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Reliability Driven Maintenance—Closing the CMMS "Value Gap"?

By P.J. Jakovljevic and Olin Thompson

The Maintenance Approach Evolution

Although *enterprise asset management* (EAM) and *computerized maintenance management systems* (CMMS) software continue to grab headlines as a realistic way to reduce expenses and increase revenues, the growing pressure for improving customer responsiveness and profits has lately pretty much changed the traditional role of asset management. Namely, the metric of plant maintenance should now be in the ability of the plant to meet the strategic goals of the company beyond customarily expected cost savings, such as improved plant output, performance predictability, product quality, customer service, safety, environmental control, etc. For one, an effective preventive maintenance program can improve equipment's required utilization and availability, enabling production schedules to be achieved, especially when an exorbitantly expensive equipment replacement is a no option during depressed economic times. Extending into the customer base, this applies as much to improved standards of customer service as it does to product quality.

The importance of ascertaining the proper maintenance work as a result of a still ongoing plant maintenance approach evolution could even be deducted from analyzing several APICS Dictionary (the 11th Edition) definitions. Namely, the 1960s and 1970s were characterized by the "Fix it when broken" approach of merely reacting to unplanned and unwanted breakdowns. Associated with breakdowns is also a bad word, *downtime*, which is the time when a resource is scheduled for operation but is not producing for reasons such as *maintenance*, *repair*, and *overhaul* (MRO), or setup. In the case of a repair, this typically consists of lost times to report or notice fault, assess fault, gain physical access to the equipment, study reference manuals (if something like that exists at all), obtain spare parts, obtain necessary tools (which also might not exist at all as a standard offering and will have to be invented or made), perform actual repair work (which is often only half of the entire downtime cycle), sign-off the work order, and accommodate certain miscellaneous time items due to the interruption.

Along similar lines of unplanned maintenance activities (given that "strategy" could hardly be an applicable word for anything that is of a reactive nature) are the following

- **breakdown maintenance**—a curative maintenance that occurs when equipment fails and must be repaired on an emergency or priority basis;
- **corrective maintenance**—the maintenance required to restore an item to a satisfactory condition;
- **remedial maintenance**—unscheduled maintenance performed to return a product or process to a specified performance level after a failure or malfunction.

Yet, the real total costs of reactive maintenance to breakdowns would emanate from lost production, poor product quality, lost sales, poor safety record, late deliveries, increased work in progress (WIP), shortened technical lifetime of equipment, etc.

Thus, the 1980s and 1990s have evolved into the "Fix it efficiently" approach of planned maintenance, scheduled overhauls, and utilizing CMMS for improved efficiency and control. Associated with this approach is scheduled downtime, which is a planned shutdown of equipment or a plant to perform maintenance (or to adjust to softening demand). To that end, the concept of CMMS was introduced, and these systems have since been used to bring efficiency to maintenance. A central concept of CMMS is *preventive maintenance*, which are the activities, including adjustments, replacements, and basic cleanliness that supposedly forestall machine breakdowns. The

purpose is to ensure that production quality is maintained and that delivery schedules are met. In addition, a machine that is well cared for will presumably last longer and cause fewer problems.

The Preventive Maintenance Approach

Using time-based approaches, CMMS modules use the above concepts of preventive maintenance as a strategy to avoid unplanned downtime, and they suggest that plants do a maintenance activity at specified intervals—regardless of whether or not they really ought to do this work. The unit of time can thereby be measured in days, weeks, or months, or in a number of work cycles of the asset. For example, a certain maintenance task is triggered every six weeks or after every one million pieces are produced.

CMMS software also characteristically recommends what should be done to the asset based upon the recommendation of the equipment manufacturer (e.g., the suggested activities at a certain maintenance time interval or at certain milestones), although the manufacturer cannot always know the real conditions under which its equipment is going to operate within various working environments. Preventive maintenance has nonetheless proven that it can lower unplanned downtime. But, applying the principles of lean manufacturing tells us that any unnecessary maintenance is a waste. That is to say, just like inventory one does not need at a certain time is considered a waste, maintenance tasks done before then they are truly required also constitute a waste.

When preventive maintenance tells us it is the time to perform a maintenance routine, the $64,000 question is, could we have waited or eliminated this routine without a negative impact on the asset's ability to meet the business objectives? We cannot know what would have happened for sure after the preventive maintenance routine was performed. Yet, since the preventive maintenance trigger points are set to minimize or eliminate unplanned downtime, they are conservative by nature, which means that the majority of preventive maintenance efforts happen "too soon", creating an unnecessary excess maintenance expense and downtime, or simply a maintenance waste. Therefore, preventive maintenance may collide with the lean principles.

Moreover, various studies have proven that less than 20 percent of all failures are time-based. Indeed, failure analysis reveals how assets fail and why, and the reason for failure is most often not time-related, since for most assets there are numerous ways how they can fail, one being the "abuse" of the equipment even if unintentional (i.e., not knowing the ideal working regimen for the asset). These studies also find that a large percent of the scheduled maintenance work done was not thus required—it was consequently the wrong work, which has only resulted with unneeded downtime (i.e., losses).

Thus, the pressure for customer responsiveness and profits has yet again changed the role of asset management in the 2000s. As mentioned earlier on, the metric of plant maintenance should now be in the ability of the plant to meet the strategic goals of the company beyond mere cost savings, such as improved plant output, predictability, quality, customer service, safety, environmental control, etc. Asset-intensive industries are realizing they need more than their traditional CMMS concepts in order to gain a competitive advantage. To be fair, CMMS (and EAM of late) products have helped many companies to work efficiently, but if one is not doing the right work, it is of little avail. The thought-leading approach nowadays is to "work effectively" by embracing the benefits of concepts like reliability assessment, business risk prioritization, *reliability centered maintenance* (RCM), condition monitoring, and so on.

A focus on reliability driven maintenance might improve equipment reliability and close the value gap of maintenance effectiveness versus maintenance efficiency. In other words, today's leading organizations are working more effectively by doing only the right, absolutely necessary work, given the above indications that often more than half of the typically performed tasks during time-based scheduled maintenance are not really needed.

Reliability Driven Maintenance

Conversely, *reliability driven maintenance* (RDM) focuses rather on understanding the "asset health" to determine what maintenance work should occur and when something should be done. It enables preemptive intervention before failure occurs, whereby failure would mean that equipment is not delivering required performance regardless of whether it is actually broken down or not. To reduce waste, assets must perform as expected and when expected. This means that failure must be redefined to mean an asset is unable to meet business objectives,

such as running at the expected rate, producing product within the expected quality standards, and being ready when it is needed for production. If an asset does not meet these objectives, it has failed. Reliability eliminates waste, since machines that are reliable produce less scrap and rather a product that is within specification, thus eliminating the cause of defect correction, whereby equipment is ready to run as soon as the demand is presented.

Intricate work identification methodologies like *reliability centered maintenance* (RCM) and *failure modes and effects analysis* (FMEA) are the foundation of reliability driven maintenance, enabling users to understand when and why assets fail, and determining the warning signs that failure is about to occur and what can be done to prevent the failure.

Zooming on the concept of RCM, which has been explored since the 1960s, it is one increasingly used methodology nowadays for understanding an asset's potential for failure. It is a process for defining possibly a cost-effective schedule for each asset necessary to maintain reliable performance. In order to establish this schedule, reasonable expectations of performance, limitations, and priorities must be established for the physical asset. Instead of focusing on preventing an asset from failing at all costs, RCM concentrates on ensuring its continued reliability by shifting the maintenance paradigm from one of prevention to one of prediction, so that appropriate action can be taken early on.

APICS Dictionary defines *predictive maintenance* as a type of preventive maintenance based on nondestructive testing and statistical analysis, used to predict when required maintenance should be scheduled. Predictive maintenance typically leverages indirect maintenance activities (e.g., condition monitoring), whereas preventive maintenance tends to focus on direct activities (e.g., cleaning, lubrication, replacement, repairs, etc.).

The RCM concept is based upon determining how assets fail, why each failure type occurs, and the symptoms that indicate potential failure. Understanding failures can also reveal the right work to be performed based upon the specific symptoms. By monitoring the asset with this view, users can detect the symptoms of failure and react to these symptoms (e.g., a low pressure of the pump) with the right work (e.g., check either for a blockage, damaged impeller, or leaking seal). The result, as found in the airline industry, are assets that are far less likely to fail and that require far lower maintenance expenditures.

Furthermore, creating a RCM environment is not a one-time process. Rather, it is a continuous, evolving, and ever improving process of analysis. Still, desired RCM functionality should entail the ability to

- Select critical equipment;
- Analyze failure patterns;
- Determine consequences of failure analysis;
- Perform selection of preventive action;
- Perform detailed analysis of the cost of prevention (calculated based on the costs of the service, including labor and materials, over the same period of time as the *mean time between failures* [MTBF]) versus the cost of failure (calculated based on the downtime-related costs multiplied by the downtime plus any additional repair cost);
- Do activation of approved action; and
- Perform automatic analysis of work order feedback.

From this thorough analysis, necessary maintenance task are then defined, with joint responsibility of maintenance and operations departments. Operationally, users start to monitor the health of the asset through sensors and process control tools (e.g., *distributed control systems* [DCS], *programmable logic controllers* [PLC], data historians, *supervisory control and data acquisition* (SCADA) systems, etc.), inspections (e.g., visual inspections, maintenance rounds, operator rounds, etc.), predictive tools (e.g., lubrication analysis, vibration analysis, infrared thermography, motor circuit analysis, non-destructive testing, etc.) and then compare current asset health to both history and a set of rules defined for the asset based on the RCM failure analysis of results. Asset health (not time) then determines the "when" and the "what" of maintenance (i.e., recommended tasks). This, in turn,

elevates the strategic significance of maintenance by linking it to business goals, and enterprises using reliability driven maintenance strategies state that the approach gives them a better answer for both the when and what issues of maintenance.

The market has consequently begun to see the rise of software vendors with extensive maintenance management expertise who are offering both services and software products which make a proactive, condition-based approach to maintenance practical and a necessity today.

These reliability centered products and services are not a replacement for existing CMMS/EAM implementations. Namely, while traditional CMMS is the way to insure an efficient maintenance operation, RDM is a necessary upfront step to recommend the when and what of maintenance, which is then executed by CMMS. In other words, within such a combination of CMMS and RDM, CMMS addresses the efficiency of maintenance and RCM the effectiveness of maintenance.

Example of Reliability Driven Maintenance Benefits

Reliability driven maintenance (RDM) focuses on understanding the "asset health" to determine what maintenance work should occur and when something should be done. It enables preemptive intervention before failure occurs, whereby failure would mean that equipment is not delivering required performance regardless of whether it is actually broken down or not. To reduce waste, assets must perform as expected and when expected. This means that failure must be redefined to mean an asset is unable to meet business objectives, such as running at the expected rate, producing product within the expected quality standards, and being ready when it is needed for production. If an asset does not meet these objectives, it has failed. Reliability eliminates waste, since machines that are reliable produce less scrap and rather a product that is within specification, thus eliminating the cause of defect correction, whereby equipment is ready to run as soon as the demand is presented.

The poster child for reliability driven maintenance could be Dofasco, a North American steel manufacturer with $3 billion (USD) in annual revenues and with a whopping asset replacement value of $5 billion (USD). Dofasco's motivation for maintenance practices improvement has come from its business performance reaching a plateau a few years ago, while the market was constantly changing. Dofasco identified equipment reliability as the strategy for better business performance, leading to improved product quality, increased production output, lower costs, and increased shareholder return.

Its management states that, due to improved equipment reliability, reactive maintenance practices have since been reduced from 70 percent to 20 percent (in favor of proactive maintenance and measured as a percentage of the total maintenance hours), equipment availability improved from 78 percent to 91 percent, while quality (i.e., prime yield) increased from 76 percent to 91 percent. These feats have been accomplished during a 50 percent reduction in maintenance staff through voluntary attrition. Incidentally, the fact is also that throughout many asset-intensive industries, one should expect fairly soon a large contingent of aging maintenance workers that will be eligible for retirement, which further complicates the time-based maintenance practices less feasible.

Today, Dofasco is reportedly the most profitable steel producer in North America, and it has ranked number one on the Dow Jones Sustainability Index for five years running. The company is also widely regarded as the North American benchmark for world-class maintenance practices and technologies. Ivara (www.ivara.com), a privately-held Canadian provider of asset reliability solutions, which has more than a usual vendor-customer relationship with Dofasco. Namely, the large steel producer took an equity position in Ivara a few years ago and has since been transferring its technology, processes, and practices for RDM strategies, including an internally developed system (since rewritten) that accelerates and streamlines reliability centered maintenance (RCM) and condition monitoring (with over 200 man-years of proactive maintenance development). Dofasco also transferred five maintenance professionals to Ivara for the period of five years and has occasionally provided consultants to assist in implementations.

Ivara

Ivara holds a promise to combine innovative RDM technology with solid maintenance expertise, a history of success with multiple *computerized maintenance management systems* (CMMS)/*enterprise asset management* (EAM) products, its sales and marketing expertise, and its current vision of the reliability-based maintenance market. Bill Shaw, formerly of ShawWare CMMS provider, founded Ivara (initially called ObjectQuest) in 1996, whereby most of its current staff are former ShawWare employees. For those that are less familiar with the company's genesis, former Marcam Solutions (now part of SSA Global) had built its former CMMS division Avantis (now part of Invensys), upon the acquisition of ShawWare, way back in 1991.

Thus, Ivara has lately turned into a primarily reliability driven maintenance vendor with a number of proven implementations. Part of its new identity includes a stronger focus on the company's WorkSmart implementation delivery approach, which ensures clients successfully make the transition to proactive, reliability-based maintenance. Particularly by focusing on the implementation planning phase, which consists of aligning reliability strategy with business goals, an elaborate business case development, identification of physical assets contributing to these goals and their prioritization by criticality or relative risk, and establishing targeted performance requirements, Ivara helps customers move to the next level in maintenance effectiveness (i.e., doing the right work at the right time on the right equipment).

Ivara's principal software offering, Ivara EXP, which is a RDM software that has resulted from the Dofasco's stint and has been written from scratch on contemporary Microsoft-centric technologies to feature asset prioritization, condition-based management, rules-based diagnostic engine, indicator-based job triggers, performance analysis and tracking, and applied RCM capabilities.

Ivara EXP accepts data from on-line sources, predictive maintenance technologies, RCM findings and visual (or other sensory) inspections collected from operator rounds or routine inspections. It analyzes the data and presents the results visually in many forms, making the data fairly easy to understand—and easy for maintenance personnel to use, such as trending graphs and flashing alarms. Ivara EXP then triggers the appropriate maintenance work in the user company's CMMS modules, while key performance indicators (KPI) provide metrics and tangible evidence on how the reliability of equipment improves business performance.

Recently, in November 2004, Ivara announced the release of Ivara EXP 4.0, a new and enhanced asset reliability software that should help customers gain new insights and better manage their asset performance challenges. New to version 4.0 are enhanced analytical capabilities, more sophisticated calculations and algorithms to allow the complex analyses customers demand, and the incorporation of more KPIs and dashboards that constantly measure the effect of asset reliability on business performance.

Equally important, EXP was devised to work fairly seamlessly with third-party CMMS, EAM, and predictive technologies already in place, significantly enhancing customers' existing investment in technology. To that end, Ivara products have been installed in over 350 sites and Ivara EXP has been installed with CMMS products from a number of vendors, including SAP, Oracle, Indus, and MRO Software. Before EXP, Ivara offered its own EAM/CMMS product, SUPREAM, which is used by a number of EXP sites. As a matter of fact, the standalone Ivara EXP product has become the core of the Ivara product line, reaching nearly 60 percent of total Ivara revenue in 2004 and being installed cohabiting with third-party EAM/CMMS products.

Ivara's VP of Sales and Marketing, and Reliability Practitioner, Brian Maguire, claims that reliability driven maintenance projects typically result in 20 percent of the enterprises maintenance budget going to the bottom line. This comes from the combination of improved profitability (often resulting from increased product availability) and reduced cost. The vendor attempts to document projected financial impact during the proposal stage for its prospects by developing detailed reliability assessment and business case, which is typically an elaborate 100 pages or so report. After conducting over twenty such exercises so far, there are indications of an average project payback within twelve to fourteen months.

Another Ivara customer, Quebec Cartier Mining, reports impressive results as well. Using EXP it has purportedly brought $7 million (USD) to the bottom line through increased equipment availability and decreased operating costs. For example, looking at the performance of wheel dozers, the plant gets more total performance with only half the fleet. Further, the operating costs of large wheel loaders have dropped by 43.4 percent, while the life span of 190-ton off-highway trucks has been extended by greater than 60 percent.

Dofasco is not the only equity partner for Ivara, which, in addition to relying on two longstanding major Canadian private venture capitalists, has been seeking a strategic direction and a vested interest from selected high-profile corporations that can help the vendor achieve its corporate goals (in part through a proof of concept by a prestigious customer-partner) and considerable financial benefits. By receiving financial and intellectual property investment from a patron that is active in industries Ivara targets (asset-intensive and plant maintenance power generation, steel and metals producing or mining, and pulp and paper sectors), Ivara hopes to expand without having to rely on expanded direct sales to fund such development.

To that end, back in 2001, Siemens signed a worldwide distribution agreement with Ivara to license, implement, and support Ivara's EAM software products. A key part of the agreement is the integration of Ivara products into Siemens' Industrial Framework, an *information technology* (IT) architecture for integration of business transactions and manufacturing data. The partnership was based on the technical appeal of a solution that can integrate plant floor systems and *manufacturing execution system* (MES) with asset management systems. Ivara has meanwhile trained a few dozens Siemens' employees to implement and support Ivara EAM and Ivara EXP products. In response to Ivara's commitment of resources to the partnership, Siemens has made a one-time commitment to acquire a 15 percent stake in Ivara. Such deals seem to be working for some other vendors too, such as IFS who has both equity and product development and integration partnerships with ABB and NEC. It is likely that Ivara will also be looking for astute implementation partners (not necessarily in terms of equity investment) within its vertical markets of focus, and with the current focus on North America (other markets, like Europe, might be considered in the foreseeable future though).

Summary and User Recommendations

Reliability driven maintenance is apparently helping some companies to think differently and to focus on doing the right work, which means working effectively, given the real value is also in recognizing when to do the right work. Thus, RDM, often with RCM at its core, is now being widely applied in asset intensive industries like power generation, paper, and mining, while other industries like food and chemicals may quickly follow suit. Given that repair-based processes drain resources and hinder productivity, any maintenance strategy that can help users to improve what they are doing now and to do it better in the future, is the best thing since sliced bread, since providing data to feed back into a process can only increase operational revenues and decrease maintenance expenses, right? Well, not always.

Namely, it takes significant investment to monitor the health of an asset, which brings us to the proverbial dilemma of opting for either cost controlled or results controlled maintenance strategy. Monitoring means inspections, sensors, and enormous amounts of information that must be gathered and analyzed. For example, SCADA systems are used to monitor and control a plant or equipment by gathering and analyzing real-time data in many asset-intensive industries such as telecommunications, energy, oil, and gas refining and transportation. A SCADA system gathers information, such as where a leak on a pipeline has occurred, transfers the information back to a central site, alerting the home station that the leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. Such systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or incredibly complex, such as a system that monitors all the activity in a nuclear power plant or the activity of a municipal water system.

Therefore, the cost of monitoring the health of the asset, the cost of failure, and the cost of maintenance operations must be evaluated on an asset-by-asset basis. This analysis might reveal that RCM is not the most appropriate for all assets, since other less rigorous and costly but still effective enough methodologies exist. How can one then determine the right maintenance strategy for a specific asset? To meet the objectives of lean manufacturing, one needs to evaluate the cost of failure in terms of both not meeting business objectives and any extra cost due to the need for unplanned or even emergency repairs. One must also understand the cost of maintenance for the asset, and comparing these produces a few alternative maintenance strategies.

Namely, if both the cost of failure and the cost of maintenance are low, one can justifiably use the strategy of simply fixing the asset when it breaks down. If the cost of failure is low but the cost of maintenance is high, one has to minimize the amount of maintenance required and this may again be best done by waiting for the asset to break before expending any maintenance cost. Where the cost of failure is high and the cost of maintenance is low, one logically has to be more proactive and accept more maintenance cost in order to insure that the asset

will not fail. Here, a time-based preventive maintenance strategy should work well. Finally, if both the cost of failure and the cost of maintenance are high, one needs to use RCM concepts and manage optimally the health of the asset to avoid failures while minimizing the maintenance cost.

Only by selecting the most justified maintenance strategy one could expect optimally increased profits due to reduced costs (e.g., reduced asset replacement costs, fewer scrap products, reduced maintenance labor, materials and purchasing costs, while the productivity is concurrently higher), reduced tied capital (i.e., less capital tied up in *work in process* [WIP] and raw material) and increased total revenue (i.e., less compensation payments due to fewer late deliveries and improved product quality, increased sales due to decreased downtime, and increased available capacity).

On a more general note, massive deployments of broader EAM systems face both opportunity and challenges, at least based on recent surveys conducted within existing install bases by some EAM thought-leading vendors like Intentia, which examine issues affecting the management, costs, and benefits of plant maintenance in manufacturing and process industries. Some of the findings are quite startling, if not unexpected or even contradictory:

- The "Fix it when broken" approach is still predominant.
- The majority of companies sees maintenance as a cost rather than as an investment, and thus do not appreciate the potential benefits. In fact, the benefits of maintenance are frequently not appreciated even at a board level.
- A vast majority recognizes that a preventive maintenance strategy should add value, but only a third of companies have a significant spend allocated for this.
- Almost three quarters of enterprises do not integrate maintenance and production planning modules, in spite of the potential of that effectively increasing production capacity.
- A vast majority agrees that maintenance improves plant safety.
- Less than a fifth of enterprises do not yet have an EAM or CMMS system, while almost two thirds of these agree that EAM or CMMS systems have delivered benefits to their companies
- There is an acute need to demonstrate return of investments (ROI) from EAM systems, which has been well noted by Ivara, given its emphasis on building a business case for every prospective customer.

Further, enterprises require an ever broader suite of extended *enterprise resource planning* (ERP) functionality ranging from a strong engineering foundation and customer service front end to support demand management, all bundled with a set of administrative and reporting capabilities and integration to financial and human resources (HR) management software, as to share information that drives operational efficiency, such as inventory control and labor control. Bad news for smaller pure-play EAM vendors could be the fact that some of their direct and likely competitors may be the ERP likes of Oracle, IFS, Intentia, SAP, and Ramco Systems that offer more integrated ERP and EAM capabilities like automated maintenance scheduling, tracking, and management; remote diagnostics; RCM; fleet and facility management and planning; centralized access to engineering data; parts planning, sourcing, valuation and category spend management; asset performance reporting, and so on.

Nevertheless, enterprises from the above-mentioned industries and the regions that Ivara covers should consider Ivara EXP (as the vendor focuses on in-process, reliability-based maintenance and can have the largest impact in that area).

About the Authors

Olin Thompson is a principal of Process ERP Partners. He has over twenty-five years experience as an executive in the software industry. Thompson has been called "the Father of Process ERP." He is a frequent author and an award-winning speaker on topics of gaining value from ERP, SCP, e-commerce and the impact of technology on industry.

Predrag Jakovljevic is a research director with Technology Evaluation Centers, Inc. (TEC), with a focus on the enterprise applications market. He has over fifteen years of manufacturing industry experience, including several years as a power user of IT/ERP, as well as being a consultant/implementer and market analyst. He holds a bachelor's degree in mechanical engineering from the University of Belgrade, Yugoslavia, and he has also been certified in production and inventory management (CPIM) and in integrated resources management (CIRM) by APICS.