

Airline Maintenance Cost Optimization Through Spare Parts Inventory Control

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Abstract: Aircraft maintenance is a key factor which has a direct impact on the value and airworthiness of aircraft and plays an important role in strategical decision making which adjusts the economic performances. Managing spare parts efficiently through proper inventory controlling is critical for airlines in order to minimize total expenditure of maintenance and as a result, it has been persuasive to work further in detail on spare parts inventory controlling and optimization. The above process is followed to cater the airline production planning and a better scheduling of work can drastically minimize the maintenance cost. The research commences with studying what special practices are used to calculate demand for inventory and corresponding stock levels for the MRO activities. A comprehensive study is done on methods used to optimize spare parts inventory and efficient demand forecasting. The models presented throughout this research work are derived by studying the behavior of landing gear spare parts inventory controlling of an aircraft and can be applied to other systems' spare parts inventory controlling too. An area of interest that has emerged is that of Rotable, Repairable, Consumable and Expendable spares, which presents scope for research. With the current forecasting methods and help of the historical data, the proposed inventory controlling policies in this research, take into consideration, the reliability concerns and forecast demands depending on spare parts data from two directions: "lead time" and "mean demand". Hence, the optimum order

number of units and ideal order period can be derived to understand the total minimization of expenditures, which results in a systematic optimization in the way of inventory controlling.

Keywords: Aircraft maintenance, Inventory controlling, Cost optimization

Introduction

In this research, it identifies four different types of aircraft spare parts as Rotable spare parts, Repairable spare parts, Consumable spare parts, Expendable spare parts. When the parts of aircraft systems fail or anyhow needs to be replaced, it generates a requirement for spare parts, and the requirement is fulfilled through the spare parts inventory. According to the expectation, above spares must be readily available in stock and those stock items should be refilled by extended processes such as repairing the reusable items or purchasing brand new. When the downtime is unplanned because of an unexpected breakdown, the results cause more damage. In some cases, disturbances in the operational procedure occur, as the flight scheduling is done based on the spare parts that are available in the inventories. This may cause decrease of service and idling time of other resources, other than the loss of production. In some instances, unexpected downtime will also generate safety hazards. As an example, when an aircraft has an unplanned grounding at the terminal, its scheduled flight should be postponed where passengers may lose their time, which may cause damages in customer

satisfaction and create empty seats; the take-off and landing slots assigned to that particular flight will be lost, causing disturbances to other flights; the crew for that flight should wait without any work, etc. As per the data collected by Federal Aviation Administration, flight delays cost the airline industry an average of 8 billion dollars annually. To reduce the grounding time, the spare part stocks must be efficiently maintained. This develops tremendous pressure on all parties connected with the aviation industry to carry out maintenance activities as efficiently as possible, which has created the space to present ideas that can reduce the grounding time of aircraft. Hence, the way to an efficient aircraft spare parts inventory controlling system is proposed through this research; considering many parameters related to spare parts inventory controlling.

Research Problem-

Airlines suffer a major cost due to aircraft spare parts. That cost is multiplied due to issues in inventory controlling. Therefore, this research is conducted to find a way to optimize the spare parts inventory controlling of an airline. This will be beneficial for airlines as well as approved maintenance organizations. Hence, the main research problem that arises is, "how to optimize the airline maintenance cost through spare parts inventory control?"

Objectives

The objectives of conducting this research are as follows.

- To develop a mechanism for the planning and control of a spare part supply chain in organizations that own and maintain equipment. This mechanism should include all the relevant decisions that should be made prior to purchase spare parts and it should explain how the decisions are related with each other.

- To identify the different types of spares used in aviation such as Rotable spare parts, Repairable spare parts, Expendable spare parts and Consumable spare parts that are significant in distinguishing various cost portions in maintenance.

- To analyze the key factors that affect efficient spare parts inventory control.

- Analyze the prevailing mechanisms and models which are relevant to spare parts inventory control and identify the issues/drawbacks incorporated with them.

- Suggesting a method to overcome the drawbacks of the systems and to bring them to the optimized state with respect to maintenance cost.

Methodology

The research group chose a survey research structure because it best served to solve the research questions and fulfilled the objectives of the study. The survey type data collection research is one in which a group of items are studied by gathering and analyzing data from only a random set of items which considered to be representing the whole group. Otherwise, only a random part of whole group is studied, and the results derived from this are expected to be applied to the entire group. In this research the group of items which were selected to study was the spare parts of the landing gear system of MA-60 aircraft i.e. the spare parts under "Chapter 32" of the MA-60 aircraft spare parts inventory. It was assumed that this particular group of spare parts will represent all the other spare parts of the MA-60 aircraft because Landing Gear system is a critical system and subjected to frequent maintenance activities with a number of fast-moving spares. Under the Chapter 32 of MA-60's spare parts inventory, 83 different spares were studied and the data related to those spare parts were collected and analyzed.

Results

The widely accepted method of calculating safety stock uses the statistical model of standard deviations of a normal distribution of numbers to determine probability. This statistical procedure has been tested and proved to be efficient and effective in calculating the best economical safety stocks in variety of operating conditions. The core for this calculation is standardized, however, its successful implementation to cater the requirements of this research needs customization of the formula and inputs to meet the specific characteristics of the Helitours (Pvt) Ltd operation.

First, the collected data from previously mentioned sources were entered to the MS Excel spreadsheet along with their,

- Part number
- Spare part name
- Expected and actual lead time
- Yearly demand
- Remaining stock as at end of each year
- Spare part unit cost
- Inventory holding cost
- Stock-out cost per trip
- Average trips per month

After entering the data to the spreadsheet, the following parameters were calculated for past seven years (i.e. 2011-2017) for each of the spare parts.

- Covariance of expected and actual lead times
- Combined standard deviation (σ_{LT}) of lead times
- Average lead time (LT_{avg})
- Monthly average demand (μ)
- Demand during lead time (DLT)
- Total inventory cost per year
- Total downtimes in terms of months
- Cost category (C)
- Service level (Q)
- Service factor (Z)
- Recommended safety stock (K)
- Re-order level (R)

Discussion

The existing methods for aircraft inventory planning which are being used by many approved maintenance organizations in Sri Lanka have many inherited drawbacks within them. Hence, this research was focused on developing an efficient spare parts inventory controlling method to forecast the time for re-ordering the spares with respect to lead time and mean demand of spares which is beneficial in maintaining inventories with high efficiency. Throughout the research, historical data of spare parts consumption for past seven years (from 2011 to 2017) were examined. Simultaneously, existing inventory controlling methods were studied and their drawbacks were identified. With reference to several studies, primary data and secondary data which collected, were analyzed using Statistical Model with Standard Deviation of a Normal Distribution. Using this method, mathematical relationships were derived and lead time and average demand analysis on each type of spare part related to the landing gear system of Xian MA-60 aircraft operated by Helitours, a reference to define a suitable safety stock and eventually a re-order point.

Conclusion

In this research, a statistical model of standard deviations of a normal distribution of numbers has been used to relate the variations in lead times to calculate the safety stock and in turn re-order point. Clarification of the statistical theoretical aspects which lies in the formula is necessary in correctly adapting it to meet the exact needs of the Helitours (Pvt) Ltd in terms of spare parts inventory control. Errors in implementation are usually the result of not factoring in variables which are not part of this statistical model. Also, a hypothetical service factor has been defined by considering the tradeoff between cost of inventory vs cost of stock-out. Hence the values obtained for recommended safety stock and re-order point have interconnection between the cost factors rather than having an arbitrary value for

service level. Further, the variations in the lead time has been considered by considering a stochastic variation and actual variation of it rather than taking the actual or expected lead time variations for the calculation of safety stock. Thus, the research team could obtain fair values for safety stock and re-order point for each of the spare part. As the conclusion it can be stated that by maintaining the safety stock and re-order points as recommended by the data analysis of this research will optimize maintenance cost of the airline (in this case it is Helitours (Pvt) Ltd). Note that airline maintenance cost would be optimized until such time the spare parts inventory managing personnel is making sure to maintain the safety stock and re-order point as recommended and not having excess or deficit amounts of spare parts other than recommended.

The developed statistical model and electronic spreadsheet are not only validated for the selected sample of spare parts, but also for optimization of all the spare parts in an inventory of an airline or an approved maintenance organization, thus fulfilling the main aim of the research.

This research has only discussed the lead time variations in this model. While operators or Approved Maintenance Organizations can use this model for predicting variations in demand for the spare parts, the research has found that demand for most of the spare parts tend to be far too random and unpredictable. Spare parts demand tends to be related more to an Approved Maintenance Programme which is constantly updating due to Service Bulletins, Airworthiness Directives, Service Information Letters and Maintenance Review Board Report and which in turn raises a non-stochastic demand rather than a demand which fall under the pattern of a normal distribution. However, if relationship which is approximate to the normal distribution could be found with respect to the variations in demand for the spare part, the safety stock

conformed to that variation can be separately calculated and that value can be added to the recommended safety stock obtained by the statistical model used in this research.

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