

Evaluation of Small Civil Aircraft Operational Dependability and Software Support

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Abstrakt:

Provozní technologičnost v užším a širším pojetí. Ukazatelé provozní technologičnosti. Současná softwarová podpora spolehlivostních výpočtů. Návrh metodiky hodnocení provozní technologičnosti malého dopravního letadla. Softwarová podpora k hodnocení provozní technologičnosti malého dopravního letadla v období návrhu a vývoje.

Abstract:

Operational dependability in the specific and generic term. Definition of the operational dependability and marker for operational dependability. Contemporary computer and software support of dependability calculation. Summary of methodology of operational dependability for small civil aircraft. Software support to work simplification along designing of operational dependability for small civil aircraft (SCA).

1 Introduction

Technologic requirements composed of production and operational requirements. Framework must be produced by production facilities and technical processes in term of production. Operational dependability deal with minimization of demands on maintenance and services. Operational dependability is ones of the technical factors of aircraft which has great influence on operational and economic effectiveness. Operational effectiveness is capability of carry out mission in the given time and operating conditions. Economic effectiveness is operating costs of mission and maintenance of serviceability within lifetime.

Operational and economic effectiveness are main aspect for evaluation of aircraft qualities in reference to safety factor.

In the 60's till the 70's was defined operational dependability as aircraft attribute. Event signal was increasing cost of aircraft system maintenance. At this time came into being essay about aircraft system maintenance. This essay showed that common maintenance methods they can even what cut down operational dependability.

Airlines cooperation and aircraftsman came into existence new methods planning and executing maintenance. For instance in the United States the aircraft authority FAA officially commended using MSG-3 [2] document by the form letter FAA/AC 120-17 "Maintenance Control by Reliability Methods".

Except of Hard Time Maintenance Method there is also On-Condition and Condition Monitoring Maintenance Method in the MSG-3 document.

Especially in the last 20 years was great advance about maintenance methods because of information technology development.

2 Definition of the operational dependability

There have been two essential accesses to aircraft operational dependability. Operational dependability by first definition is engaged in technique aircraft attribute. This definition is called as specific term.

2.1 Attributes to evaluation technical aircraft attribute

This attributes are:

- ✖ Man-hours and continuous time carrying out replacement of component/aircraft units;
- ✖ Coefficient of accessibility (portion of maintenance man-hours of definite operation to total maintenance man-hours);
- ✖ Coefficient of interchangeability.

According to this attributes we can determine general attributes:

- ✖ Specific time of operative and total maintenance;
- ✖ Probability of corrective maintenance at the specific time;
- ✖ Specific man-hours of scheduled and unscheduled maintenance;
- ✖ Specific cost of replacement part and materials;
- ✖ Maintenance has to enable enough annual utilization.

This definition of came into being at the beginning of the 70's of 20th century. This methods meant advantage, but nowadays the definition has fundamental shortcomings as cost of servicing and maintenance, access to maintenance and most of the attributes was determined to very high value of maximum take-off weight (MTOW).

Generic term of operational dependability is not only aircraft attributes, but also all activities about working order about minimum cost.

Both of definitions say that operational dependability is inherency and so have to been included with system design.

3 Attributes of operational dependability

Operational dependability attributes is possible divide into three essential units:

- ✖ Attributes with influence on aircraft operational effectiveness;
- ✖ Attributes with influence on aircraft economic effectiveness;
- ✖ Attributes of inherency operational dependability.

Criteria of attributes first and second unit influence on not only operational dependability but also on service conditions, securing and executing maintenance.

Maintenance time						
Preventive maintenance time		Corrective maintenance time				
Logistic delay	Active preventive maintenance time	Active corrective maintenance time				Logistic delay
		Technical delay	Correction time			
			Fault location time	Active correction time	Checkout time	
	Active maintenance time					

Tab. 3.1 – Diagram of maintenance time

3.1 Attributes with influence on operational effectiveness:

Specific time of planning periodic maintenance relative to the flying hour

$$K_{PM} \quad [h/fh]$$

Specific time of operative maintenance and operator relative to the flying hour

$$K_{OM} \quad [h/fh]$$

Specific time to repair relative to the flying hour

$$K_{RP} \quad [h/fh]$$

Specific total time of maintenance and operator relative to the flying hour

$$K_{TM} \quad [h/fh]$$

Probability of successful completion mission with a view to dependability and restorability of operation efficiency of aircraft

$$P_{SCM} \quad [1]$$

h ... hours
fh ... flying hours
ph ... person hours

3.2 Attributes with influence on economic effectiveness:

Specific man-hours of maintenance relative to the flying hour

$$K_{MHM} \quad [ph/fh]$$

Specific cost of replacement parts and materials of maintenance relative to the flying hour

$$K_{RPM} \quad [czk/fh]$$

Specific total cost to repair relative to the flying hour

$$K_{CR} \quad [czk/fh]$$

3.2 Attributes of inherency operational dependability:

Attributes of accessibility

$$K_{ACB} = \frac{MH_M}{MH_M + MH_A} \left[\frac{ph}{ph} \right] \quad (1)$$

MH_M [ph] man-hours maintenance
 MH_A [ph] man-hours auxiliary operation

Total maintenance man-hours

$$MH_{TM} = MH_M + MH_A \left[\frac{ph}{ph} \right] \quad (2)$$

Attributes of interchangeability

$$K_{CG} = \frac{MH_U}{MH_U + MH_M} [1] \quad (3)$$

MH_U [ph] man-hours onto unit
 MH_M [ph] man-hours onto modification

4 Proposal project of operational dependability methods

- ✗ Carry out analysis of maintainability;
- ✗ Maintenance division into periodic and operative maintenance;
- ✗ Assessment of maintenance man-hours;
- ✗ Allocation of fail, failure state according possibility completion recovery of operation efficiency;
- ✗ Determine recovery of operation efficiency man-hours;
- ✗ Calculate total maintenance man-hours to year;
- ✗ Using assessment (K_{MHM} a K_{CR});
- ✗ Calculate total maintenance time;
- ✗ Determine coefficients of operational dependability:

$$K_{OD}^T = \frac{1 - P_{SCM}^*}{1 - P_{SCM}^A} \quad K_{OD}^{CR} = \frac{K_{CR}^*}{K_{CR}^A} \quad K_{OD}^{TM} = \frac{K_{TM}^*}{K_{TM}^A}$$

Superscript [*] analysis value
 Superscript [A] allocation value

When
 $K_{PT} > 1$... increase operational dependability
 $K_{PT} < 1$... operational dependability is acceptable

5 Dependability and software support

Software gone through system development from relatively simple algorithm to solving boolean equations. From among first dependability software was legendary software FRANTIC. This software was developed under the auspices of International atomic agency in

Vienna. Software was in turn improving about graphical interface as a fault tree and number of probability modules. Nowadays is effort solving a task of dependability already at design time of product.

In the market exists a large number of reliability software like FaultTree+, Reliability Workbench (by Isograph software), Relex. Reliability studio (by Relex software).

Aircraft instructions feature these methods as useful:

- ✖ FMEA – Failure Mode and Effects Analysis;
- ✖ FMECA – Failure Mode, Effects and Criticality Analysis;
- ✖ FTA – Fault Tree Analysis;
- ✖ RBD – Reliability Block Diagram.

Is not useful make use of only one analysis method, but whole package of methods (quantitative and qualitative).

Among main supplier reliability software can be include in:

- ✖ BQR;
- ✖ Isograph;
- ✖ ITEM software;
- ✖ Reliasoft.

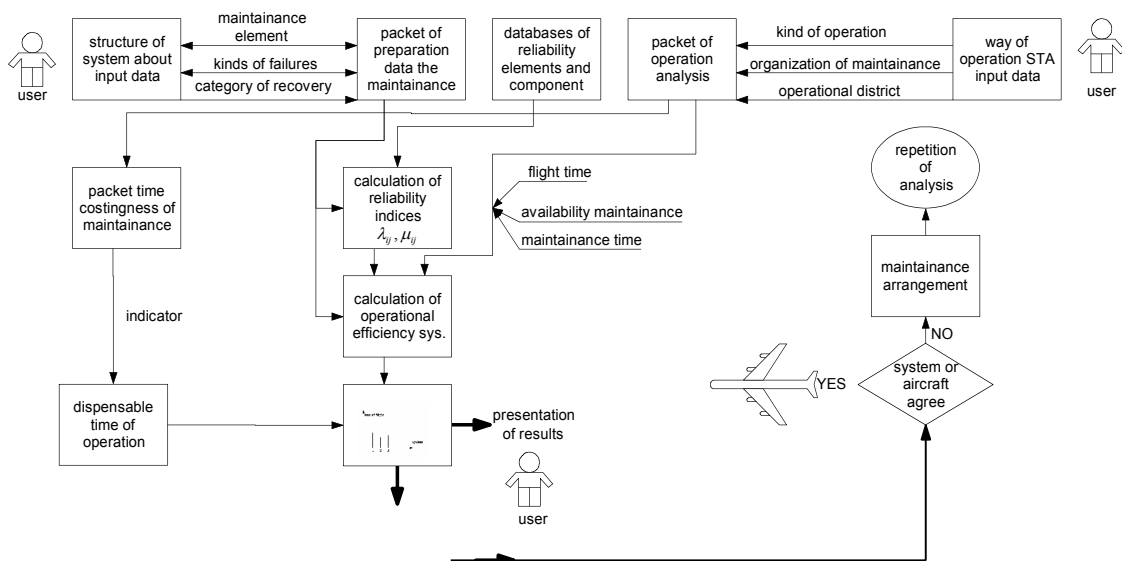


Fig. 5.1 – Preliminary proposal software support of operational reliability analyses for SCA

6 Conclusions

Application theoretical probability methods to evaluation dependability are still more popular part of reliability management.

Contributor and methodology contain general explanation definition of operational dependability and schematic of attributes, account of maintainability analysis. Methodology of evaluation of small civil aircraft operational dependability [1] is in turn improving in terms of project of science and research Ministry of Industry and Trade of Czech Republic – FOREMADE T3. This project is coordinated by VZLÚ Prague.

7 References

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- [2] MSG-3 – Maintenance Program Development Document, Air Transport Association of America (ATA), Revision 2, 12. září 1993
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- [5] Analýza spolehlivosti jako faktoru výrazně ovlivňujícího provozní technologičnost, ÚJV Řež, 2004

8 Web-sites

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- [6] www.ReliaSoft.com
- [7] www.isograph-software.com
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- [8] www.bqr.com