

Reliability-Centered Maintenance RCM

The 5 Elements of Life Cycle Costing

Life Cycle Costing Element 1 – Risk Management, Defining Business Goals and Quantifying Risks

Key Challenge – The need for a rigorous, auditable, defensible process that would enable all stakeholders to develop and understand the business goals and what the project must achieve.

In order to determine life-cycle-costing and support engineering recommendations, it is important to define the business goals. By defining business goals (safety, environmental, water quality, operational etc.), your company will set the standards and acceptance criteria for reasonable risk thresholds. This will allow the review team to make decisions on purchasing, replacement, maintenance and stocking policies based on the identified risk thresholds integrated with your business objectives for each specific failure consequence. This becomes the baseline for further improvement. The stakeholders (design, procurement, operations, maintenance etc.) can use our process to continue to improve reliability and reduce associated risks beyond what was initially expected and acceptable through following design, operations and maintenance best practices.

It is therefore important to produce an equipment list ranked by overall business criticality and risk. NDS facilitates this process with system experts with final approval by management.

These criticality factors are integrated with the actual failure consequences that are an output of the RCM process (Element 3), and then input into multiple failure scenarios run in the Monte Carlo simulator (Element 5).

Key Benefit – Much of the tendency to “over-buy” in terms of design capability or redundancy can be traced to a less rigorous “rule-of-thumb” approach to risk assessment and/or a lack of confidence in the efficacy of the maintenance program to maintain equipment availability. Knowing how equipment fails, knowing the consequences of those failures, managing those consequences within your business strategy with an integrated maintenance and spares philosophy creates a coherent, auditable and defensible approach to risk management and demonstrates proactive financial stewardship for costly assets and infrastructure.

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Life Cycle Costing Element 2 – Equipment Failure Analysis

Key Challenge – Obtain equipment performance and failure history data from maintenance records to identify failure mode information unique to the operating context of critical systems.

What lessons can be learned from previous designs? What failure modes are most prevalent? NDS has found that analyzing the failure patterns your organization is already experiencing with like equipment provides a powerful lens for analyzing the proposed design.

The failure history provides real data for comparing the reliability of previous design configurations and their associated maintenance regimes. This data is then compared to NDS' extensive failure library and the RAC national equipment reliability databases.

We have found that performing this analysis on the front-end provides key insights to our clients and accelerates progress of the life-cycle costing program and builds momentum for a deeper more effective implementation.

Key Benefits - New Dimension Solutions' has conducted numerous Equipment Failure Analysis engagements. Here are some samples:

Equipment Failure Analysis

Problem: After 2.5 years of operation pump experienced high vibration intermittently. The pump was shut down due to 12mils vibration and root cause investigation was ordered. A review of redundant system pumps operational history demonstrated that they had high vibration. Mr. Wilde recommended that the pump from the warehouse not be put in place until the cause was determined, and that other pumps be torn down. The other pumps demonstrated the same anomaly.

Cause: The origin of the problem was determined to be manufacturing design deficiently in the vortex splitter.

Solution: Splitter was modified at a cost of approximately \$700. Loss of production cost \$3 million +.

Results: Failure was never repeated

Maintenance Program Development and Implementation:

Problem: Major pharmaceutical company had several plants worldwide and needed to change their approach to maintenance in order to compete with the generic drug market. The company had bought a new CMMS but did not know how to use it effectively.

Solution: Provided training, mentoring and coaching of maintenance personnel in root cause, failure modes and effects, reliability, equipment performance trending, developed work plans for maintenance instruction, identified critical components and needed inventory.

Results: Company applied the program corporate-wide and the total program saved over \$25 million on operation cost with substantial gains in plant availability.

Equipment Failure Analysis:

Problem: Company experienced two 500 kva single-phase transformer failures resulting in total loss of substation due to fire. A loss was incurred in excess of \$3 million in equipment.

Solution: Perform root causes on second fire and prevent reoccurrence.

Results: Determined causes to be manufacturing design defect. Took preventive action and failure has not reoccurred.

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Life Cycle Costing Element 3 – Reliability-Centered Maintenance Analysis

Key Challenge – Obtain detailed data about the system/s under consideration in a form suitable for performing Life Cycle costing calculations utilizing the knowledge base of the personnel who know the equipment best.

The RCM analyses are performed on the chosen systems and subsystems. The analyses performed are “zero base” (not building on any current maintenance program or assumptions about the equipment) and are performed with system experts. The RCM results are used as inputs to the RCS analysis, the Life-Cycle-Costing calculations and computer simulations.

The functions (what the users want the asset to do) form the basis for the inputs to the real life model in the simulation software and are continuously reviewed as the decisions reach finalization.

The outputs from the RCM reviews are the following:

- Asset functions and desired performance standards
- Design-affecting requirements (redesigns and modifications)
- Maintenance strategy (PM's)
- Operating Philosophy

Key Benefits – The strategic benefits of using RCM are best expressed by John Moubray himself:

- *Greater safety and environmental integrity:* RCM considers the safety and environmental implications of every failure mode before considering its effect on operations. This means that steps are taken to minimize all identifiable equipment-related safety and environmental hazards, if not eliminate them altogether. By integrating safety into the mainstream of maintenance decision-making, RCM also improves attitudes to safety.
- *Improved operating performance (output, product quality and customer service):* RCM recognizes that all types of maintenance have some value, and provides rules for deciding which is most suitable in every situation. By doing so, it helps ensure that only the most effective forms of maintenance are chosen for each asset, and that suitable action is taken in cases where maintenance cannot help. This much more tightly focused maintenance effort leads to quantum jumps in the performance of existing assets where these are sought.
RCM was developed to help airlines draw up maintenance programs for new types of aircraft before they enter service. As a result, it is an ideal way to develop such programs for new assets, especially complex equipment for which no historical information is available. This saves much of the trial and error that is so often part of the development of new maintenance programs – trial that is time-consuming and frustrating, and error that can be very costly.
- *Greater maintenance cost-effectiveness:* RCM continually focuses attention on the maintenance activities that have most effect on the performance of the plant. This helps to ensure that everything spent on maintenance is spent where it will do the most good.

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In addition, if RCM is correctly applied to existing maintenance systems, it reduces the amount of routine work (in other words, maintenance tasks to be undertaken on a cyclic basis) issued in each period, usually by 40% to 70%. On the other hand, if RCM is used to develop a new maintenance program, the resulting scheduled workload is much lower than if the program is developed by traditional methods.

- *A comprehensive database:* An RCM review ends with a comprehensive and fully documented record of the maintenance requirements of all the significant assets used by the organization. This makes it possible to adapt to changing circumstances (such as changing shift patterns or new technology) without having to reconsider all maintenance policies from scratch. It also enables equipment users to demonstrate that their maintenance programs are built on rational foundations (the audit trail required by more and more regulators). Finally, the information stored on RCM worksheets reduces the effects of staff turnover with its attendant loss of experience and expertise.

An RCM review of the maintenance requirements of each asset also provides a much clearer view of the skills required to maintain each asset, and for deciding what spares should be held in stock.

- *Greater motivation of individuals,* especially people who are involved in the review process. This is accompanied by much wider 'ownership' of maintenance problems and their solutions. It also means that solutions are more likely to endure.
- *Better teamwork:* RCM provides a common, easily understood technical language for everyone who has any-thing to do with maintenance. This gives maintenance and operations people a better understanding of what maintenance can (and cannot) achieve and what must be done to achieve it.

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Life Cycle Costing Element 4 – Reliability-Centered Spares

Key Challenge - Providing adequate resources and personnel that know the equipment's spare part requirements best up front and throughout the process.

Reliability Centered Spares is an extension to the Reliability Centered Maintenance program. The RCS analyses will follow the RCM analysis and it will determine the spare part requirements to support maintenance and operations at all levels. The outputs from the RCS analysis will determine the following:

- Critical spare parts
- Logistics and distribution policies
- Supplier contracting
- Replacement vs. refurbishment
- Redesign

RCM2 is built upon seven vital questions. The power of RCM2 is derived from how rigorously those questions are asked and answered. The Reliability Centered Spares methodology and software was created with the cooperation of John Moubray and integrates and extends the power of RCM2 into the functional areas of procurement, warehousing, and vendor support.

Marius Basson leads the RCS practice for New Dimension Solutions. He has applied it successfully for over 6 years and is the most experienced practitioner in North America.

RCS: Five Basic Questions

What are the maintenance requirements of the equipment?

What happens if no spare part is available?

Can the spares requirement be anticipated?

What stock holding of the spare is needed?

What if the maintenance requirements cannot be met?

Key Benefits – The strategic customer advantage of this approach to the process pays off in the following ways:

- Reduced MRO spare parts throughout the useful life of the asset
- Spare parts selection not only based on vendor recommendations but also on the recommended maintenance program (developed through RCM)
- Complete spare part requirements input into CMMS system
- Determine and optimize Life-Cycle-Costing (i.e. cost of newer model vs. cost of maintaining old with decreasing spare availability, vendor support, etc.) by developing a well defined stocking policy directly linked to and driven by from user requirements and business objectives.

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Life Cycle Costing Element 5 – Enhanced Strategic Planning using Computer Simulation

Key Challenge – The entire maintenance function is viewed by many traditional business managers as a cost center – a necessary evil. Proper asset management strategies and life-cycle costing can convert the maintenance function into a profit center for companies when measured by increased availability and useful life. In order to support recommendations for redesign, replacement, maintenance and spare parts, NDS simulates the results in "real life conditions".

The first task is to collect data (failure rates, time to repair, spare part deliveries, etc.) about the systems and plant in order to draft the maintenance and stocking concept developed through RCM and RCS. On the basis of the information obtained, a data bank will be created in what is called the Failure Mode Library. The FM Library is a grouped set of parts and components, together with their specific Functional failures, Failure modes, and maintenance actions.

After completing the inventory and populating the FM Library, we will commence building the FMECA system. Next, parts and components from the FM Library will be added. The FMECA system also contains the set business goals and objectives and probability classifications that are required for a risk analysis.

In this way, it is possible to generate a survey of the possible impact of failures. In addition, the criticality will be determined using the Risk Matrix.

By adapting the maintenance strategies in a corrective or preventive manner, it is possible to adjust the maintenance concept. The next step will be to do further calculations for the maintenance concept calculations. This first requires creating one or more scenarios. These scenarios are the starting-point for simulations covering a period in the future (for calculating Life-Cycle-Costing).

Using a variety of reporting functions, the maintenance concept can be analyzed after completion of the simulation. By creating alternative scenarios, running their simulations, and comparing these results with the results of earlier simulations, it is possible to establish an optimized maintenance concept and lowest Life-Cycle-Cost.

Scenarios are used for a number of applications. In all cases they help find an answer to the question: What if...? What happens if only corrective (FBM) maintenance is carried out for a specific installation? How much additional downtime will there be compared to another situation? Is it cheaper? Is the installation made safer by this or will it be just as unsafe? And what will availability be like? And what is the answer to all these questions if preventive maintenance is carried out after all? How much will this cost and what will it deliver, etc.

Models of various technical systems are created. Each model comprises a large number of elements (subsystems, parts, failure causes, maintenance actions, etc.) that in turn have a large number of adjustable parameters (Type of maintenance, statistical distribution, etc.). The results of modeled maintenance concepts can be viewed and compared. A model is calculated via a statistical simulation known as the "Monte Carlo Method".

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Key Benefits – Our computer modeling software is based on a Monte Carlo simulator and an extensive failure model library. The software can simulate, test and optimize design, operation, and the maintenance strategy for managers. It can then extrapolate the effects of their decisions over the extended life cycle of the capital equipment and calculate the cost savings and impact to bottom line over every year of expected asset life.