Putting data to use in maintenance – A method to introduce data driven risk centered maintenance in companies

The market of computerized management systems that are used for maintenance purposes has increased massively over the past years. This development shows the massive boost in importance of maintenance throughout asset intensive industries and the return on maintenance concept. With the rise of very sophisticated maintenance management tools, which are not only able to collect and structure data, but to find the right conclusions with statistical/analytical engines and fuzzy logic modules, the focus needs to be on the use and generation of sufficient data concepts. Companies begin to explore their historic data and usually find bad data quality and blind spots in their collection process. They also begin to understand that data generation is a cost factor which needs to be taken into account in light of lean maintenance and cost efficiency. The goal of this article is to give the reader a comprehensive understanding of the right tools and the right data for a reliability centered maintenance approach and to point the way to a smart maintenance system.

You can find more information about this subject in the FIR-whitepaper „Return on Maintenance. A paradigm shift in maintenance services due to Industrie 4.0“ from 2018. Link: rom-en.fir-whitepaper.de

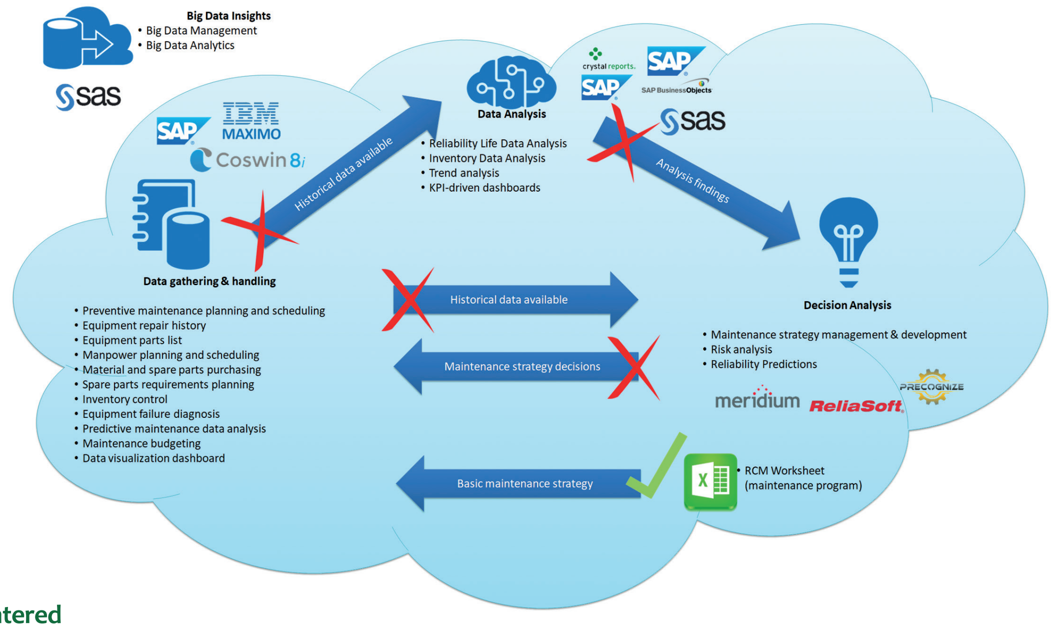

Figure 1: Common approach for data management and analysis

Core ingredients: Reliability Centered Maintenance (RCM) and data management

RCM was introduced in the late 1970s in the aircraft sector and has spread to various industries since then. The basic idea behind RCM is to focus on the Life Cycle Cost (LCC) of the asset and indirect default costs, such as e.g. quality, production loss or safety regards. The challenge in the implementation of this maintenance concept is to gain sufficient knowledge of the assets, which is a very difficult task for complex assets or plants, new assets, and in terms of knowledge exchange across various departments. In the past the only way to cost efficiently generate sufficient data for RCM was mostly done with workshops and the help of experts. Even in the future, experiential knowledge of the maintenance engineering team will be more important than ever, but like all human behavior, the knowledge of experts always tends towards biases. The first expert is more focused on electrical components, so a lot of money is invested in electrical systems; the other one is an expert in lubrication, and thus the focus is placed there. The biggest advantage of a data management system is that it does not have a passion for a specific asset or engineering topic, so the data is always presented in the same way.

The ability of data storage solutions has increased tremendously over the past years, the industrial internet of things generates an unthinkable amount of data, and with the possibilities of machine learning / data analytics the data can be transformed into business decisions. Company-specific data management is complex and varies greatly, so the printed logos only show examples of product groups and do not suggest or promote any system.

In figure 1 a common approach to maintenance data management is shown. For the purpose of this paper we abstract the process into three steps: raw data gathering and handling, data analysis and decision analysis. In what follows we will explain every step in detail and specify the right method of implementing and improving RCM with an intelligent data management system.

Equipment Code	Equipment description	FMECA prior to event; RCA - after event																RCM											CIP assessment				
			Failure cause analysis			Failure effect analysis		Existing maintenance program					Basic RPN				Updated maintenance program							Target RPN					ΔKPI	Actual RPN			
		Equipment function	Functional failure	Failure mode	Failure cause	For component/ unit	For system/ process line/ plant	Maintenance strategy	Routine maintenance actions	Frequency	Duration	Machine status	Severity (S)	Occurrence (O)	Detection (D)	RPN	Maintenance strategy	Routine maintenance actions	Strategic/Organizational measures	Frequency	Duration	Machine status	Cost estimation (optional)	Severity (S)	Occurrence (O)	Detection (D)	RPN		Severity (S)	Occurrence (O)	Detection (D)	RPN

Figure 2: Example for a risk centered maintenance worksheet

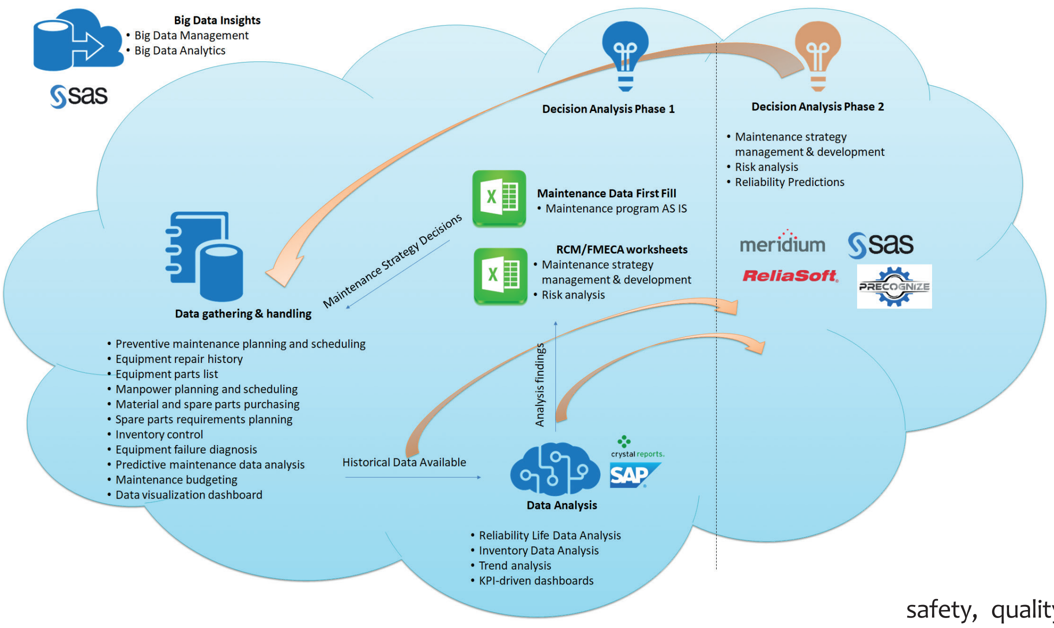

Figure 3: Recommended approach for data management and analysis

Setting the foundation – data gathering and handling

To get the right data in the right quality is the first and usually completely underestimated step in the process of data driven maintenance execution. The good news is that there is a variety of software available with little or no need for alteration, since processes are fairly similar in the production industries. The bad news is that the challenge usually does not lie in the selection of a program, but in the implementation and process deployment. While the software investment commonly is around €100,000 – 150,000, the implementation, training and consulting cost exceed this usually by far.
Typically the lack of sufficient master data, various non-formalized data sources and the lack of user acceptance and benefits stand in the way of an easy implementation of the maintenance data system.

Essential insights generated in multiple maintenance data implementations are:

- Generating data costs money: Always think first before you create and possibly over-engineer equipment structures, workflows and maintenance routines. Focus on the important tasks, equipment and orders. It is always possible to add detail; it is very hard to take it away from a running system.
- Maintenance data is company data: When implementing maintenance data management, always keep in mind that there is more than the maintenance engineering team is involved in, such as asset management and the maintenance process. There need to be sufficient links to accounting, purchasing, controlling, production, and so on.
- Focus on the data, not the software solution: The software must have a flexible interface allowing to upload massive data sets from Excel as well as to make amendments for collections of records simultaneously in the system itself.
- Easy to work with: The less time the input and management of the data needs, the more time the maintenance engineering team has for productive work and for actually using the generated data.
- Centralized knowledge: Convert all experiential knowledge, HSQE (health, safety, quality and environment) and OEM (original equipment manufacturer) manuals into digital job descriptions, instructions and task lists and identify the appropriate level of competence, which allows the system in the future to allocate resources accordingly during work planning.
- Cluster failures to gain a better asset understanding: Define a library of all actual and possible failures and their causes. It is vital to keep in mind during specification and standardization of failures that only a combination of both the equipment name and failure name give a unique character to the event. Therefore, attempts to put too much specification in the designation of failures leads to over-growth of the catalog and to wrong conclusions.
- Priorities for continuous improvement: Develop a measuring system with reasonable ranking criteria of failures and remedial actions (e.g., Risk Priority Number – RPN), which help to track progress while reviewing the maintenance strategy, and measure the results.

There are well known and proven methodologies like FMECA (Failure Mode, Effect, and Criticality Analysis) and RCA (Root Cause Analysis) that provide – even with basic analytical tools like Excel – a robust approach for the implementation of risk based maintenance.

A case study below (see figure 2, page 16) represents all insights listed above in one Excel sheet. In the implementation phase, a cross-functional team starts to fill in the left part of the table (FMECA and RCA) during initial workshops. With a good cross-functional team and an experienced moderator, about 60 to 70 % of failures can be identified and preventive measures defined. The next step is to upload the results to a computerized system for the implementation in normal operations and collection of feedback for continues improvement.

In this stage the user centricity of the software solution is key, because especially in the implementation of processes and routines every complication, every failure or time loss will be remembered by the team. In the next weeks or months, the data will be tested and used. The team needs to be able to navigate easily through the equipment structures and failure catalogues, and to filter or add information to the existing data. It is also necessary to identify any limitations of the current catalogue framework or equipment structure for further improvement in the following steps.

Priorities for improvement – data analysis

Add the information gained in the operational test to table 1. In the following workshops, the goal is to conduct an RCA analysis in regards to the worst assets in the equipment structure, enabling the team to cover 80 to 90% of failures with the predefined catalogues. In this step, data visualization and data management of the software solution are of utmost importance. Diagrams, individual KPIs, CAD drawings and other information linked to the object help to identify and visualize the problems with the assets and direct you to the right strategy for improvement. The easier the information is provided, the easier it is for a variety of users to exchange their knowledge and help with the decision analysis.

Putting the data to use – decision analysis

The aim of the following workshops is to complete the middle and left parts of table 1, reviewing and assessing the current maintenance program. The team needs to view all necessary information, starting with the bottom ten assets in terms of availability or failure rate and question the maintenance processes currently in place. While the data enables the team to get a more complete picture of the situation and to address problems, it is only a tool to adjust business processes. The use of sophisticated maintenance solutions with machine learning and other fancy technologies will not make up for any mistake made in earlier steps or shortcuts taken, which prevent fine tuning of the systems. Since the adjustment and implementation will take up significant time, we offer an approach which includes a combination of the tools used in the first two steps and postpones the use the high priced advanced decision analysis software to the second phase (see figure 3, page 17).

The process needs to be done regularly to establish a continuous improvement process. At this stage, every team member needs to have access to all relevant information. The team needs to decide together on adjustments of the maintenance strategy and measures for specific assets, and track all decisions based on the accepted asset risks (RPN). The improvement process does not only consist of the improvement of assets, but also of setting the bar for failure occurrence higher on a regular basis.
For instance, the company agreed to set the highest acceptable occurrence rate of failures (MTBF – Mean Time Between Failures) for the RPN criterion to 3 months and the lowest occurrence to 18 months. Thus, every asset that has a likelihood of failure of more than once in three months requires a thorough RCM analysis, while for an asset that is likely to fail less than once in 1.5 years a less intensive maintenance strategy can be implemented. To improve asset availability, the company could alter the limits to 4 months / 2 years and so on. This assessment does not solve all the challenges in a modern production landscape; HSQE guidelines, for example, need to be regularly updated and the assets need to be improved accordingly.

Intelligent and thorough data management comes first

Before starting with smart maintenance and machine learning, get things done right. Big data and analytics are a great way to get the most out of your assets, but they are not always the biggest lever and require a solid data foundation. As shown it is possible to get more out of the resources you have with relatively simple tools by applying the right method and bringing together the right people. To turn a computer system into a working tool and take full advantage of the capabilities of modern software solutions, specific steps must be taken, and both management and personnel need to be involved in shaping the future business processes. Only the right processes are able to generate a solid data foundation and enable the RCM method to work and improve asset lifecycle management and overall costs. *df · Kryukov*

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