounding and pile-up of maintenance inspection makes it more critical. Such tasks are planned, organized and controlled by aircraft maintenance planning professionals by fair assessment, evaluation of requirements, nature of aircraft operation and criticality of the aircraft grounding. These professionals look after and ensure aircraft maintenance executed before the due date by liaising with all support functions and required resources so that no impact on original flight plan can be achieved without any additional cost [6]. Airworthiness of the aircraft itself is one particular aspect of safety which directly involves the maintenance function of an airline [8]. Due to complexity of the aircraft maintenance and level of capability of maintenance organization, planning function vary. Aviation companies need to focus on the present market trends and estimate the future demand so that accordingly the long term plan can be set up to compete in highly cost effective environment [7].

3. Methodology

The Research methodology for the project is distributed in several parts and need to accomplish in orderly manner. Below is the snap shot for the complete process.

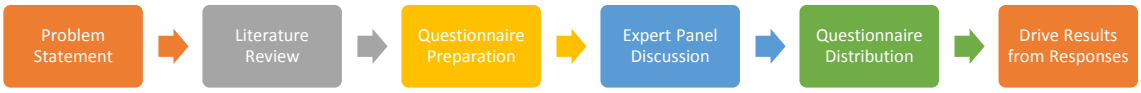

Figure 1: Research methodology framework

3.1. Problem statement

With the literature review it has been observed that aircraft maintenance cost is a factor contributing 10 % of total operation cost and it require more effective control to maximize profit revenue. Such control can be achieved by effective aircraft maintenance planning by proper utilization of resources in conjunction with long term schedule maintenance planning. Effective long-term planning may span from 2-5 years depend on organization objective, vision and mission. Finding a quantitative impact of long-term planning in reducing cost will be a boon for aircraft maintenance industry.

3.2. Hypothesis

Below is the hypothesis which is being tested through this research.

H1: Aircraft maintenance cost can be reduced with the help of long-term schedule maintenance planning

3.3. Research design

This research study aims to find the significance level and relation between aircraft maintenance cost and long-term planning. This study is based on literature review and expert panel discussion, where experts are aircraft maintenance planning professionals. Based on literature and expert panel discussion it has been highlighted that 04 aspect are the important one affecting long-term schedule maintenance planning. These fours aspects are listed below:

- Resource requirement planning
- Accuracy of long-term schedule maintenance planning
- Aircraft maintenance program
- Accuracy of aircraft ground time

3.4. Questionnaire design and data collection

Initially designed questionnaire discussed with expert panel group and based on outcome of discussion, 13 questions are finalised for the questionnaire which includes 02 general, 06 descriptive, and 05 Likert scale questions. These 05 Likert scale questions including 01 question for dependent variable (DV) and other 04 are independent variables (IV). Among different kinds of data collection methods, semi structured questionnaire used to communicate with the respondents.

3.5. Sample size and technique

A sample size of 115 used for this research and convenience sampling techniques were utilized. Questionnaire was communicated and shared with all aircraft maintenance planning professionals around the world working in airlines, maintenance repair and overhaul centres (MRO), military aviation companies, general aviation and flying clubs. After successful receipt of 115 responses, data processed with the help of statistical tool.

3.6. Statistical tool and technique

Upon successful collection of questionnaire response from 115 respondents, data responses are analysed in Microsoft excel. Statistical method used to process the data is multiple regression analysis between independent and dependent variable to identify the significant relationship and impact between dependent and independent variables. Dependent variable is cost, and independent variables are aspect from long-term schedule maintenance planning prospect.

4. Result and discussion

Outcome of multiple regression analysis on SPSS Software is mentioned below. This analysis performed based the response received and defined as independent variable (04 aspects from long-term schedule maintenance planning) and dependent variable (cost).

Table 1. Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Q49, Q51, Q44, Q46[b]	.	Enter

a. Dependent Variable: Cost_Score
b. All requested variables entered.

Variable entered are four questions asked from respondents on Likert scale about long term schedule maintenance planning components. Here, Q44 denotes resource requirements planning, Q46 denotes accuracy of aircraft schedule maintenance planning, Q51 denotes aircraft maintenance programme and Q49 denotes accuracy of aircraft ground time. All four are used as independent variables.

Table 2. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.708[a]	.502	.484	.31253

a. Predictors: (Constant), Q49, Q51, Q44, Q46

From model summary interpretation, adjusted R Square value explains that 48.4 % of variance in cost is explained by variance in independent variables.

Table 3. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.818	4	2.705	27.690	.000[b]
	Residual	10.744	110	.098		
	Total	21.563	114			

a. Dependent Variable: Cost_Score
b. Predictors: (Constant), Q49, Q51, Q44, Q46

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From ANOVA summary it clearly states that proposed model is highly significant with F = 27.690, where p < 0.001. Therefore, regression equation model is excellent.

Table 3. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.572	.270		5.829	.000	1.038	2.107
	Q44	.336	.054	.472	6.187	.000	.228	.443
	Q46	.109	.056	.167	1.949	.054	-.002	.220
	Q51	.062	.036	.125	1.731	.086	-.009	.133
	Q49	.116	.057	.178	2.033	.045	.003	.229

a. Dependent Variable: Cost_Score

From above table linear regression equation can be explained as $b_0 = 1.572$, $b_1 = 0.336$, $b_2 = 0.109$, $b_3 = 0.0.062$ & b4 = 0.116. Based on outcome of regression, equation can be presented as $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$. With its coefficients values it can be explained as $Y = 1.572 + 0.336 (X_1) + 0.109 (X_2) + 0.062 (X_3) + 0.0116 (X_4)$

X_1= Resource requirements planning,
X_2= Accuracy of aircraft schedule maintenance planning,
X_3= Aircraft maintenance programme
X_4= Accuracy of aircraft ground time

Therefore, hypothesis **H1:** Aircraft maintenance cost can be reduced with the help of long-term schedule maintenance planning; proved significant.

5. Conclusion and Future Scope

Based on outcome of research, it is concluded that aircraft maintenance cost can be reduced further by performing effective long-term schedule maintenance planning. It can be achieved by a detailed analysis of resources requirements, aircraft maintenance program and accuracy of aircraft schedule maintenance planning and aircraft ground time. An effective long-term schedule maintenance planning has a significant impact in saving cost and it will be proved as an effective tool for aircraft maintenance industry. The key improvement areas to focus is the resource requirements, schedule maintenance planning, aircraft maintenance program and ground time aligned with organisation mission, vision and strategy. This research further can be taken up to identify other areas of improvement in aircraft maintenance industry so that maximum serviceability and availability of fleet and further reduction in cost can be achieved.

References

[1] A. Markou, Chris; Cros, Geraldine; Sng, "Airline Maintenance Cost Executive Commentary," 2017.

[2] Saxon, "Taking on airlines ' toughest challenges," 2019.

[3] A. Dichter, A. J. Sørensen, and S. Saxon, "Buying and flying: Next generation airline procurement," 2017.

[4] P. Glowacki, "Influence of the Selected Exploitation Tasks on Airline Operating Cost and Flight Safety Taking As an Example Turbofan Engine," J. KONES. Powertrain Transp., vol. 23, no. 2, pp. 129–136, 2016.

[5] S. Saxon and M. Weber, "A Better Approach to airline costs," 2017.

[6] Z. Yang and G. Yang, "Optimization of Aircraft Maintenance plan based on Genetic Algorithm," Phys. Procedia, vol. 33, pp. 580–586, 2012.

[7] H.-M. Chang and A. Kora, "The Operation Management Model of Aircraft Maintenance, Repair and Overhaul (MRO) Business," III, Issue II Index Copernicus J-Gate Acad. J. Database, vol. III, no. II, pp. 21–28, 2014.

[8] J. W. Norberg, "Aircraft Maintenance," Aeronaut. J., vol. 75, pp. 153–158, 1971.

[9] T. S. G. U. of W. London, "Innovative Cooperative Actions of Research & Development in EUROCONTROL Programme CARE INO III Dynamic Cost Indexing Innovative Cooperative Actions of R&D in EUROCONTROL Programme CARE INO III Dynamic Cost Indexing," London, 2008.

[10] EASA, Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Annex I (PART-M) to Commission Regulation (EU) No 1321/2014, no. 2, Amendment 1. 2016.

[11] S. J. Carmichael, "Review of airline line maintenance from an operations management perspective to assist in management strategy decisions," 2017.

[12] P. Samaranayake, "Current Practices and Problem Areas in Aircraft Maintenance Planning and Scheduling – Interfaced/Integrated System Perspective," Proc. 7th Asia Pacific Ind. Eng. Manag. Syst. Conf. 2006 17-20 December 2006, Bangkok, Thail., no. December, pp. 2245–2256, 2006.

Author Biography

Deepak Chandra Chandola has more than 10 years of experience in aircraft maintenance planning function of airlines, business jet, general aviation and military aviation organizations. He received Aircraft Maintenance Engineering Degree (AME) from Indian Institute of Aeronautical Science, New Delhi, India in 2009, Bachelor of Technology (B. Tech.) in Mechanical Engineering from Institution of Engineers, India in 2017 and Master of Technology (M. Tech.) in Engineering Management from Manipal Academy of Higher Education, Dubai Campus, United Arab Emirates in 2019. His email address is <deepak.chandola@outlook.com>