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Reliability Centered Support

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Introduction

For those who have attended an RCM course it is likely that you formed the impression that the RCM method is designed for use in an existing operation. The way that the method is usually presented is tailored for RCM's largest market – existing operations. However, it was designed for use during asset design and deployment!

In "Greenfield" projects the emphasis is on building the asset and project managers are extremely task oriented to achieve that. When commissioned and turned over to operations the operational and maintenance crews quickly learn that little thought was given to their actual needs. Performance of the asset usually suffers for the first year while they sort out the many problems that were given next to no thought by designers and even less by project managers.

Start up and initial operations do not need to be so chaotic and fraught with problems. Imagine if new aircraft were put into service the way that many plants are! Would you fly on them?

RCM works best in those "Greenfield" applications, but it is rarely applied outside of aviation and nuclear power. The decision-making processes for such projects are often focused exclusively on future returns on the investment, so project costs are shaved to the minimum. The financial decision makers often trust that once it is built, it will work, work right, and sustainably. They are often dead wrong. Fortunately, a relatively small up-front investment (e.g.: 2 – 3 % of capital costs) can turn that around, ensuring rapid ramp up and sustained reliable performance. Greenfield projects are ideal places to apply RCM because of the tremendous opportunities it enables. This "paper" will describe an entire support process based on RCM as its foundation.

Greenfield RCM

At any "Greenfield" site you are faced with much the same challenge that the US civil aviation industry faced in the early 1960's. New and much larger aircraft were being designed that required a more efficient and more effective approach to maintenance in order to leave some time for flying and in order to improve on the rather high percentage of equipment related crashes. By 1965 the first decision diagram was developed and by 1968 MSG-1 was used on the Boeing 747. In 1970 it was applied to the DC-10 and the Tristar. In 1976, the US DoD asked United Airlines to report on how the civil aviation industry developed maintenance programs. Nowlan and Heap produced their "Reliability Centered Maintenance" report in 1978. RCM now had a name. By 1980 the Air Transport Association (ATA) produced MSG-3. It is still in use in that industry today at rev 3 (2002). In parallel with this development the US DoD published Mil Std 2173 (1986) that was used in military applications until a "commercial standard" arose to replace it. In 1982 another Nowlan and Heap offshoot appeared in S Africa implemented by John Moubray. By 1986, his offering was being adopted in a variety of industries all over the world. In 1990 John Moubray published his book, "Reliability-centred Maintenance II". In 1998, a standard, SAE JA-1011, was based on that book and since then, several other compliant methods have emerged and other books written. One of the most recent is "Reliability Centred Maintenance – Re-Engineered", by Jesus Sifonte, and James Reyes-Picknell[1].

The rest of this paper discusses Reliability Centered Support (RCS) as a method for applying and leveraging the success of RCM in "Greenfield" applications.

Leveraging RCM

In performing "Greenfield" RCM the only substantial difference to the method is the composition of the review group - clearly it can't include operators and maintainers from plant that doesn't yet exist. Major reasons the method as applied in existing operations uses operators and maintainers is that they know the assets best, they are therefore best suited to know the causes and effects of failures and to make the decisions. Another reason is that they must ultimately "buy into" the results of the analysis. In those operations, a key success factor is how well change is managed. If they do the RCM analysis work, they generally buy-into the results of it. In a "Greenfield" application buy-in won't be a challenge as there is no status-quo for anyone to defend.

You do however have experienced operations and maintenance people participating in the design effort. They can be utilized very effectively in RCM review groups to represent those operational and maintenance interests. The challenge of having no operating experience to fall back on is the same as that faced by the aviation industry introducing the B747. Related experience, similar systems from other operations, generic failure data and sometimes just plain educated gut feel will need to be used. Assumptions can be captured and validated once the systems enter service. RCM produces an excellent by-product. You know exactly what data you need to use to manage failures and thus reliability and risk.

By doing RCM at the design stage it is possible to identify reliability, operability and maintainability challenges. All of these are easily dealt with at this early stage in the asset life cycle. Traditional engineering style FMEAs (failure modes and effects analyses) are intended to achieve this but their approach that focuses on parts and assemblies rather than functions, is prone to missing the big picture functionality. FMEA also stops short of leading the analyst through any sort of process to define actions required to manage failures and their consequences. RCM, goes those extra few steps.

To leverage the RCM output to maximum effect and return on investment you must also go well beyond merely defining what work is needed to manage failures. You have the opportunity to set up the entire supporting infrastructure for the new operation. Reliability Centered Support provides this leverage. The process recognizes that you have far more influence over life cycle, operating and maintenance costs at the design stage than you will have once the asset is built and in service. It is the best time to apply RCM!

RCS is designed to be cost effective. Throughout industry cost reduction is very important and operational readiness can be sacrificed if it is more cost effective to do so. RCS, because of its starting point (RCM) achieves that trade-off when deciding on whether or not any activity is worth doing.

RCS begins with RCM to define what must be done. You identify all proactive work (PM, PdM), Detective Maintenance / Failure Finding (FF), you identify design deficiencies at the time when you can actually have them changed relatively easily and you identify where Run-to-Failure (RTF) is appropriate.

[1] "Reliability Centered Maintenance – Re-Engineered", Jesus Sifonte, James Reyes-Picknell, 2017, Productivity Press, NY

Maintenance Review

Complementary to the RCM activity is a maintenance review of equipment prior to purchase. It is essential in this process to ensure that what is bought is maintainable. RCM will almost certainly design related problems before the assets are acquired but this visible review adds tremendous value both to the RCM analysis itself and to the maintainability of the assets as installed. RCM's "functional" approach at the design stage can miss some of the maintainability details that may not be evident at design reviewing models, drawings, simulations, etc. We have seen many mining operations where Operations had the only say in equipment selection and Maintenance were left trying to maintain equipment that was not suited for the application, or had serious design faults that created Maintenance nightmares and attendant high costs and low availabilities. This (Operations selection of equipment) seems to be the norm in the mining industry. High levels of Maintenance involvement, including RCM analysis, at the equipment selection stage enables them to identify potential issues before they arise.

Maintenance Task Resources

The RCS process then defines all support resources (crafts, tools, test equipment, parts, materials, instructions, manuals, drawings, etc.) that are required to carry out the tasks that RCM defines. This arises from a process of planning the work and putting it on schedules to be executed, most likely in your CMMS or EAM system. The military folks call that "Maintenance Task Analysis". For all PM, PdM, FF tasks you can be extremely precise because demand is known very precisely. For RTF corrective maintenance you know what you will need to do to repair the failures but you won't know exactly when. Despite that, you know approximately demand rates and you can base sparing decisions on those. Note that due to the RCM process the failures that are allowed to RTF are always those with very low consequences to safety, environment or production so there is no need to respond to them on an "emergency" basis, even though the equipment will be down. Again, this saves considerably on costs down the road: emergency work in a remote mining operation can cost upwards of 10 times the cost of planned non-emergency corrective work.

In RCS we make decisions about repair vs. replace, where to repair, whether or not to stock spares, how many, where, when to acquire them based on anticipate failure profiles. In a “Greenfield” application, these decisions must be made in parallel with the RCM analysis because there is no established practice on which RCM will make its "is it worth it?" decisions. The opportunity to apply optimized decision-making support tools, such as Life Cycle Cost analysis, is best in a “Greenfield” application. The best place in the process to make these decisions is during the RCM analysis at the point where you are working through the decision diagram and asking the "is it worth it?" questions. To answer those correctly you need to decide on the basis of a future practice so you must use a simple life cycle cost decision-making tool to decide on repair vs. replace strategies and on where you should repair the failed repairable items removed from service. Once you know the most economic repair approach you can compare the costs of proactive tasks (PM and PdM) with the costs of those most economic repair decisions.

When we consider using extensive repair by replacement, we make sure it makes economic sense. The decision process puts an economic justification in place for the decisions to ensure that they are "sensible", not just gut feel. It's also highly defensible.

RCS then defines the training required for the crafts to do the tasks that were defined, delivers the training with all its support (classroom aids, manuals, exercises, lesson plans, etc.). You know the work that must be done in detail so you can identify needed skills and knowledge in a thorough training task analysis and produce a very targeted training program that doesn't over or under do it.

Technical Documentation

RCS defines all needed documentation (manuals, drawings, computer files, etc.) as required to support the above activities and either produces them or acquires them for use in whatever format and media best suits the site and the desired application of the information (hard copy, CD ROM, on-line, web-enabled, etc.)

Information Technology (Data Strategy)

Storage of information and future collection of data requires a "data strategy" leading to an IT infrastructure and application strategy that must be deployed. No doubt, you already have corporate systems standards that will be deployed, but do you know exactly what data is needed to enable optimization of maintenance and sparing decisions as the plant matures and experience is gained. We often find established organizations with excellent IT infrastructure and systems that can't seem to get much information that is really valuable out of all the data they collect.

RCS also produces a data strategy that defines what data is needed to provide the sort of information you need to make decisions down the road. It is not just a programmer's idea of what data should be collected. It is highly targeted. For example, in RCM you will find that you are often required to make decisions using MTBFs that are "best guesses" or "generic" to an equipment type. In the design stage that's the best you can do because you don't have data from operations in your operating context to work with. Since it's possible those estimates, you used will be slightly wrong you need to refine them as operating experience is gained over the years. You might expect that MTBF (or its inverse, failure rate) is easily extracted from your corporate systems. Look again - do you really capture the relevant event data? You need to know when it failed, how much operation it has been used for (time, cycles, miles, tonnes, etc.) as well as the fact that it actually failed. Simply knowing that work was done doesn't tell you it failed - it may have been removed from service proactively. Statistically that's a suspension and it must be handled differently than a failure event in optimization tools. You can't do that with most systems that are on the market today unless you really think these things through at the outset.

In our experience IT departments, even excellent ones, don't think this way. They will trust that the programmers knew what they were doing. How many programmers have you met who were reliability engineers? Again, RCS ensures this is done so that your future data is going to be readily available, in the right form and useful. We eliminate "garbage in, garbage out" and ensure your data is truly a valuable corporate asset. This effort is not depicted below, it is a layer that covers the entire range of activities.

MRO Supply Chain

Following from the sparing decision part of planning (task analysis) you can then make decisions about how best to manage your MRO supply chain. You don't want a lot of money tied up in inventory but on the other hand you don't want to run out. From the earlier analyses you will already know what you need, when or approximately how often you will need it. You can then decide on the most cost-effective way to provide that material where and when needed. The timing of purchases can be linked with demand rates instead of simply using inventory levels. If probability of a failure requiring an expensive capital spare is low you are faced with tough choices about those. You can buy it and have it sit there tying up working capital for a long time or you can use risk analysis to decide on the timing of the buy so the item arrives at the time when the cumulative probability of failure rises to some intolerable level. That could be many years away for some assets. Using such a risk-based approach also enables your finance people to mitigate the business risks because they will be well defined and quantified. Too often capital spares are purchased "just in case" and are never used, are non-returnable and sit and rust in a bone yard somewhere. RCS helps to avoid having a bone yard at all.

RCS contributes to lower total costs of sparing by enabling supply chain folks to negotiate agreements for spares/services purchases concurrent with the capital acquisition - including pricing and supplier performance guarantees on delivery and other elements determined in the initial reviews. All too often, the norm is that spares have no supply agreement around them, and if they do, it is one that is put in place after the capital purchase, where the supplier has the upper hand and parts/service supply costs are thus much higher than could have been realized if these were negotiated as a part of the capital purchase.

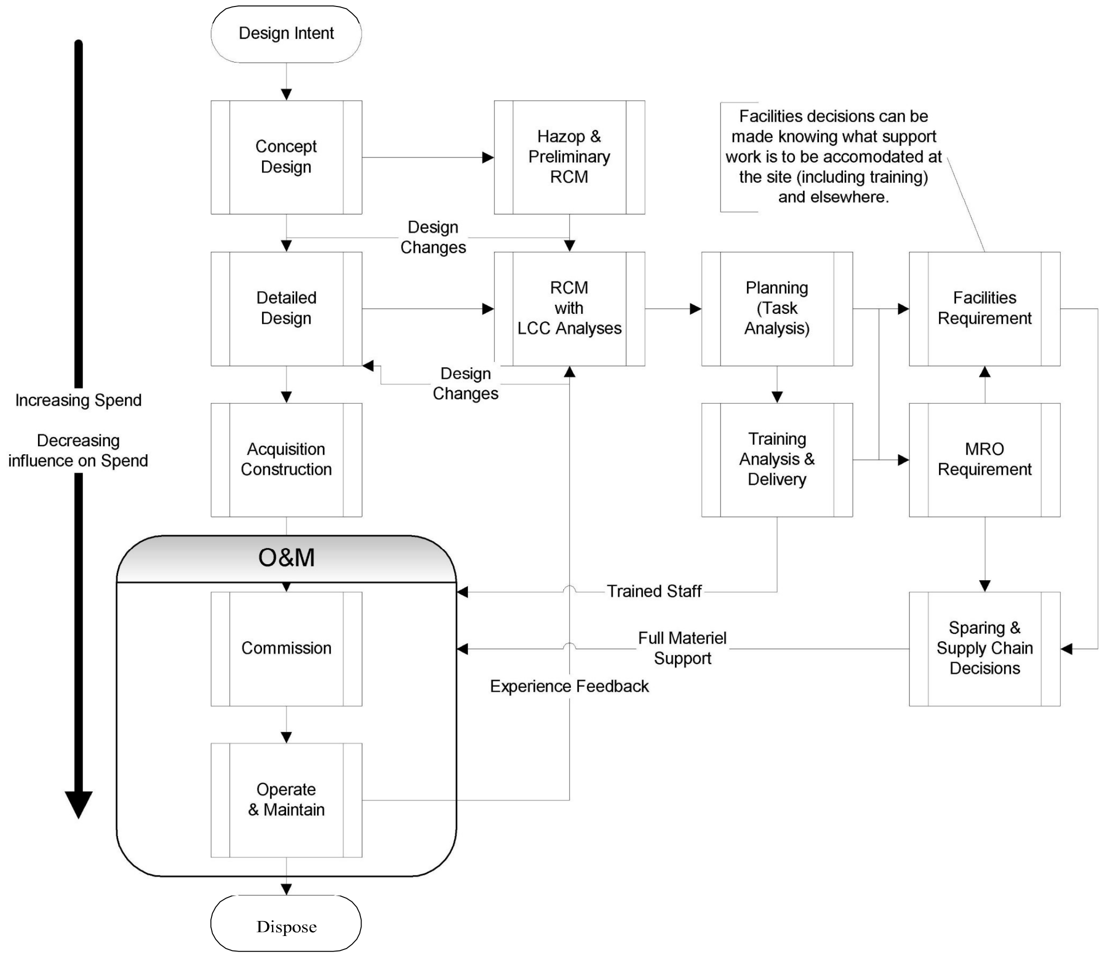
Facilities

Maintenance work, training, spares storage, data storage, systems infrastructure, administration, etc. all require facilities. Again, a detailed analysis of the tasks to be performed, the volume of spares to be held, the training workload, etc. can be used to help define the facilities requirements.

Capital Replacement Programs

Finally for an ongoing capital replacement program - mobile mining equipment for example - RCS can drive the replacement purchase decision, and enable total cost reduction or control. Again, optimization tools are used to determine the age of the asset when it experiences it's lowest "Equivalent Annual Cost" of ownership. At that point the accumulation of financing costs, depreciation costs, replacement costs, salvage value, etc. combine at their lowest point on a curve that is often high early in the useful life of the asset and again high way down the road. We pick the optimum point. We also know of at least one major Canadian lending institution that will offer more favorable loan / lease terms for mining equipment that is subject to RCM analysis. From the bank’s perspective, a client who is this thorough and deliberately proactive is a client that is low risk. With optimized costs designed in from the start your business risk is reduced and thus their loan / leasing risk is reduced.

The following diagram depicts the approach. It is not a new concept. It is based on proven methods. In industry this is innovative. It costs a bit more up front and can negatively impact financing decisions that are made with only short-term payback requirements in mind. Long-term paybacks can be vastly improved.



Conclusion

RCM is a highly successful and proven method for defining what to do to support any asset so that it continues to do what you want it to do. On its own it can provide substantial cost savings, risk reduction, safer and more environmentally friendly operations and it improves reliability. It can be leveraged for substantial additional benefits in defining the support requirements that are needed to keep that maintenance program going effectively. Up front application of RCM and RCS in a "Greenfield" application minimizes Life Cycle Costs and can substantially improve return on the investment in that new asset.

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James Reyes-Picknell is the author of "Uptime - Strategies for Excellence in Maintenance Management" (2015), "Reliability Centered Maintenance – Reengineered" (2017), and "Paying Your Way" (2020). He is a Mechanical Engineer (University of Toronto 1977) with over 45 years working in Reliability, Maintenance and Asset Management. James is widely regarded as a subject matter expert in ensuring the delivery of value from physical assets. His experience spans a wide range of industries, mostly in the private sector, many in natural resources, all dependent on physical assets for their success. James' career includes naval service (Canada), petrochemicals, aerospace, shipbuilding, pulp and paper, mining, oil and gas, manufacturing, gas and electric utilities, project management, software implementation, management consulting and training delivery. James is a professional engineer (PEng, Ontario), certified management consultant (CMC, Canada), maintenance management professional (MMP, PEMAC), certified asset management assessor (CAMA, WPiAM), certified blockchain professional (CBPro, York University), certified senior principal in asset management (CSAM, PEMAC/GFMAM). He is the 2016 recipient of Canada's prestigious Serio Guy Award for outstanding contributions to the profession. He has published numerous articles (all free) in his blog: https://consciousasset.com/resources/blog/ and run an online training academy focused on Maintenance, Reliability and Asset Management: https://academy.consciousasset.com/

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