Risk-based Asset Management identifies the most appropriate and sustainable maintenance, operating, and replacement strategies based on the actual risk to the business posed by a crane asset in its current operating context.

It is important to recognize that cranes operate as part of a system; risk is usually a function of the entire system’s performance, rather than an individual unit’s. Therefore if funds and resources are limited, it is best to optimize an individual crane’s performance only when it contributes significantly to the overall risk.

In other words, deal with the weakest links in the chain first. As one link is strengthened, begin work on the next weakest and so on.

To implement an RBAM approach, four major steps are required:

1. **Identify priorities.** If the organization has a number of different crane systems, it is important to work out which system should be analyzed first.

2. **Understand the risks** posed by an operating system, and identify its weak points. These may vary for different types of risk. One crane may be contributing the most to cost, while another poses the greatest environmental threat.

3. **Identify strategies** for reducing the risk, or risks, posed by that specific crane/s.

4. **Manage corporate knowledge** to ensure the business can adequately implement and sustain the initiatives developed in steps 2 and 3.

\[
\text{Risk} = \text{probability} \times \text{consequence} \times \text{confidence}
\]
Undertaking a RBAM analysis and implementation process takes time and commitment. With a large and disparate asset base that is made up of lots of different cranes, it is impossible to solve all problems in one pass. It is also important to get some big wins early. So determining the order in which cranes will be analyzed is an important first step in applying RBAM.

Technically speaking, highest risk cranes should be tackled first. However, these may be the hardest to change. So a more flexible strategy is generally warranted.

A basic ranking exercise, based on a set of agreed risk criteria, is the easiest way to get started. This ranking should be performed in a group, which includes representatives from the organization that manage the business as well as the cranes themselves, in addition to experienced risk analysts to facilitate the process.

Many crane owners have a standard risk matrix that can be applied; however if no appropriate approach exists, ranking criteria might include:

• Safety and environmental risks posed by failure of the crane
• Operational criticality of the crane
• Historical cost of maintenance (in the current configuration)
• Operating costs
• Number of similar cranes within the entire asset base
• Ability to effect the required changes (e.g. unionized site, highly regulated, prevalence of old-school attitudes or openness to new ideas)

All unique configurations are then ranked according to the combined total of all risk criteria. This determines the order in which cranes should be evaluated.
Once the system has been modeled, individual components that contribute significantly to overall system risk and/or cost are easily identified. More comprehensive analysis and/or improvement strategies can then be implemented.

Reducing risk is usually achieved by reducing the number of unexpected failures in critical system components. Reducing whole of life cost however, is a little more complicated. As reducing unexpected failures also reduces cost (unplanned failures can be 10 times more expensive than planned maintenance), these factors will be considered together.

Get Smarter About Maintenance

To reduce risk and minimize whole-of-life costs, cranes should be maintained in accordance with their combined risk/consequence and failure profiles. There are four options:

(1) Run to failure is appropriate for low consequence scenarios where the cost of failure is approximately the same as the cost of replacement/refurbishment. It is also appropriate when the risk of failure is the highest immediately after installation and reduces with age. Electronic components typically fall into this category.  

(2) Preventive replacement/refurbishment is appropriate when assets fail predictably with time-dependent failure modes. Age (e.g. Run-hours, days, cycles, etc) is then monitored and parts/cranes are replaced or refurbished when this age reaches a predefined level. Applying this regime when failure is not time-dependent does nothing to reduce the risk of failure. It is also called fixed-term maintenance.

(3) Condition-based maintenance should be considered when cranes have no strong time-dependent failure modes (i.e. failure age is random), or when consequences of failure are significant and must be avoided at any (reasonable) cost. Most large cranes generally fit into this category, which is also called predictive maintenance. This approach requires suitable condition indicators that are able to warn of incipient failure.

(4) Redesign is required when no other maintenance strategy can cost-effectively mitigate the risk of failure.
Risk Based Asset Management of Cranes

CBM assumes that the risk of failure of a crane is a function of its age, and its response to its operating environment.

However CBM implies much more than just collecting information about the crane’s integrity; it assumes that this condition data will then be used intelligently to decide what and when particular maintenance tasks should be performed. Unlike condition monitoring, CBM is a maintenance management philosophy, not an inspection process.

The major components of a CBM approach are illustrated in Figure 3. Associated work tasks include:

• Sourcing, acquiring, cleansing and formatting data (crane’s failure history and condition monitoring or process data).
• Developing models that relate failure events to CM data.
• Evaluating data shortfalls and auditing data quality.
• Determining appropriate on-condition maintenance tasks.
• Implementing FMEA (failure mode effects analysis) to determine if failure modes that have not occurred historically may still pose a significant risk to the business.
• Disseminating information appropriately.
• Changing maintenance philosophies when current strategies are inappropriate.

So why do CBM?

Several tangible benefits to an organization are expected from the introduction of CBM practices. Specific benefits depend on the extent to which CBM is implemented, however, these generally include:

1) Cost reductions via:
• Reduction of unnecessary maintenance & replacement
• Establishment of more appropriate maintenance requirements for individual cranes and crane types
• Reduced reactive maintenance
• Less collateral damage from failed equipment
• Fewer surprises during major overhauls
• Reduced sparing
• Informed decision-making
2) **Increased availability through:**
- Improved planning and decision making
- Reduced number of breakdowns and less collateral damage
- Improved understanding of machinery and maintenance limitations
- Improved troubleshooting

3) **Improved data capture** and exploitation

4) **Improved knowledge transfer** between personnel collecting, analyzing and using data, resulting in improved diligence in performing maintenance tasks and data collection.

5) **Reduced risks of crane failure** and consequent loss of availability.

For **CBM to be useful a particular failure mode must produce one or more measurable warning indicators prior to failure, and these indicators must provide sufficient time for systems and/or personnel to react appropriately.**

If a crane has multiple failure modes, then multiple indicators usually need to be monitored. For defining suitable maintenance each failure mode must be distinguishable by a unique set of parameter values.

With a large number of failure modes and CM indicators, this mapping can not be achieved manually. We use a program which analyses the relationships between historical failure data and available condition monitoring data. It also:

- Identifies which condition monitoring parameters are useful in warning of incipient failure, and which are not; these can be safely removed from the inspection program
- Predicts remaining useful life (time to repair/replacement)
- Quantifies the current risk of failure
- Estimates the risk of failure at a specified time in the future
- Determines how much is saved by implementing the recommended maintenance policy, as compared to the current policy and/or run-to-failure.

A typical output from the software is shown in Figure 3.
Risk Based Asset Management of Cranes

The Life-Cycle Cost (LCC) Equation makes the assumption that the crane is only purchased once in the plant’s lifecycle.

In practice, it may be feasible to replace a crane at periodic intervals due to escalating costs of operation and maintenance. Therefore to minimize the overall lifecycle costs, the optimal time to replace should be determined and the LCC equation adjusted accordingly. Common reasons for considering replacing functioning cranes with new models include:

- Cheaper to replace than repair.
- Requirements have changed from the time of original installation, resulting in the equipment operating under sub-optimal conditions, increasing maintenance and/or operating costs.
- No longer possible to restore the crane to an as-new state resulting in increased maintenance and/or operating costs. Newer, technologically-improved models are available with lower operating and maintenance costs.

The quantities of spare parts carried by an organization typically reflect the variety of the equipment to be maintained, the availability of parts and the equipment’s criticality to the operation. The least cost for storing parts results from minimizing the effect of these factors on operational risk.

Spares management is something that should be considered once initiatives specific to the needs of a crane and the systems it works in have been put in place and are well proven. Thereafter, programs that can often yield value include:

**Rationalizing crane types** – This allows an organization to share spares across sites. But beware: efficiency and integrity should not be compromised for the sake of rationalization. Ensuring an crane is fit for purpose will have a greater effect on minimizing risk and/or whole-of-life cost than needing a few extra spares.

**Reducing spares holdings** – Once remaining useful life is known, replacements or refurbishments can be organized well in advance, removing the requirement to hold large numbers of spares on site. This reduces the overheads associated with their storage, inventory management and depreciation.
Establishing supply agreements – These become easier to arrange when work is pre-planned, parts have been rationalized and spares are no longer held on site as suppliers are able to better estimate their revenue and manage their stock holdings. Their reduction in risk can be returned to the asset owner in reduced parts costs.

Vendor management of on-site spares – This moves the parts management and carrying cost of stocking appropriate spares to the supply vendor. They are the people best situated to provide the correct inventory mix to match the equipment mix for the site. The vendor is most aware of their manufacturing and supply capability and can make the more optimal stocking decisions.

Creating Knowledge Workers

Analysis tools have fundamental data requirements and data outputs. This data output needs to find its way to whomever needs that data in order to make better business decisions. Be it an operator, maintenance planner, or reliability engineer in multiple locations, with each needing the information presented in a slightly different way. This is the essence of a “knowledge worker”. Good business decisions therefore require good quality data and an efficient delivery mechanism. These factors are not independent.

Experience tells us that maintenance related data held by most organizations is not fit for purpose. Ultimately, this is because it is not being used. Reasons for data not being used include:

• Data is difficult to access and/or combine in a meaningful way (required information may be held in disparate systems)
• Data fields are incomplete or not suitable for the task at hand (e.g. failure mode descriptions are inconsistent);
• Wrong data is being captured
• No-one is responsible for ensuring data integrity.

Knowledge management (KM) help organizations overcome these issues, and underpin the savings and risk reduction strategies discussed, by reducing the time taken to collate, analyze and present data.

As interoperability between disparate systems is improved, data can be accessed efficiently and effectively. Thus analysis of data becomes a more convenient and trusted input to decision making.
The greatest benefit for an organization that RBAM offers is that it can be applied in a staged and controlled way.

Although some upfront investment is required to develop an implementation plan and install tools that facilitate appropriate data mining and interpretation, each system analysis and subsequent implementation of its recommendations can be justified against the savings on offer.

These are discrete, specific and objective. Performance of the program, as well as consultants brought in to help in its implementation, can therefore be closely monitored. Costs are controlled and further initiatives become much easier to justify.

References