Integrated Vehicle Health Management into Legacy Toolsets

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ABSTRACT

The information generated by diagnostics and prognostics tools produces economic benefits when it is used to make informed decisions regarding maintenance management and logistics. Retrofitting this technology into pre-existing support infrastructures introduces challenges that could be easily avoided on a new platform. This research focuses on finding the optimum way of selecting which of these tools should be retrofitted and how this process should take place. [*]

1. INTRODUCTION

In order to reduce costs and increase the availability of aircraft, diagnostic and prognostics can be used to generate information to be used to make decisions regarding maintenance and logistics. Advances in automated decision making can also be applied to reduce the need for human intervention. When these tools are implemented in conjunction to improve the performance of the support infrastructure we talk of Integrated Vehicle Health Management (IVHM).

IVHM can produce additional benefits besides those they were originally intended for. It has been proposed to use this technology during manufacturing, testing and certification phases (Scandura 2005); and to use it as a quality management tool for the continuous improvement of the aircraft and its support system (Benedettini et al. 2009).

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2. PROBLEM ADRESSED

Many organizations have made a strategic investment in the development of IVHM tools. To be profitably exploited they must interfaced with current platform support infrastructures. Understanding these interfaces is crucial to the direction of research and development of the underlying IVHM capabilities. Constraints at the system integration level could have far reaching implications for the nature and mode of operation of individual components in the IVHM value chain, such as the qualities, quantities and availability of data used in vehicle health assessment (Keller, Majkowski & Swearingen 2009).

IVHM is a new concept and has stimulated multiple branches of technology and process development. Substantial capability is building in the component technologies, but an essential missing link is the bridge between these and the first line operator systems. These are often bespoke to platforms owned and controlled by diverse stakeholders. Commercial exploitation of IVHM ultimately depends on the seamless integration of the capability at this level.

3. EXPECTED CONTRIBUTIONS

As a result of this project it is expected to have reduced the gap between IVHM technology developed for the aerospace industry and the support systems which are currently in use to help to increase platform and mission availability and reduce costs.

To achieve this objective a comprehensive study of the technical and organizational challenges regarding the retrofit of diagnostic and prognostic tools on legacy aircraft will be presented for the first time.

Additionally, a new methodology will be developed to estimate to what extent the put in service of diagnostic and prognostic tools reduces maintenance costs and increase the availability of the aircraft.

Finally, a methodology on how the implementation of IVHM on legacy systems should be developed regarding all technical, economic and organisational aspects will be proposed. Special attention will be paid to potential disruptions in the normal operation.

4. PROPOSED PLAN

Since the success of retrofitting IVHM depends on the benefits it can bring to the aerospace industry, the first stage of the project consists of studying the state of the art of health monitoring technology and what challenges are faced when trying to install these tools on a legacy system.

In order to analyze the effect of the new information generated with prognostic tools, it has been decided to develop a model of the support system of an aircraft and study the changes produced by the implementation of different tools. The Eurofighter Typhoon has been chosen for this analysis. To make sure the model provides the best results possible, a study the end-to-end support processes for the chose platforms and an assessment of process modeling techniques will be carried out. Once the definitive technique has been chose the model will be developed an adjusted.

Additionally it will be necessary to determine which components are responsible for most of the availability losses and waste of resources in the process. Once these components have been identified, it will be necessary to develop a method to analyze which diagnostic and prognostics tools can be retrofitted given the limitations to measure some of the parameters of the component and the performance of the tool. Once the IVHM tools have been selected and the model adjusted it will be possible to verify how the use of this technology would benefit the support system of the aircraft.

5. WORK ALREADY PERFORMED

5.1 Analysis of technical and organizational issues

Examples of organizational and technical problems regarding the development and implementation of IVHM tools are mentioned very often in the literature. Technical challenges have been segregated into three main groups: tool-related, platform-related and integration-related. Organizational problems, on the other hand, can be classified according to the character of the problem (cultural or structural) or the stage of the project (development or implementation).

The technical issues raised have been analyzed taking into account the limitations and advantages of pre-existing platforms and their support systems. There are technical limitations of diagnostic and prognostic tools related only to their intrinsic characteristics and not to the aircraft they are installed in. On the other hand, the vehicle imposes limitations regarding the quantity and quality of the information than can be fed to the algorithms that govern theses tools. Finally, the implementation generates a new set of problems regarding the integration of these with other systems.

Many of organizational problems that the development of IVHM faces nowadays are similar to those any new technology faces in its early stages, although being such an interdisciplinary topic introduces additional challenges. Also, since this technology produces changes in the way maintenance and logistics are managed, the issues concerning their implementation have also been studied.

5.2 Impact of IVHM tools on costs and availability.

In order to decide which components should be selected to analyze the technical viability of retrofitting a diagnostic or prognostic tool on them, it is necessary to study first the impact that such implementation would have on the maintenance costs and the availability of the vehicle. With this objective, an Event Tree Analysis (ETA) was carried out to study how a fault can be detected or prevented by a monitoring tool and the effects of such fault on the mission.

For each of the 22 possible outcomes, the cost and the effect on the downtime are calculated taking into account the cost of components, cost of labor, warranties, maintenance times and delays. Additionally, the possibility of operating the aircraft on an availability contract basis is also considered, which adds factors like the loss of income in case the aircraft cannot carry out its next mission as expected and the economic compensation to be paid to the operator.

The functions of the sensitivities of the maintenance cost and the increase of downtime to the performance of the diagnostic and prognostic tools have been obtained for those components assuming the probability of failure follows a Weibull or normal distribution.

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