DINALOG
Dutch Institute
for Advanced Logistics

PREVENTIVE MAINTENANCE

MAINTENANCE CONCEPT DEVELOPMENT FOR NAVAL COMPONENTS VIA QUALITY FUNCTION DEPLOYMENT AT DAMEN SCHELDE NAVAL SHIPBUILDING

Why a new maintenance concept?

Maintenance concepts include specific rules for guiding the maintenance selection procedure. This procedure involves rules for selecting critical components and appropriate maintenance policies for naval components (failure-based, use-based, condition-based). For maritime companies, developing maintenance concepts depends on fulfilling customer requirements at low costs, while at the same time assuring high functional system performance. Thus, such companies deal with business/added value, costs and functional/risk types of criteria.

Traditionally, preventive maintenance concepts are based on Reliability Centered Maintenance (RCM). Such concepts focus only on functional/risk types of criteria, and less on costs. In order to include all the remaining business and cost criteria, additional analysis should be performed, making RCM time-inefficient. Furthermore, RCM cannot handle specific customer requirements very well. For example, some customers give priority to availability, while others prefer low life cycle costs. For this reason, a shift to a combinatorial evaluation of criteria is advised using multi-criteria decision making (MCDM) techniques. Quality Function Deployment (QFD) is such a technique, which is used for translating the customer's needs into maintenance engineering needs.

DAMEN SCHELDE NAVAL SHIPBUILDING (DSNS)

DSNS is responsible for delivering complete maintenance advice for the components of each vessel, and is looking for a way to develop a maintenance concept in a much quicker and holistic way, easily adaptable to each customer's needs.

QFD APPROACH

QFD starts by identifying and prioritizing the customer's requirements (Figure 1).

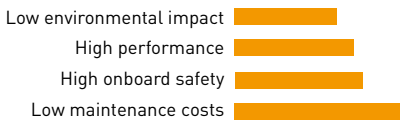

Figure 1: Customers' requirements ranking

The customer's requirements are ultimately translated into measurable parameters, expressing the performance of each component. These parameters show what should be measured in every component in order for the maintenance engineers to fulfil the customer's requirements. The parameters are twenty in total, with inspection and monitoring costs being the most important ones, followed by the complexity of detecting a component's failure and lastly transportability issues.

For each of the twenty parameters, appropriate performance measurements have been summarized in twenty Tables. Two examples are shown in Figure 2.

1. Probability of detection (PoD)		2. Complexity of detection (CoD)	
Description	Grade	Description	Grade
≤ 20% PoD: Low PoD	3	Detection by intrusive method	3
20% < PoD ≤ 70%: Medium PoD	2	Detection by inspection	2
> 70%: High PoD	1	Self-announcing failure	1

Figure2: Examples of parameters' threshold values

MAINTENANCE POLICY SELECTION GUIDES

The parameters' performance measurements along with each parameter's weight are aggregated into two overall values of each component's importance: the criticality (CR_I) and the cost index (C_I). The criticality index is used for determining which component is critical. The selection of the appropriate maintenance policy for each component is the result of the combination of the criticality and the cost index as Figures 3 illustrates. So, for example, when a component is within the medium criticality class (CR_I between

20% and 40%), and at the same time its cost index is high (C_I is within 40% and 80%), then this component will be assigned to use-based maintenance (UBM*). Figure 3 shows a situation where altering the design of a component in order to make it more maintainable is not an option; design for maintenance is not implemented within DSNS. The QFD concept takes also into account a future situation where design for maintenance is being performed. In that case, Figure 3 will be slightly altered, in a way that when a component scores CR_I within 80% and 100%, then modification in design should be performed.

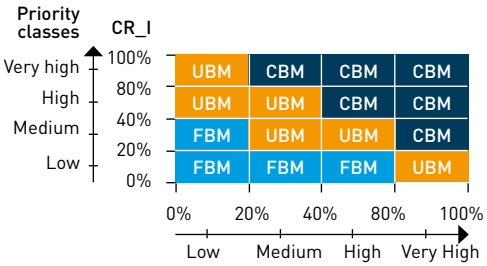

Figure 3: Maintenance policy selection guide: no design for maintenance

**UBM stands for Use based Maintenance, CBM for Condition Based Maintenance, FBM for Failure based Maintenance.*

THE CONCEPT

The concept focuses on systems where their predominant components are mechanical, pneumatic or fluidic in nature, and also on systems for which maintenance instructed by law (MM) is executed for a component percentage lower than 70%. The concept execution steps are shown in Figure 4.

CONCLUSIONS

- Easy to use
- Realistic time and manpower resources needs
- Includes customers in the decisions
- Time-efficient (combinatorial evaluations)
- Budget restrictions are taken into account
- New to most customers

RECOMMENDATIONS

Concept specific:

- Surveys on more specialists to validate customer's importance
- Criticality & cost priority classes validation
- Test for correctness on at least one system (~ 70 components)

In general:

- Research on the added value of predictive CBM & CBM installations
- Evaluation of analyses correctness: accurate performance measurements per component
- Research on the value of implementing design for maintenance

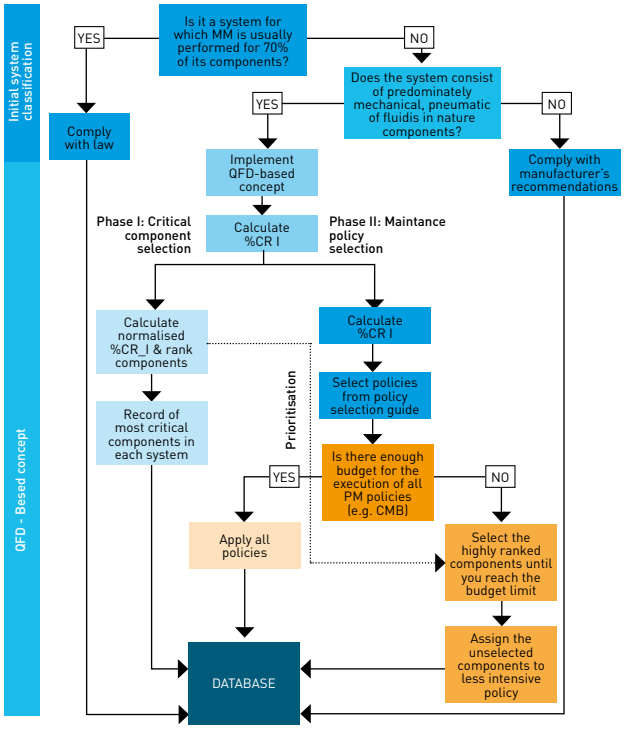

Figure 4: The concept

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