Alert value calculation model for aircraft rotable components

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Abstract*— Timely release and delays in scheduled flights endangers all aspects of aviation industry. Hence, buffer stocks should be maintained in inventory. However, maintaining inventories incurs huge costs in addition to other considerations of component shelf life and material deterioration. The primary objective of this research is to develop an efficient alert value calculation by means of mathematical relationship to predict on what component would be near failure and needed on when and its minimum order quantity, thus optimizing inventories, expenditures and time, while ensuring safety is been maintained at required levels. By quantitative data collection from prominent aircraft operators, components that require an alert value were thoroughly scrutinized with historical and trend analysis. Mathematical relationship was derived considering several important parameters against life of component. With this relationship a reference to when a component needs to be alerted was defined individually. This developed mathematical solution was validated to several aircraft components simultaneously addressing drawbacks of existent alert value calculation methods. Moreover, an inventory planning software prototype was proposed which can utilize the developed alert value calculation model. Hence finally recommendations were made for aircraft operators to benefit the outcome of this study to optimize inventory storage, costs and time.*

Keywords—**Aviation, Alert value, Inventory, Optimization**

I. INTRODUCTION

Alert value calculation of the rotable components relative to flying demand relates to a prediction on when an operator should be alerted on a specific rotable component that would near failure after a period of flying operations. This calculation is prepared by analysing data based on past experience, and would play a major role in enhancing the reliability of aircraft maintenance.

A common problem faced by several aircraft operators at present, is the managing of stocks of spare parts in the inventory with minimum expenses, while attempting to achieve a higher service efficiency and quality. Consequently, they would have to implement different strategies or philosophies to suit their cause.

Running an aviation industry deals with huge costs, especially when it comes to maintaining the aircraft, apart from its capital investment. For instance if consider a basic commercial aircraft, the complete aircraft itself would perhaps cost around tens of millions of USD, while its engine alone would cost millions of USD and its turbine blade or vanes would cost thousands of USD. Hence, for aircraft operators concerning the stock control of rotable components alone, for optimization and value creation is more than a challenge considering the number of moving parts, events of predictable and unpredictable failures the aircraft could possibly have during operation. Thus, preparing to face these situations while planning to reduce inventories, time, and expenditures is a real challenge and would require a wide area of knowledge and skills (C.H.Friend, 1992).

An alert value calculation focusing on rotable components alone, would indicate which particular rotable component(s) requires attention. Hence, this information would give an opportunity to for decision making in order and maintain the required stocks of rotable components accordingly in the inventory at the appropriate time to meet the demand.

Further, the alert value calculation could be optimized by utilizing computer programs or tailor- made software which would improve the efficiency and reliability of the predicting and thus the positioning aircraft parts.

II. METHODOLOGY

A. Data Collection

This research was based by correlation study which involved sampling, quantitative and qualitative data collection, surveys and aggregate data. Hence, the collection of existing data were analysed to obtain results that have fulfilled the objectives of this study.

Selection of aircraft satisfied the following criteria;

- The aircraft must represent a cross-section of Sri Lankan aviation.
- The aircraft or fleet must have historical data available for at least five years.

- The data or information must be accessible for collection
- The collected data must be possible to analyze

Through the historical and trend analysis carried out on selected aircraft, rotable components were identified and analysed for the alert value calculation based on the following criteria:

- Components subjected to most unscheduled removals/ failures
- Number of component usage hours up to failure
- Number of landings/ flight cycles up to failure
- Defined TBO (Time Between Overhaul)
- Criticality of usage
- Availability of standby systems

B. Data Analysis

For the purpose of analysing the data collected from the selected aircraft operators, the following methods were reviewed and compared for applicability to this research. Methods are:

- Regression analysis
- Statistical Process control

1) Regression Analysis

Regression analysis can be used as an attempt to identify most prominent parameters for failures for each component. I.e. as an example consider a component such as Trim motor, it will be impossible to conclude exactly whether it is failed with respect to flying hours, flight cycles or both by mere judgement.

However in the long run this method cannot be used because, it is impossible to derive a common mathematical model which can be applied to all components. Additionally, it doesn't give the opportunity to identify deviations of flying hours/ flight cycles up to failure for each component relative to its defined TBO.

2) Statistical Process Control

In comparison to other Statistical process control methods, Control chart was selected to analyse data, since in general control charts are used to study how a process changes over time. Additionally, previous researches focusing on similar studies have used Control charts for analysing data (Amborski, 2006) (Zeljko, et al., 2007).

With data are plotted in time order, control chart will have a Mean line for the average, an upper line for the upper control limit, a lower line for the lower control limit and, a reference line to define alert. These lines were determined from historical data.

Prominent parameters affecting a component were identified by referring to Manufacturer's definitions in the Maintenance Planning Document (MPD).

Hence using control charts it was possible to achieve the following

- Representation of population of failure of components relative to Flying hours, flight cycles separately for each selected component.
- Observation for deviations from defined TBO
- Differentiate between special cause and common cause variation.
- Definition of a suitable reference line for alert for each component separately as per failing trend.

C. Calculation Definition

For the control chart; Mean line, upper control line, lower control line and reference line (for alert) was defined.

1) Mean

Mean of the population of component running hours upto failure should be calculated.

$$\text{Mean } (\bar{h}) = \frac{\sum_{h=1}^{n} hi}{n} \tag{1}$$

Where,
h – Component running hours upto failure
n- The number of values (the population)

2) Standard Deviation

Then using the calculated mean value the standard deviation must be determined

$$\text{Standard deviation } (\sigma) = \sqrt{\frac{\sum_{h-1}^{n}(h_i - \bar{h})^2}{n}} \tag{2}$$

3) Upper and Lower control limits

As per secondary data analysis, an unstructured interview was carried out to identify the level of confidence. A 95% confidence level was identified to suit this research since most of the component unscheduled removals would more likely be found within the control limits. (Silva, 2016)

However there may exist a very few exceptional cases where component removals occurring at lower flying hours will deceed below the LCL level in the control chart. Irrespectively, these points will be neglected for the alert value calculation since it is not pratical to define an alert in such lower number of flying hours as it is not economical to consider as a whole for the alert calculation.

Hence the remaining flying 5% will be treated as exceptional case and will not considered to define an alert value.

Considering 95% confidence level,

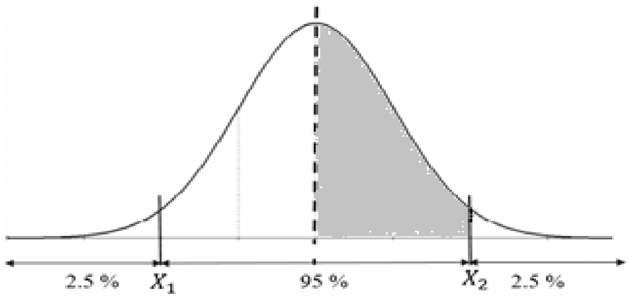

Figure 1: Normal Distribution curve for 95% confidence level

$$X = \bar{h} + Z\sigma \tag{3}$$

Area under standard normal curve for 2.5%,

= 0.5 – 0.025

= 0.475

Hence from Normal distribution curve,

Z = 1.96

Z_{X_1} = 1.96

Z_{X_2} = -1.96

$$\text{UCL} = \bar{h} + 1.96\sigma \tag{4}$$

$$\text{LCL} = \bar{h} - 1.96\sigma \tag{5}$$

After calculating UCL & LCL control limits, all the data and control lines are plotted in a control chart along with the mean.

The UCL & LCL are presented in blue lines, and the mean ($\bar{h}$) is presented in a green line, as shown in Figure 2 below.

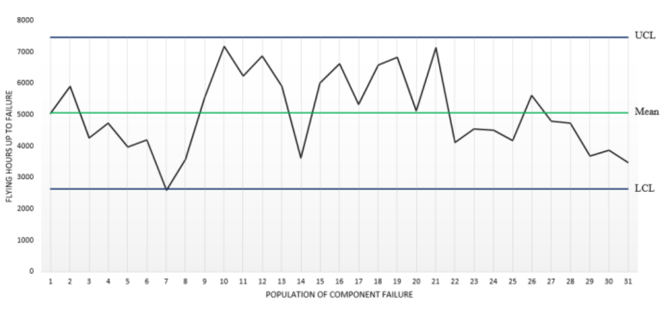

Figure 2: Control chart depicting UCL, LCL (Blue) and Mean (Green) lines

4) Reference Line

After plotting the control chart, it can be observed that a considerable amount of data points exist below the mean line (as shown in Figure 3). However, by considering all the points that exist below the mean line it can be seen that most of them were closer to the mean line, with the exception of few points which have deviated largely.

Hence, taking out all the data points which are below the mean line, a reference line was defined.

Difference of Mean and flying hours up to failure = Flying hours - Mean

$$R = h_i - \frac{\sum_{h-1}^{h} h_i}{n} \tag{6}$$

Where,

R- Difference of Mean and flying hours up to failure

All corresponding flying hours up to failure of R > 0 values =*r* (all the component running hours below the mean reference line)

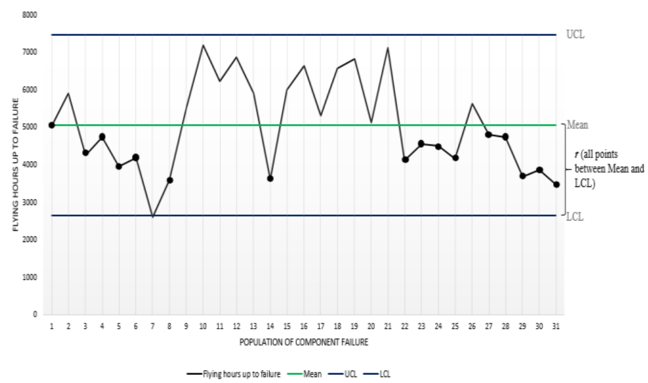

Figure 3: Control chart depicting "r" (all points between Mean and LCL)

All the component running hours up to failure below the reference mean value are treated as another data distribution.

Consider r_1 to r_i

The mean of r values are the calculated,

$$\bar{r} = \frac{\sum_{r=i}^{n} r_i}{n_r} \tag{7}$$

Where,

n_r – Number of *r* values

Then the value of $\bar{r}$ is plotted in the same control chart as the reference line for the data distribution.

Here the $\bar{r}$ line will be considered as the reference line and will be used to define the alert.

The reference line is presented in an orange line in the control chart, as shown in Figure 4 below.

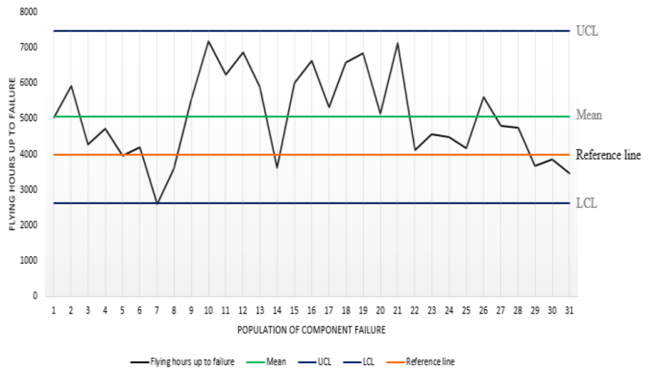

Figure 4: Control chart depicting Reference line (orange)

Defining an equation for the reference line:
Calculated mean of r values = $\bar{r}$
Considering $\bar{r}$ as the LCL of distribution

$$k = \frac{\frac{\sum_{h=1}^{n} h_i}{n} - \frac{\sum_{r=1}^{n_r} r_i}{n_r}}{\sqrt{\frac{1}{n}\left(\sum_{h=1}^{n}(h_i-\bar{h})^2\right)}}$$

$$k = \frac{\bar{h} - \bar{r}}{\sigma}$$

$$\bar{r} = \bar{h} - k\sigma \quad (8)$$

III. RESULTS AND DISCUSSION

Initially for each selected component, the flying hours or flight cycles up to failure and its TBO are entered into the Microsoft Excel spreadsheet table. Then the Mean, Standard deviation. UCL, LCL and Reference line were calculated for each case.
Finally, a control chart indicating all lines was obtained from the computed table.

A. Sample tests

1) Fuel Control Unit

The TBO for Fuel control unit is defined only with relative to Flying hours
Calculations:

$$\text{Mean of flying hours up to failure } (\bar{h}) = \frac{\sum_{h=1}^{n} h_i}{n}$$

= 5057.094

$$\text{Standard deviation} = \sqrt{\frac{\sum_{h=1}^{n}(h_i - h)^2}{n}}$$

= 1233.026

For Control limits,

Z value for 95% confidence level = 1.96

$\text{UCL} = \bar{h} + 1.96\sigma$
= 5057.094 + 1.96 x 1233.026
=7473.824

$\text{LCL} = \bar{h} - 1.96\sigma$
= 5057.094 - 1.96 x 1233.026
= 2640.363

Finding *k* value,

By considering to data points below to mean line

$$\text{Mean } (\bar{r}) = \frac{\sum_{r=1}^{n} r_i}{n_r}$$

=3988.182

k value for the fuel control limit,

$$k = \frac{\frac{\sum_{h=1}^{n} h_i}{n} - \frac{\sum_{r=1}^{n_r} r_i}{n_r}}{\sqrt{\frac{1}{n}\left(\sum_{h=1}^{n}(h_i - \bar{h})^2\right)}}$$

$$k = \frac{\bar{h} - \bar{r}}{\sigma}$$

$$k = \frac{5057.094 - 3988.182}{1233.026}$$

= 0.8667

So the alert level equation for the Fuel control unit relative to flying hours is:

$\bar{r} = \bar{h} - k\sigma$
$\bar{r} = \bar{h} - 0.8667\sigma$

Finally, the obtained control chart is shown in Figure 5

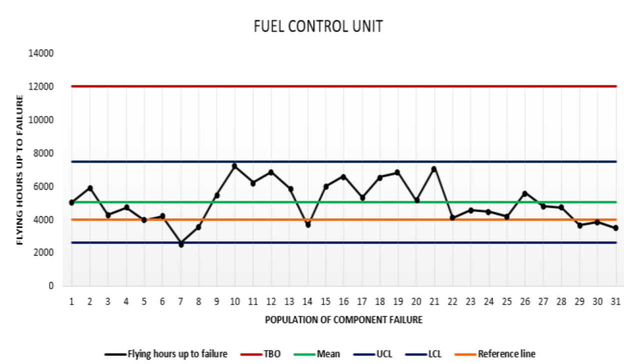

Figure 5: Control chart for fuel control unit relative to flying hours

2) Landing Light

The TBO for Landing light is defined by both Flying hours and flight cycles. Hence, it should be removed after whichever is met first.

Calculations were done for both cases:

$$\text{Mean of flying hours upto failure } (\bar{h}) = \frac{\sum_{h=1}^{n} h_i}{n}$$

= 2241.781

$$\text{Standard deviation } = \sqrt{\frac{\sum_{h=1}^{n}(h_i - h)^2}{n}}$$

= 305.8488

For Control limits,

Z value for 95% confidence level = 1.96

$\mathrm{UCL} = \bar{h} + 1.96\sigma$
= 2241.781+ 1.96 x 305.8488
=2841.24459

$\mathrm{LCL} = \bar{h} - 1.96\sigma$
= 2241.781- 1.96 x 305.8488
= 1642.317285

Finding *k* value,

By considering to data points below to mean line

$$\text{Mean } (\bar{r}) = \frac{\sum_{r=1}^{n} r_i}{n_r}$$

=1985.366

k value for the fuel control limit,

$$k = \frac{\frac{\sum_{n=1}^{n} h_i}{n} - \frac{\sum_{r=1}^{n_r} r_i}{n_r}}{\sqrt{\frac{1}{n}\left(\sum_{h=1}^{n}\left(h_i - \bar{h}\right)^2\right)}}$$

$$k = \frac{\bar{h} - \bar{r}}{\sigma}$$

$$k = \frac{2241.781 - 1985.366}{305.8488}$$

= 0.8383

So the alert level equation for the Landing light relative to flying hours is:

$\bar{r} = \bar{h} - k\sigma$
$\bar{r} = \bar{h} - 0.8383\sigma$

Hence, obtained control chart is shown in Figure 6.

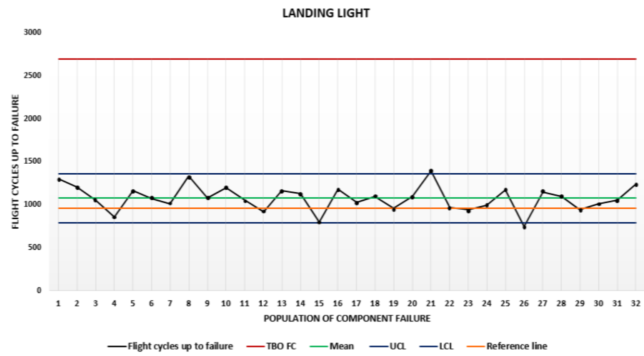

Figure 6: Control chart for Landing light relative to flying hours

Calculations for flight cycles,

$$\textbf{Mean of flight cycles upto failure } (\bar{\boldsymbol{h}}) = \frac{\sum_{h=1}^{n} \boldsymbol{h_i}}{\boldsymbol{n}}$$

= 1073.781

$$\text{Standard deviation } = \sqrt{\frac{\sum_{h=1}^{n}(h_i - h)^2}{n}}$$

= 145.8618

For Control limits,

Z value for 95% confidence level = 1.96

$\mathrm{UCL} = \bar{h} + 1.96\sigma$
= 1073.781+ 1.96 x 145.8618
=1359.67

$\mathrm{LCL} = \bar{h} - 1.96\sigma$
= 1073.781- 1.96 x 145.8618
= 787.8922

Finding *k* value,

By considering to data points below to mean line

$$\text{Mean } (\bar{r}) = \frac{\sum_{r=1}^{n} r_i}{n_r}$$

=961.5

k value for the landing light for flying cycles,

$$k = \frac{\frac{\sum_{n=1}^{n} h_i}{n} - \frac{\sum_{r=1}^{n_r} r_i}{n_r}}{\sqrt{\frac{1}{n}\left(\sum_{h=1}^{n}\left(h_i - \bar{h}\right)^2\right)}}$$

$$k = \frac{\bar{h} - \bar{r}}{\sigma}$$

$$k = \frac{1073.781 - 961.5}{145.8618}$$

= 0.7698

So the alert level equation for the landing light relative to flight cycles is:

$$\bar{r} = \bar{h} - k\sigma$$
$$\bar{r} = \bar{h} - 0.7698\sigma$$

Hence, obtained control chart for landing light relative to flight cycles is shown in figure 7.

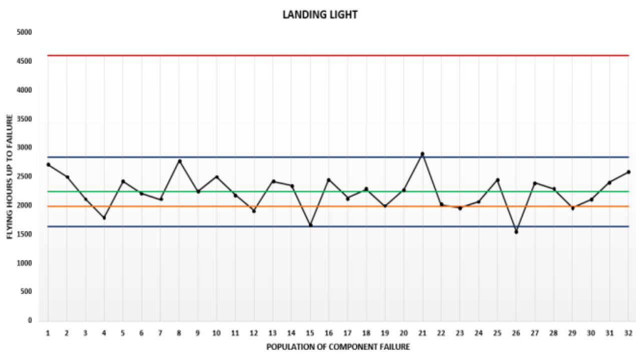

Figure 7: Control chart for Landing light relative to flight cycles

Hence the alert level for Landing light should be defined for both; relative to flying hours and flight cycles. Thus, it should be removed when whichever alert level is defined first.

B. *Observations*

Following can be observed from obtained results;

- Population up to failure points of every component mostly exist within the defined UCL and LCL of the control chart.
- In common, all the components had deviations from its defined TBO.
- A very few number of outliers existed in some components, however these were neglected.
- The initially defined reference line (orange) proved to be suitable for defining the alert in most cases

C. *Conclusion Of Data Analysis*

The developed equations had perfectly validated the data.

Hence, recalling drawback of alert value definitions of existing systems;

Some operators use pireps to predict failure, which is not very reliable because, there is no consistency, i.e. in some months more pireps could be obtained for the same component than other months. Further, practically some reports may not even be recorded in the pirep form.

Other operators define alert level for every component only with respect to flying hours, which is incorrect, since not every component are affected by flying hours or, atleast flying hours alone.

Additionally a common drawback from operators are, alert value defined fleet wise which is not very accurate. To elaborate, consider a new aircraft being purchased to join existing fleet, so assuming the new aircraft doesn't have any failures, it will not be right to consider it to define a fleet alert. Hence using this method is more successful and directly address the above drawbacks of existing alert value calculation methods by having the following features;

- Defines an alert to a component and gives predict accordingly by taking into account the appropriate parameters that affects it as defined in MPD. For example, the failure for fuel control valve will be predicted by Flying hours, while the failure for a landing light will be predicted by Flying hours or Flight cycles (whichever comes first)
- Each component individually will have its own definition for reference line to suit it best as per historical trend analysis
- Considers historical data and trends of more than 12 months, making results more accurate.

Moreover, this method illustrates the deviations of each component from its TBO, which could give the opportunity for the operator to investigate for reasons, or to make recommendations to manufacturer.

IV. PROCESS IMPLEMENTATION

By developing an Inventory planning software for rotable components inputting the derived relationships it would be possible to define predicted alerts for both upcoming months and TBO alerting.

This way this software would;

- Enable the operator with the freedom to obtain the prediction for alerts as per expected plans, i.e. the operator will not be limited to predict only for a pre-defined fixed time period.
- Enable a live updating platform, hence operators can update accordingly in case of unexpected changes in original flight plan.
- Indicate the alert taking into account all situations that affect the particular aircraft component. i.e. some components may be affected by only flying hours, flight cycles, or both (whichever comes first)
- Have a separate system to indicate scheduled alerts for each component individually considering its TBO.
- Monitor each rotable component individually rather than fleet wise since they are unlikely to be installed in the same aircraft until failure. Hence, it would be possible to know the current health of a particular component individually.

Additionally, using the calculation concept, the operator can within the same software use it for several types of aircraft it operates.

Figure 8 below is a proposed prototype for inventory planning software

	ANNUAL INVENTORY CONTROL PLANING													
T.B.O Alerting	Select Your Aircraft Type	2016 YEAR IN [MONTHS]												
	A319/A320 (5 A/C)	1 (Jan)	2 (Feb)	3 (Mar)	4 (Apr)	5 (May)	6 (Jun)	7 (Jul)	8 (Aug)	9 (Sep)	10 (Oct)	11 (Nov)	12 (Dec)	
	Y-12 (II)													
Total F.H or Cycles	Fuel Control Unit (FCU)													Expected Sheduled or Unsheduled Removels
1100 F.H	FCU (1)	124	245	153	187	161	151	154	85	140	171	115	89	1
1987 F.H	FCU (2)	80	25	35	54	147	125	174	85	65	98	47	75	0
1500 F.H	FCU (3)	28	120	45	89	47	72	65	71	59	83	43	78	0
12000 F.H	FCU (4)	113	124	174	165	127	84	117	54	87	49	133	122	1
1189 F.H	FCU(5)	45	89	71	112	72	34	43	94	134	94	114	117	1
	High Presure Valve (HPV)													
6358 F.H	HPV (1)	113	124	174	165	127	84	117	54	87	49	133	122	0
12000 F.H	HPV (2)	45	89	71	112	72	34	43	94	134	94	114	117	1
1200 F.H	HPV (3)	124	245	153	187	161	151	154	85	140	171	115	89	0
3854 F.H	HPV (4)	28	120	45	89	47	72	65	71	59	83	43	78	1
1234 F.H	HPV (5)	80	25	35	54	147	125	174	85	65	98	47	75	0
	Trim Air Presure Reg.Valve													
3000 F.H	TPARV(1)	80	25	35	54	147	125	174	85	65	98	47	75	1
4120 F.H	TPARV (2)	113	124	174	165	127	84	117	54	87	49	133	122	1
874 F.H	TPARV (3)	28	120	45	89	47	72	65	71	59	83	43	78	0
1200 F.H	TPARV (4)	45	89	71	112	72	34	43	94	134	94	114	117	0
541 F.H	TPARV (5)	124	245	153	187	161	151	154	85	140	171	115	89	0
	Flow Control Unit													
7826 F.H	Flow Control Unit (1)	113	124	174	165	127	84	117	54	87	49	133	122	0
8000 F.H	Flow Control Unit (2)	45	89	71	112	72	34	43	94	134	94	114	117	0
3784 F.H	Flow Control Unit (3)	124	245	153	187	161	151	154	85	140	171	115	89	1
1789 F.H	Flow Control Unit (4)	28	120	45	89	47	72	65	71	59	83	43	78	0
9784 F.H	Flow Control Unit (5)	80	25	35	54	147	125	174	85	65	98	47	75	0
	A/H Indicator (n=2)													
457 F.H	A/H Indicator (1)	113	124	174	165	127	84	117	54	87	49	133	122	0
1000 F.H	A/H Indicator (2)	45	89	71	112	72	34	43	94	134	94	114	117	0
3794 F.H	A/H Indicator (3)	124	245	153	187	161	151	154	85	140	171	115	89	1
1789 F.H	A/H Indicator (4)	28	120	45	89	47	72	65	71	59	83	43	78	0
2784 F.H	A/H Indicator (5)	80	25	35	54	147	125	174	85	65	98	47	75	1
826 F.H	A/H Indicator (6)	113	124	174	165	127	84	117	54	87	49	133	122	0
3600 F.H	A/H Indicator (7)	45	89	71	112	72	34	43	94	134	94	114	117	1
2584 F.H	A/H Indicator (8)	124	245	153	187	161	151	154	85	140	171	115	89	0
1789 F.H	A/H Indicator (9)	28	120	45	89	47	72	65	71	59	83	43	78	1
4784 F.H	A/H Indicator (10)	80	25	35	54	147	125	174	85	65	98	47	75	0

Figure 8: Prototype of proposed Inventory Planning software

This prototype will the following features,
Under "Aircraft type" top-down approach, the operator could select the specific aircraft fleet

Under each component type, the individual components can be monitored;

- Once flying hours/flight cycles entered for each month as per flight plan, the alert will be represented in three colours
- Green; safe region
- Yellow; prepare time for alert region
- Red: Critical alert region

Initially, the red alert will be defined, based on that the maximum time for corrective action for the component will be considered to define the yellow alert.

Additionally, an alert for TBO will be generated separately.

Operator can input flying demand for each component for any time period (not limited to one year) and can go for a predict. The software would analyse the input data and define alerting systems which will be indicated in all areas including red, yellow and green. Where the yellow alert would provide sufficient time for the operator to prepare for failure.
To elaborate the using of this software further, as an example consider an operator operating a fleet of five Airbus A320 needs to predict for component, Fuel control unit (FCU) for the coming year. So there are five FCUs fixed in all aircraft with around three extras in the inventory as safety stock. Using the software, the operator can input data under each FCU by serial number individually and predict for the coming year. Hence, the operator can monitor each component individually at his convenience with the time to check for alert situations.
With this information the operator will have the opportunity to be aware on when a FCU would likely fail and accordingly take necessary decisions and prepare for unscheduled removals/failure without difficulty.
Figure 9 below is a model illustration of how alert regions are defined once data is input.

	ANNUAL INVENTORY CONTROL PLANING													
T.B.O Alerting	Select Your Aircraft Type	2016 YEAR IN [MONTHS]												
	A319/A320 (5 A/C)	1 (Jan)	2 (Feb)	3 (Mar)	4 (Apr)	5 (May)	6 (Jun)	7 (Jul)	8 (Aug)	9 (Sep)	10 (Oct)	11 (Nov)	12 (Dec)	
	Y-12 (II)													
Total F.H or Cycles	Fuel Control Unit (FCU)													Expected Sheduled or Unsheduled Removels
	FCU (1)													
	FCU (2)													
	FCU (3)													
	FCU (4)													
	FCU(5)													
	High Presure Valve (HPV)													
	HPV (1)													
	HPV (2)													
	HPV (3)													
	HPV (4)													
	HPV (5)													
	Trim Air Presure Reg.Valve													
	TPARV(1)													
	TPARV (2)													
	TPARV (3)													
	TPARV (4)													
	TPARV (5)													
	Flow Control Unit													
	Flow Control Unit (1)													
	Flow Control Unit (2)													
	Flow Control Unit (3)													
	Flow Control Unit (4)													
	Flow Control Unit (5)													
	A/H Indicator (n=2)													
	A/H Indicator (1)													
	A/H Indicator (2)													
	A/H Indicator (3)													
	A/H Indicator (4)													
	A/H Indicator (5)													
	A/H Indicator (6)													
	A/H Indicator (7)													
	A/H Indicator (8)													
	A/H Indicator (9)													
	A/H Indicator (10)													

Figure 9: Prototype illustration of predict for alert regions

V. RECOMMENDATIONS

- Using the calculation concept, aircraft operators can derive reference line to define alert for every rotable component individually by conducting historical and trend analysis
- Components can be classified by ATA (Air Traffic Association) Chapters
- Operators can develop a tailor-made software inputting the relationships for all rotable components.
- Hence, the tailor made software can be used as an inventory planning tool; by using the alert value information, operators should ensure the required stocks, safety stocks are available in the inventory to face the demand.
- Operators should be given proper training in using the software and input data accurately: This is very important, since the prediction will be generated based on the data input.
- Operators should frequently monitor each component for alert situations and be prepared to face component removals.
- By results of prediction, operator could implement a JIT similar concept
- By effective use of this concept, the operator can optimize inventory costs and storage.

VI. CONCLUSION

A common problem faced by the aviation industry, is the managing of stocks of spare parts in the inventory with minimum expenses, while attempting to achieve a higher service efficiency and quality. Especially, concerning Sri Lankan aviation context, existing methods for aircraft inventory planning was proven to be unsatisfactory.

This research focused on developing an efficient method to define alert values for rotable components which can be used to predict the time for removal with respect to flying demand which is beneficial in maintaining inventories with optimized cost.

Throughout the study, historical trends of rotable component removals and failures were examined. Simultaneously, existing alert value calculation methods were studied and their drawbacks were identified.

With reference to several studies and secondary data collection methods to analyse data were reviewed, in which Statistical Process Control method was selected. Using SPC, mathematical relationships were derived and based on historical trend analysis on each type of rotable component, a reference to define a suitable alert was developed.

The developed mathematical concept not only validated all selected sample components, but have also addressed the drawbacks of existing methods, thus fulfilling the main aim of the research.

Additionally, a prototype for an inventory planning software was proposed based on the developed mathematical concept which can be used to predict the period for removal of rotable components relative to future flying demand. Consequently, recommendations were made to the operators to benefit the alert value calculation outcome

References

Amborski, J., 2006. Calculation of alert levels for reliability.

C.H.Friend, 1992. *Aircraft Maintenance Management.* :Longman Scientific and Technical.

Silva, G.T.F., 2016. *Statistical Process Control* [Interview] (24 April 2016).

Zeljko, M., Borivoj, G. & Omer, P., 2007. Optimizing maintenance reliability program for small fleets.

Anon., 1991. *Civil Aircraft Airworthiness Information and Procedures (CAP 562),* London: UK Civil Aviation Authority.

Peters, C., 2001. Statistics for Analysis of Experimental Data.

Besterfield, D. H., Besterfield, C., Besterfield, G. H. & Besterfield, M., 2003. *Total Quality Management.* :Pearson Education, Inc.