TKI DINALOG
Dutch Institute for Advanced Logistics

OPTIMIZING MAINTENANCE ON MOVING ASSETS

IMPLEMENTING CONDITION-BASED MAINTENANCE AT FOKKER SERVICES B.V.

Fokker Services is a business unit of Fokker Technologies, that focuses on providing availability services within the aviation industry with an emphasis on maintenance, repair and overhaul (MRO) services. Fokker continuously aims to improve its maintenance practices, and therefore wants to investigate the possibilities of implementing condition-based maintenance (CBM). Fokker, however, does not know on which components it should implement CBM, and if this implementation will benefit Fokker. Therefore, this study focuses on two topics: the requirements and processes necessary for implementing CBM and the benefits that such an implementation can give. For the first topic, we create a methodology for selection of components for CBM implementation and a framework for the implementation of CBM. Next, we create a mathematical model that is able to assess the benefits of CBM implementation for the second topic. In both topics, we apply the methodology and model in a case study at Fokker to assess the effectiveness.

CURRENT SITUATION REQUIREMENTS AND PROCESSES

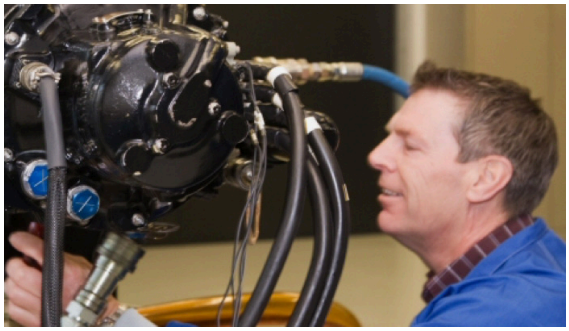
To find out which components are best suited for CBM implementation, we apply a five-step selection method created in this study. We assess components on criteria within three categories : technical, financial and organizational feasibility. An example of technical feasibility is system reliability, which has a big influence on the effectiveness of CBM. When applied, the result of the methodology is a ranking of the assessed components. Management can then decide on which components to implement CBM.

We next develop a framework for the implementation of CBM. For Fokker, the CBM implementation process is unclear. The CBM implementation framework that we create is built around three distinct phases: the site & equipment audit, the CBM policy set-up and the CBM execution. Furthermore, Fokker wants to know which stakeholders are relevant when implementing CBM. Therefore, we have performed a literature study that we have used to define a set of guidelines for the management of the organization when implementing CBM. We find that good organizational management is vital to the effectiveness of a CBM implementation.

BENEFITS

To be able to perform a comparison between the current age-based maintenance policy (ABM) and CBM, we create a mathematical model that fits both policies. The mathematical model that represents Fokker's maintenance processes is unique, since Fokker is not able to decide on the moment that it maintains its components. Operators send in their components to Fokker when components have failed, which therefore create a-periodic inspection times for Fokker to check the condition of components. In the mathematical model, a continuous-time Markov chain is used to model the failure behavior of the components which enables us to model a CBM policy. The CBM model is based on a-periodic inspections that are based on the failures of the component itself, making inspections a random

event. To the best of our knowledge, this model is unique in CBM modeling which therefore fills a knowledge gap. Furthermore, the model is applicable to similar situations for maintenance on systems, which is common at 3rd party MRO providers (e.g. KLM E&R or Lufthansa Technik).
In the current ABM policy, we can evaluate performance by using the degradation characteristics as an Erlang-k distribution combined with (constant rate) random Poisson shock failures. This model is based on time and not condition, but enables us to compare both policies in the same model.
The model is then applied in a case study for a Fokker component that was chosen as a result of the selection methodology discussed above. We run the model with two different cost settings: in one setting, Fokker's costs are combined with those of the operator, while in the other setting only Fokker's costs are considered.
We compare three different policies: the current ABM policy that Fokker uses, an optimal ABM policy and an optimal CBM policy. For both cost settings we find that CBM is the optimal choice over both ABM policies, as it is cheaper and has higher availability. CBM is upto 20% cheaper than the current ABM policy and 8% cheaper than the optimal ABM policy. Furthermore, the savings are higher in the situation where Fokker and operator costs are combined, than for the Fokker costs only, which provides an incentive for cooperation between operators and Fokker.



CONCLUSION

In this study, we have presented methodologies and guidelines for the implementation of CBM in Fokker's environment. These methodologies and guidelines should be used by Fokker when implementing CBM, to have more confidence in the outcomes and perceive the implementation process with more ease. Next to that, we have developed a selection methodology that was tested in a case study, this led to the selection of a component. Using the mathematical model that we have developed, we showed that applying CBM to this component would lead to significant savings in maintenance costs. Furthermore, the model also showed that the current policy is not optimized, as savings within the current ABM policy were possible by changing the decision variables.
For Fokker, the study imposes practical solutions and recommendations. First, even though Fokker is currently not able to continuously monitor its components, a specific form of CBM can still be implemented. Fokker can check component conditions when components arrive at Fokker for maintenance, and then decide to preventively overhaul components. In return, the adoption of this maintenance technique can lead to significant savings, which we have seen in the previous section. The implementation of CBM takes some time, as the process for transitioning to CBM is extensive and complex. Until CBM is implemented, Fokker can also improve its current ABM policy to an optimized ABM policy, which can also lead to savings.

Finally, an incentive for more cooperation between Fokker and operator is given. Especially for the situation that Fokker is in, heavier cooperation with operators can open up more opportunities for better maintenance. For example, Fokker can reach an agreement with operators to install sensors on components and obtain a mandate to call in components for repair when necessary. In return, the implementation of CBM has shown to generate savings for Fokker, and even higher savings when Fokker cooperates with operators.

Topsector Logistiek

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