CLAIMS

I/ We claim,

1. An optimization method for forecasting the shop visit build goals and prediction of optimal cost for an aero-engine maintenance, the method comprising the steps of:
   a prediction of the shop visit build goals for an aero-engine maintenance based on user-defined operational parameters;
   a prediction of the required work scope being performed;
   a forecasting and computation of the costs associated with the respective forecasted shop visit;
   an optimization and determination of an aero-engine maintenance schedule based on the optimal/ minimum shop visit cost required over the forecasted maintenance time period.

2. The method as claimed in claim 1, wherein the operational parameters used for the prediction of the shop visit build goals for an aero-engine maintenance are EGTM degradation and LLP remaining cycles.

3. The method as claimed in claim 1, wherein the method of predicting the shop visit build goals for an aero-engine maintenance further comprising:
   a monitoring of EGTM profile and predicting the Remaining Useful Life (RUL) based on the degradation trend of EGTM;
   a monitoring of LLP remaining life and determining a trade-off between utilizing the LLPs to their limit and minimizing the number of shop visits with an affordable LLP residual value;
   a prediction of the time required for maintenance based on EGTM degradation and LLP remaining cycle;
   a forecasting of shop visits by optimizing the time required for a trade-off between maximum LLP usage, minimum number of shop visits and cycles remaining till the EGTM reaches the threshold set by the airline operators.

4. The method as claimed in claim 1, wherein the EGTM profile is built by simulating the EGTM data by the Non-linear Weiner process, which is used for modeling the aero-engine performance degradation using time series data and can be defined as:

$$y_t = a\tau(t,\theta) + b\mathcal{W}(t) + \varepsilon_t$$

5. The method as claimed in claim 3, wherein the Remaining Useful Life (RUL)/ Reliability being determined by Weibull analysis based on simulated data; the RUL/ Reliability being calculated by the formula:

$$R(t) = \boldsymbol{e}^{-(t/\eta)^{\beta}}$$

6. The method as claimed in claim 3, wherein the RUL/ Reliability based on other operational parameters that influence being calculated by the formula:

$$R(t) = \boldsymbol{e}^{-(t(\sum_{i=1}^{n}(w_i s_i)/\eta)^{\beta}}$$

7. The method as claimed in claim 3, wherein the time period required for the EGTM degradation being calculated by:

$$t = \frac{e^{\left(\frac{\ln\left(\ln\left(\frac{1}{R(t)}\right)\right)+\beta\ln(\eta)}{\beta}\right)}}{\sum_{i=1}^{n}(w_i s_i)}$$

8. The method as claimed in claim 1, wherein the shop visit cost associated with a forecasted maintenance schedule includes Direct Maintenance Cost and LLP cost.

9. The method as claimed in claim 8, wherein Labour Cost (total man hour cost) is calculated by the formula:

$$Total\ Man\ hour\ cost = Man\ hour\ routine\ cost * (R\&I_{hrs} + Man_{hrs} + Inspection_{hrs})$$

10. The method as claimed in claim 8, wherein the material cost is calculated by the formula:

$$C_{material} = \sum \begin{cases} C_{unit} * QPA & if\ s_{prob} = 100\% \\ C_{unit} * QPA & if\ C_{repair} > 0.65 * C_{unit} \\ C_{repair} * QPA & if\ C_{repair} < 0.65 * C_{unit} \end{cases}$$

Where, $C_{material}$ = material cost, s_{prob} = scrap probability, QPA = quantity per assembly, C_{unit} = unit price of the part, C_{repair} = repair price.

11. The method as claimed in claim 1 & 8, wherein after predicting work scope for each module, LLP cost is being calculated by comparing LLP remaining cycles associated with the module and the predicted build goals for the shop visit.

12. The method as claimed in claim 1, wherein the future value of the final DMC and LLP cost being forecasted based on the economy and currency inflation rate; the yearly inflation rates being forecasted from the historic data using Dynamic Mode Decomposition (DOI: 10.1109/ICCCNT54827.2022.9984629).

13. The method as claimed in claim 12, wherein using the forecasted rates, monthly rate can be calculated as:

$$1 + r_{annual} = \left(1 + r_{monthly}\right)^{12}$$

$$r_{monthly} = (1 + r_{annual})^{\frac{1}{12}} - 1$$

and future value is calculated by

$$\text{future value} = \text{current value}\left(1 + \frac{r_{monthly}}{100}\right)$$

14. An optimization model for forecasting the shop visit build goals and prediction of optimal cost for an aero-engine maintenance, the model comprising:
a processor coupled to the memory; and
at least one application stored in the memory and executable by the processor for:

a prediction of the shop visit build goals for an aero-engine maintenance based on user-defined operational parameters;

a prediction of the required work scope being performed;

a forecasting and computation of the costs associated with the respective forecasted shop visit;

an optimization and determination of an aero-engine maintenance schedule based on the optimal/ minimum shop visit cost required over the forecasted maintenance time period.

15. The model as claimed in claim 14, wherein the operational parameters used for the prediction of the shop visit build goals for an aero-engine maintenance are EGTM degradation and LLP remaining cycles.

16. The model as claimed in claim 14, wherein the prediction of the shop visit build goals for an aero-engine maintenance further comprising:

a monitoring of EGTM profile and predicting the Remaining Useful Life (RUL) based on the degradation trend of EGTM;

a monitoring of LLP remaining life and determining a trade-off between utilizing the LLPs to their limit and minimizing the number of shop visits with an affordable LLP residual value;

a prediction of the time required for maintenance based on EGTM degradation and LLP remaining cycle;

a forecasting of shop visits by optimizing the time required for a trade-off between maximum LLP usage, minimum number of shop visits and cycles remaining till the EGTM reaches the threshold set by the airline operators.

17. The model as claimed in claim 14, wherein the EGTM profile is built by simulating the EGTM data by the Non-linear Weiner process, which is used for modeling the aero-engine performance degradation using time series data and can be defined as:

$$y_t = a\tau(t, \theta) + b\mathcal{W}(t) + \varepsilon_t$$

18. The model as claimed in claim 16, wherein the Remaining Useful Life (RUL)/ Reliability being determined by Weibull analysis based on simulated data; the RUL/ Reliability being calculated by the formula:

$$R(t) = e^{-(t/\eta)^{\beta}}$$

19. The model as claimed in claim 16, wherein the RUL/ Reliability based on other operational parameters that influence being calculated by the formula:

$$R(t) = e^{-(t(\sum_{i=1}^{n}(w_i s_i)/\eta)^{\beta}}$$

20. The model as claimed in claim 16, wherein the time period required for the EGTM degradation being calculated by:

$$t = \frac{e^{\left(\frac{\ln\left(\ln\left(\frac{1}{R(t)}\right)\right)+\beta\ln(\eta)}{\beta}\right)}}{\sum_{i=1}^{n}(w_i s_i)}$$

21. The model as claimed in claim 16, wherein the shop visit cost associated with a forecasted maintenance schedule includes Direct Maintenance Cost and LLP cost.

22. The model as claimed in claim 21, wherein Labour Cost (total man hour cost) is calculated by the formula:

$$Total\ Man\ hour\ cost = Man\ hour\ routine\ cost * (R\&I_{hrs} + Man_{hrs} + Inspection_{hrs})$$

23. The model as claimed in claim 21, wherein the material cost is calculated by the formula:

$$C_{material} = \sum \begin{cases} C_{unit} * QPA & if\ s_{prob} = 100\% \\ C_{unit} * QPA & if\ C_{repair} > 0.65 * C_{unit} \\ C_{repair} * QPA & if\ C_{repair} < 0.65 * C_{unit} \end{cases}$$

Where, $C_{material}$ = material cost, s_{prob} = scrap probability, QPA = quantity per assembly, C_{unit} = unit price of the part, C_{repair} = repair price.

24. The model as claimed in claim 14 & 21, wherein after predicting work scope for each module, LLP cost is being calculated by comparing LLP remaining cycles associated with the module and the predicted build goals for the shop visit.

25. The model as claimed in claim 14, wherein the future value of the final DMC and LLP cost being forecasted based on the economy and currency inflation rate; the yearly inflation rates being forecasted from the historic data using Dynamic Mode Decomposition (DOI: 10.1109/ICCCNT54827.2022.9984629).

26. The model as claimed in claim 25, wherein using the forecasted rates, monthly rate can be calculated as:

$$1 + \mathrm{r}_{\mathrm{annual}} = \left(1 + \mathrm{r}_{\mathrm{monthly}}\right)^{12}$$

$$\mathrm{r}_{\mathrm{monthly}} = (1 + \mathrm{r}_{\mathrm{annual}})^{\frac{1}{12}} - 1$$

and future value is calculated by

$$future\ value = current\ value\left(1 + \frac{r_{monthly}}{100}\right)$$