



Application of Bayesian networks in prognostics for a new Integrated Vehicle Health Management concept

Susana Ferreiro^{a,*}, Aitor Arnaiz^a, Basilio Sierra^b, Itziar Irigoien^b

^a *Fundación TEKNIKER, Eibar, Gipuzcoa, Spain*

^b *UPV-EHU, San Sebastián, Gipuzcoa, Spain*

ARTICLE INFO

Keywords:

Prognosis
Bayesian network
Aircraft maintenance
Prediction
Brake degradation
PHM system
Predictive maintenance
Operability

ABSTRACT

The aeronautics industry is attempting to implement important changes to its maintenance strategy. The article presents a new framework for making final decision on aeroplane maintenance actions. It emphasizes on the use of prognostics within this global framework to replace corrective and Preventive Maintenance practise for a predictive maintenance to minimize the cost of the maintenance support and to increase aircraft/fleet operability. The main objective of the article is to show the Bayesian network model as a useful technique for prognosis. The specific use case for predicting brake wear on the plane is developed based on this technique. The network allows estimate brake wear from the aircraft operational plan. This model, together with other models to make predictions for various components of the aeroplane (that should be monitored) offers a forward-looking approach of the status of the plane, allowing later the evaluation of different operational plans based on operational risk assessment and economic cost of each one of them depending on the scheduled checks.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

At present, all airline operators strive to reduce both the amount and cost of aircraft engineering maintenance while at the same time ensuring aircraft safety and reliability. Aircraft manufacturers are continually providing more novel maintenance solutions with the use of new technologies. Nevertheless, current aircraft maintenance practice is still a heavy labor and unscheduled maintenance that remains a significant problem.

Therefore, it is necessary to identify and explain the significance of the major weakness that impact on the maintenance practice, and then, based on these finding, make recommendations for aircraft manufacturers and airline operators so that the identified weakness may be minimized by considering the way in which they impact on the airline operating cost. These cost drivers is established by sub-dividing the whole of the aircraft maintenance process into three convenient areas explained below.

Aircraft maintenance (from the operator's perspective) requires that the plane needs to be sufficiently reliable and easy to maintain with the minimum impact to operations performed on it, it is vital issue. An analysis of the operational disruptions caused by technical problems identifies certain aircraft components (engine, air conditioning, compressed air systems, landing gear or hydraulics, etc.) weakness, taking into account their impact on maintenance

costs. Maintenance execution and Maintenance Management are closely related components because the responsible for maintenance execution depends largely on the management (planning, training, spare parts, logistics, etc.) to ensure the ability to perform tasks safety and efficiently. An analysis of the impact of both in maintenance costs identifies the following weaknesses: the lack of technicians and engineers, and the high cost in recurrent training; the lack of integration in the machine system; poor management decisions, leading to the lack of spare parts, materials or pieces for the maintenance execution; mismanagement in complex situations, etc.

All these weakness can be grouped into a major feature, the operability of the aeroplane, which involves ensuring operational reliability (the punctuality of the flights), maximizing availability (asset utilization) and reducing maintenance cost. Operational reliability identifies the percentage of scheduled flights which depart and arrive without falling into an operational interruption, in such a way that it would be necessary more robustness against defects, no maintenance during turn times and a rapid ground servicing. Availability implies the probability that the aircraft is available for the service at any time during its operational life and it requires a pro-active maintenance, more flexible maintenance scheduling and more robustness against defects. Finally, maintenance cost groups direct and indirect cost of maintenance activities such as check-ins, equipment, data and record keeping, planning, engineering, supervision, tooling, test equipment, facilities, logistics and administration, etc. These costs must be reduced as much as possible either through less fuel or low maintenance costs.

* Corresponding author.

E-mail address: sferreiro@tekniker.es (S. Ferreiro).

Nomenclature

ANN	Artificial Neural Network	OREDA	Offshore Reliability Data Repository
BATS	Bayesian Automated Troubleshooting System	OSA-EAI	Open Systems Architecture for Enterprise Application Integration
BN	Bayesian network, Bayesian net	OSA-CBM	Open Systems Architecture for Condition Based Maintenance
CPT	Conditional Probability Table	PHM	Prognostics and Health Management
CPD	Conditional Probability Distribution	PLM	Product Lifetime Management
CRIS	Common Relational Information Schema	PM	Preventive Maintenance
DBN	Dynamic Bayesian Network	RCA	Root Cause Analysis
DM	Data Management	RUL	Remaining Useful Life
DS	Decision support	SACSO	System for Automatic Customer Support Operations
EM	Expectation maximization	SCSI	Small Computer System Interface
FTA	Fault Tree Analysis	TAN	Tree augmented Naïve Bayes
HMI	Human Machine Interface	TAT	Turn Around Time
HUMS	Health and Usage Monitoring Systems	TATEM	Technologies And Techniques for nEw Maintenance Concepts
IDM	Integrated Data Management	TD	Technical Data
IVHM	Integrated Vehicle Health Management	TTF	Time To Failure
MIMOSA	Machinery Information Management Open Systems Architecture		
MMEL	Minimum Equipment List		
MROs	Maintenance Repair Offices		
MTBF	Mean Time Between Failures		
NB	Naïve Bayes		

The operability of the aircraft is linked with 'on-aircraft' maintenance concept. This concept includes aircraft line maintenance which refers to regularly scheduled maintenance and implies the proper maintenance actions between flights, ensuring the punctuality, availability and reliability for the aircraft. Aircraft line maintenance set if the aircraft is able to perform the next flight or on the contrary needs to be repaired and the flight should be delayed or cancelled. Final decision is based on a check of certain aircraft components within a 'Minimum Equipment List' (MMEL) carried out on the time interval 'Turn Around Time' (TAT) between two flights. Today, the current decision support carried out in the aircraft line maintenance is a reactive process, focused on unexpected or deferred maintenance activities, which represents a high percentage of the reduction in the operability.

Fig. 1 represents the actual aircraft line (ramp) maintenance limited to a go or no-go decision for the aircraft's next flight based on a pre-flight check on certain components of the aircraft, where failures not detected at early stage could be cause delays or cancellations in the next flight, affecting the operational plan of the aircraft/fleet.

More flexible and opportunistic maintenance planning with support for decision making is required in order to achieve a suitable

maintenance, to avoid potential disruptions in the operation of the aircraft, to maximize asset utilization and to reduce downtimes (maintenance opportunity times). In summary, a new type of maintenance (not corrective or preventive) is necessary in order to maximize the operability of the aircraft. The current maintenance should be covered with a new decision support system by means of a proactive maintenance based on prognostics.

Nevertheless, although there are more and more new maintenance solutions thanks to developing technologies, maintenance problems are still unpredictable and this represents a significant obstacle. The article presents a new framework for making final decision on airplane maintenance actions, designed to aircraft line maintenance explained before. The aim of the article is to emphasize on the use of prognostics within this global framework to replace corrective and Preventive Maintenance based on time for a predictive maintenance based on condition and system/subsystem Remaining Useful Life estimation. Moreover, the article presents the Bayesian network model as a useful technique, among the models that could be used for prediction making, in cases where its implementation is feasible. The specific use case for predicting brake wear on the aeroplane base on Bayesian network is developed. This network allows estimate the degradation of the brake

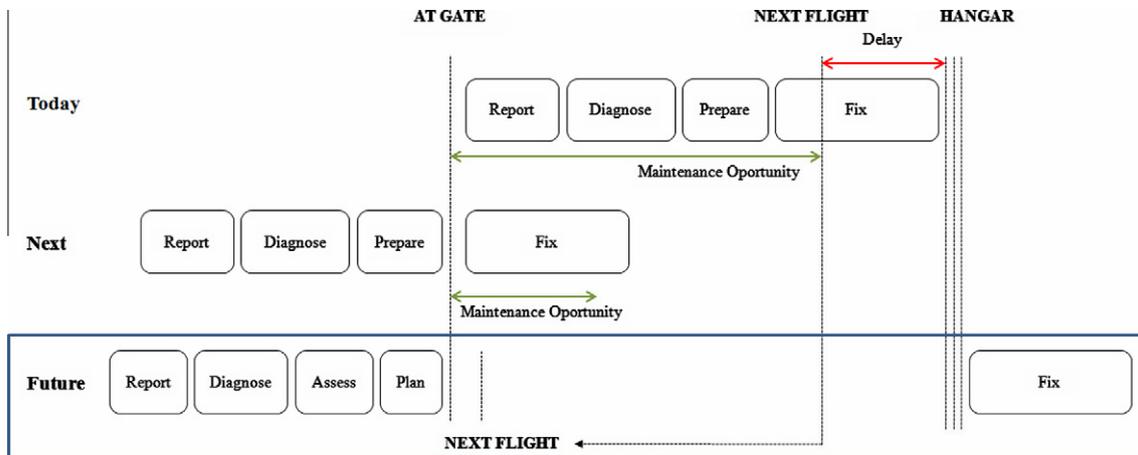


Fig. 1. Aircraft line maintenance execution.

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات