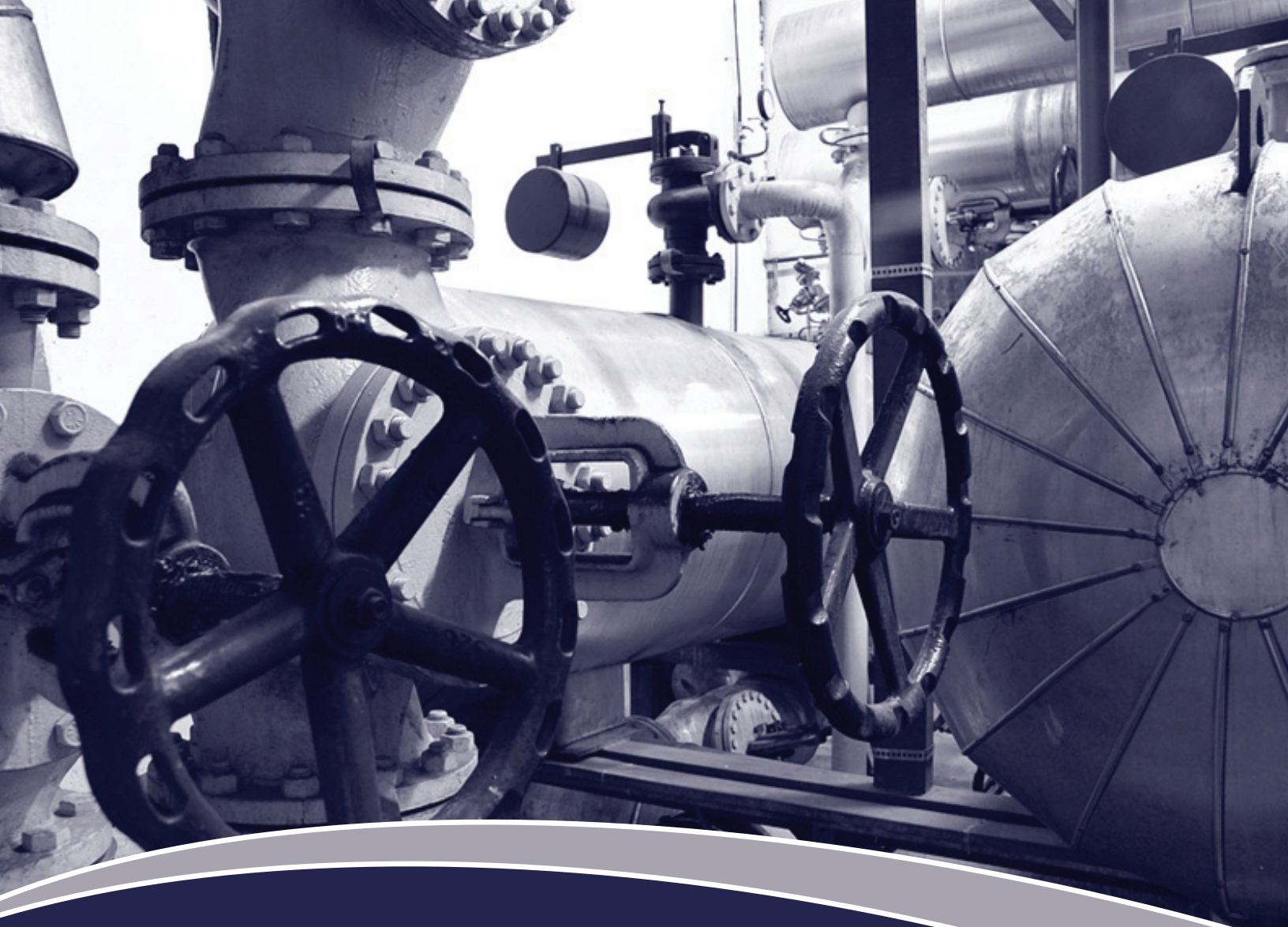

CHEMICAL PROCESSING SPECIAL REPORT

BEYOND CONDITION MONITORING:

Prevent failures through condition management

Go beyond condition monitoring

Despite condition monitoring, unplanned outages continue to be an issue, significantly impacting financial performance through lost production and extra repair costs.

By Neil Cooper, Invensys Operations Management

In today's environment, chemicals makers face ongoing pressure to operate safely and reliably at the lowest possible cost. Most companies have adopted condition monitoring technologies as a key approach to improve the availability and reliability of process equipment and to proactively avoid downtime.

While these condition monitoring solutions are providing solid value for most plants, unplanned outages continue to be an issue, significantly impacting financial performance through lost production and extra repair costs.

So, in this article, we'll explore the underlying challenges and introduce the concept of condition management — an enhanced approach that helps companies reap the full benefit from their condition monitoring investments. We'll also discuss how to get started in condition management, looking at both business and technical considerations.

Building upon a baseline

For years plants have tracked the health of key equipment. Sites generally have focused on a relatively limited deployment of specific monitoring technologies aimed at protecting critical assets — primarily large rotating equipment. This has become simpler with the widespread availability of highly capable fieldbus-enabled monitoring tools, e.g., for vibration, temperature, pressure, corrosion and fluid analysis.

Now, the advent of intelligent field devices and sensors as well as low-cost wireless units that can be deployed into areas where hard wiring would have been cost-prohibitive is extending these base capabilities and the data they provide.

Unfortunately, plants aren't enjoying the full potential of the data for three reasons:

1. The focus of condition monitoring deployments is too narrow. Sites need to instrument a wider range of assets, so management can look beyond specific equipment to entire process areas or complex asset sets such as heat exchangers, dryers and other plant units.
2. The volume of data available now is huge and will continue to grow exponentially. This creates a significant knowledge management challenge around making sense of the data. Exacerbating the problem, the aging workforce means that plants are losing more and more people with critical operational experience, knowledge and interpretive skills.
3. Many companies still have operational silos. Plant personnel aren't collaborating to detect, manage and analyze emerging issues. The net result is continued outages, even when the underlying condition or trend had been correctly detected.

Condition management defined

Addressing this set of challenges requires an enhanced, more holistic approach – condition management. Under this approach, the vast array of condition data is the entry point to a five-step process where the data are:

1. aggregated and rationalized;
2. combined to create context and support proper analysis;
3. clearly presented and communicated;
4. systematically managed to ensure the timely, accurate, consistent and effective resolution of the underlying issues; and
5. used as input to an ongoing continuous improvement process.

The first three elements are aimed at turning the data into information, changing the condition information from "noise" in the eyes of operations personnel into useful decision support intelligence for all personnel.

The aggregation and rationalization also need to address the varying types of data, the time element (real-time, near-time and offline) as well as the various access and communication methods utilized by vendors.

Once the data are turned into properly contextualized and actionable information, it's critical to manage the use of the information. It comes back to the fundamental difference between condition monitoring and condition management. Condition management information helps unlock the usefulness of the condition data by:

- driving the appropriate workflow/processes to resolve the issue(s), bringing together the key personnel across operational disciplines (engineering, maintenance, control, safety, etc.).
- providing input to an ongoing knowledge management process where new situations and their appropriate resolution are systematically captured and documented.

Further, condition management supports Six Sigma or Lean Sigma initiatives by supplying input for an ongoing process where the knowledge base is regularly reviewed and refined.

A telling example

A leading specialty chemicals maker discovered the value of the approach but only after a serious incident. The process uses a significant amount of power, so the company operates a 300-MW captive power plant. The site had deployed condition monitoring tools on assets there — vibration, rpm, and amperage on the pumps in the cooling towers, the manufacturer's monitoring tools on the turbine, and assorted flow and temperature meters throughout the cooling system.

When the primary pump in the cooling tower failed, the control system initiated a cutover to a back-up pump and then cleared the alarm. An operator entered the occurrence in the log, where the required follow-up was to have maintenance staff repair the primary pump.

Shortly after this initial incident, the operator started receiving alarms that the temperatures in the cooling system were drifting out of range, coupled with pressure warnings. Assuming that this was a "storm" created by the cutover to the back-up pump, the operator acknowledged and cleared the alarm set.

Close on the heels of this second set of indications, the turbine monitoring system flagged a significant temperature variance and recommended an immediate shutdown. Again, on the assumption that this was a blip caused by the cutover, the operator cleared the alarm.

After two minutes, which was the defined "re-alarm" time, the turbine monitoring system reported dangerously high temperatures and again recommended a shutdown. This time, the operator (per the written procedures) contacted the plant manager, who gave approval to proceed with the shutdown.

This caused a production outage that impacted delivery of a critical intermediate to one of the company's key customers. Further, the sequence of events and the elapsed time from initial warnings to shutdown resulted

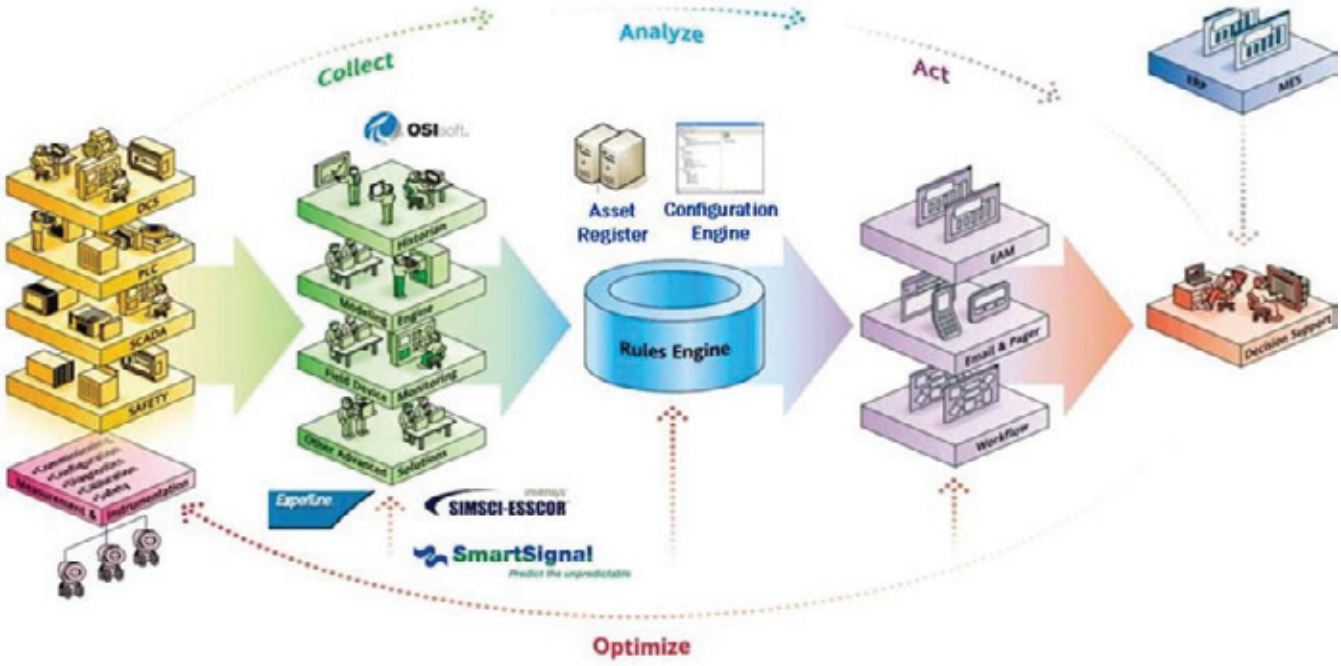

Figure 1. Success depends upon properly using wide variety of inputs from all plant levels.

in extreme temperatures within the turbine. This led to significant damage, necessitating the replacement of its main bearings.

The root cause turned out to be that back-up pump had not come online as expected. In doing the situation analysis, the company discovered a number of specific issues:

1. The back-up pump wasn't instrumented in the same manner as the primary one, so there wasn't any critical warning to the operator.
2. Condition information for the primary pump and the back-up pump weren't linked.
3. The pump, temperature/pressure and turbine data weren't connected. Each was handled discretely by the operator in separate areas of the human/machine interface (HMI); the combined elapsed time in dealing with the discrete events exceeded the safe shutdown point for the turbine.
4. No automated communication alerted maintenance, engineering or plant management to the developing issue.
5. The operator didn't have any way of seeing the maintenance status of the primary assets including the pumps — this would have shown that the back-up pump had a pending inspection because of previously reported issues.

Looking at this real-life example in its entirety, no particular action or practice alone could be blamed. Instead, the situation arose because of the lack of context and ineffective use (i.e., management) of available information.

The foundation for success

As the example underlines, effective condition management must address all of the elements together. Specifically this means:

- collecting the right data (condition, process area and system);
- gathering the complete set of data necessary to provide the context needed to accurately assess an issue and its impact;
- automating the response, including actions and escalations; and
- enforcing the post-event analysis and continuous improvement process.

Moving to condition management is ultimately a knowledge management challenge. In many companies, such a move requires a change in both technical and business process practices. This challenge is manageable but firms need to be committed to the change in approach and need the discipline to effectively implement and sustain it.

The process has to include the use of supporting tools and technologies that allow the capture of the institutional knowledge currently existing in plant personnel across all the disciplines.

Condition management fundamentally is a closed-loop model with four main elements — collect, analyze, act and optimize. This model provides the framework for translating the business needs into a solution architecture for a plant. **Figure 1** shows the relationships among these ele-

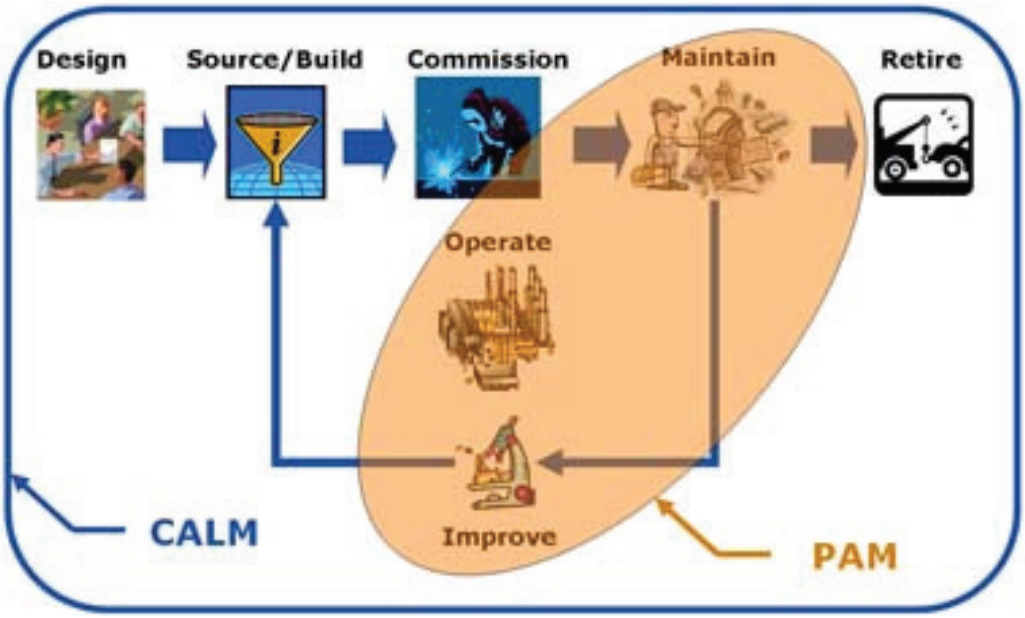

Figure 2. In CALM, the operate/maintain stage offers the largest portion of return-on-asset improvement. Source: ARC

ments, starting at the process measurement level through decision support and feeding back to the process.

Getting started

As with any change process, it's critical to understand the starting point. This demands taking a hard look at several areas and asking some tough questions:

Culture. Does the company understand that there are issues and that there's inherent and significant value in resolving them? As a simple test, can people articulate the impact or cost of an unplanned outage? Is the company really willing and ready to change? Effective condition management will include changes to business processes and roles, so these points are fundamental.

Business processes. Are the firm's processes documented? Have they recently been validated or benchmarked against others in the industry and best practices? In many cases, simple process enhancements or better communication can deliver significant performance improvements. Don't apply technology without this process baseline. Note in particular that a formal approach based on root-cause analysis and including continuous improvement efforts is a fundamental requirement.

At a broader level check whether a formal lifecycle management program is in place. A recent survey conducted by the ARC Advisory Group found that companies that had adopted such a program had a significantly better return on assets than those that hadn't. The research also indicated that the largest portion of the gains come from properly managing the "operate and maintain" stages of the lifecycle. It's precisely here where condition management is a key enabler of improvements. The ARC lifecycle model, (**Figure 2**) shows the relationship between plant asset management (PAM) and an asset lifecycle management scheme. Corporate knowledge. Does the company have a knowledge management process or tools? What's the current state of the work force? Is a retirement bubble coming up that necessitates immediate action? Does the company really know where the necessary knowledge resides?

Skill base. Does the firm have the essential expertise in areas such as reliability-centered or condition-based maintenance, optimization, advanced process control (APC), and condition monitoring and analysis?

Technology base. To fully achieve the promise of condition management, a wide range of technologies both

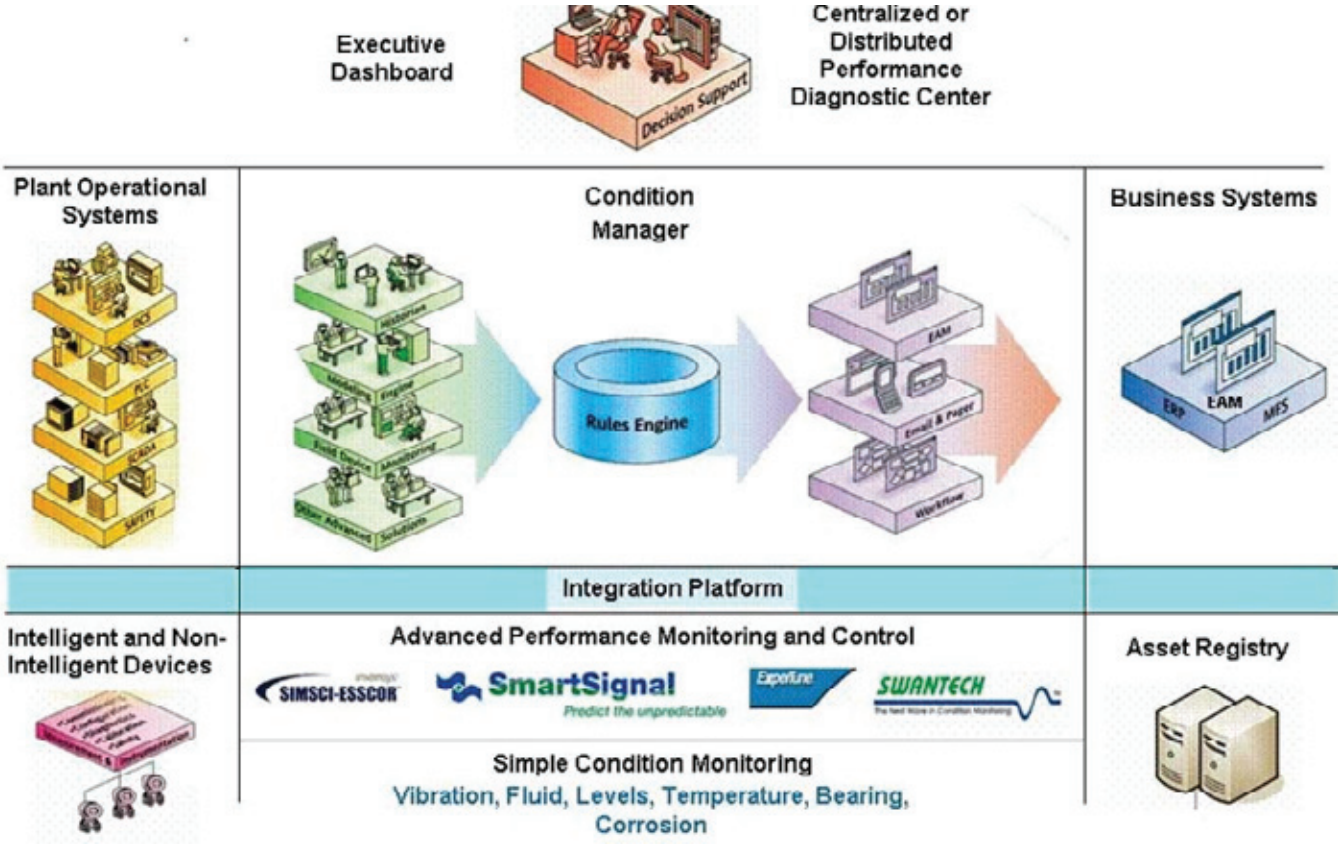

Figure 3. Plant- and corporate-level technologies need to come together effectively.

in the plant and at the corporate level need to come together (**Figure 3**).

So, engineers, planners and managers need to work together and ask themselves a series of technology questions that focus on five key areas.

1. **The state of the core automation systems.** Is the distributed control system current? Is the plant using a digital fieldbus with intelligent devices, traditional 4–20-mA analog or both? This will impact what data are available and how to access them. It's important to understand that the plant doesn't need to be "state of the art." Many new analytic tools can infer conditions from the simple data points that are being collected as part of the control strategy.

   It's also crucial not to confuse alarm management with condition management. Alarm management plays a critical role in dealing with the huge number of discrete input/output points that are part of the control strategy, working in real time at a discrete level. Condition management complements alarm management by performing the advanced analytics that warn of a developing issue long before it becomes a process or system alarm or alarm storm.

2. **The current level of condition monitoring.** What instrumentation is in place? Which assets are addressed? What data can these current tools provide? How are the data currently used? What tools are being used? What processes are in place to deal with the issues identified? Is there any automation of these processes? Find out if the information already being gathered is handled in systematic or automated fashion and moves across departmental boundaries. One of the major values of condition management is making information useful beyond the realm of the collection point or device — putting it in a broader context.

3. **The current level of APC and process optimization**. Is the company using such solutions? These models can play a key role in identifying and understanding the dependencies and context for the condition data.

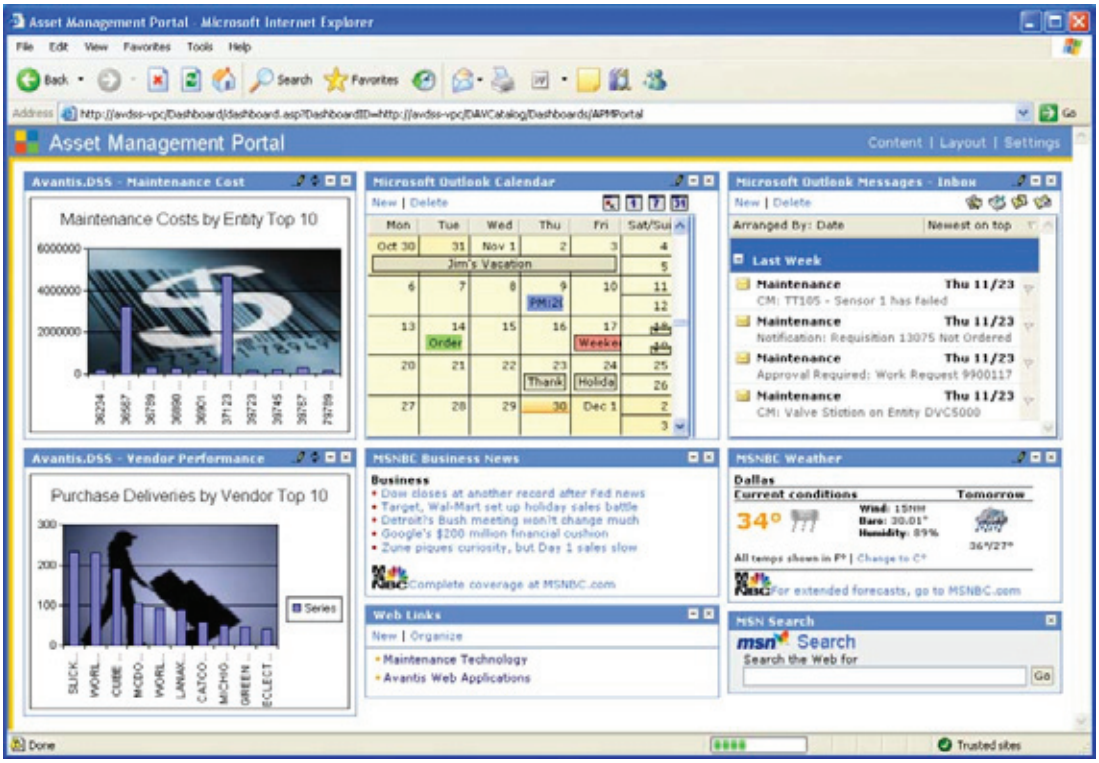

Figure 4. Such a graphical display often serves as the vehicle for delivering information.

4. **Integration infrastructure.** Does the firm have a standardized way for integrating applications at the plant level, applications at the business level and among plant and business applications? This will be critical for gathering the condition information at the plant level and then driving the workflow necessary to resolve issues. For example, if a critical condition is recognized, automated workflow tools should page or email the key personnel, automatically trigger the necessary work requests or work orders to the maintenance team and update the necessary HMIs and management dashboards.

5. **Business intelligence.** Is there an integrated measurement system as well as a vehicle to deliver the information across the company? The vehicle most commonly employed is some form of portal or dashboard solution such as the one shown in **Figure 4.**

The next steps

The analysis that establishes the foundation or starting point is the most important step in the path to condition management. It is a comprehensive effort that brings information and, importantly, people, together. It also provides the groundwork for setting priorities and expectations and for understanding the implications on processes and roles.

With the foundation effort complete, a company can better see the possibilities for value and improvement, determine risk/reward and identify which parts of condition management can be implemented first. The success of initial low-risk/high-reward projects, in turn, can fund an ongoing program.

Many chemical makers can gather the information for a condition management baseline from within. This valuable effort can enable them to more clearly understand their resources, processes, limitations and options.

However, the subsequent steps can be complex and likely will involve the assistance of a technology partner familiar with the tools and solutions required for a condition management architecture, not just condition monitoring.

Condition management is an over-arching solution that makes use of the mountains of data generated by individual condition monitoring systems. It combines, rationalizes, presents and communicates decision support information effectively. It truly can help management identify the actions and practices needed to get full benefit from monitoring investments and, in turn, optimize the return from plant asset investments.

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CMMS provides real-time transparency

How your CMMS gives maintenance a clear view of the current situation.

By David Berger, P.Eng., Contributing Editor, Plant Services

Many contemporary CMMS software packages provide two key functions. First, the CMMS is a planning tool, from long-term capacity and capital planning, to medium-term budgeting and work planning, to short-term work order planning and scheduling. Second, the CMMS analyzes and reports on collected data and compares it to plan, which gives users much-needed transparency into maintenance operations on a real-time basis. Let's explore some of the features modern CMMS packages use to maximize this transparency.

Business intelligence provides a user-friendly interface that gives insight into what is working and what isn't working relative to plan. With its dashboards, graphs, alerts, reports, ticker tapes and other output formats, business intelligence makes it quick and easy for users to interpret the collected data and, in turn, make better decisions. However, like any software product, business intelligence is no panacea. In fact, business intelligence requires significant human intelligence to configure properly and ensure it's at all useful.

For example, dashboards use speedometers, stoplights and gauges to alert the user when management's attention is required. You'll know when PM compliance is too low, a project is over budget, spare parts haven't been delivered on time, and so on. This is great stuff, to be sure, but significant thought is required to determine which measures are priorities, how best to display them, what algorithm best defines each measure, how often the measure should be refreshed, appropriate upper and lower control limits, and many other configuration decisions. It's well worth the effort needed to obtain this improved visibility into maintenance operations. But be wary. It requires a good understanding of what's important to you and how to measure it.

Condition-based maintenance (CbM) functionality, either built into the CMMS or through integration with specialized software, achieves greater transparency in maintenance operations and provides insight into four key areas.

By monitoring the state of a process, CbM can alert you to when corrective action is required. For example, if a valve doesn't open wide enough to allow the correct flow of raw material, production quality or volume might suffer. Visibility into the process will, therefore, ensure that you can react quickly to the situation. In some cases, an automated control loop can bypass the need for human intervention, although a record of the incident might be warranted.

Another dimension to consider for gaining transparency is monitoring the measures that are relevant to the product, such as critical external dimensions. If a problem with a given asset causes product defects, determine which metrics, such as a gradual loss of power, correlate with the defects. By configuring CBM to monitor the variables, you can better anticipate and correct problems before product defects appear.

The third transparency-producing capability is monitoring the environment through which products and processes pass. This can sometimes provide important insight into asset health. For example, if the ambient temperature exceeds an acceptable upper control limit, there might be a problem with another asset.

The fourth and most obvious dimension in terms of providing visibility into maintenance operations is monitoring the assets themselves, using measures such as downtime and performance. In some cases, this requires finding a metric that correlates well with higher-level measures, such as vibration, current drawn or the number of pieces that pass a proximity sensor every hour.

Partners and customers want transparency in the maintenance department. For example, when a maintenance customer initiates a work request, maintenance has an obligation to manage customer expectations. This includes acknowledgement that the work request was received, notification that the work has been scheduled and will be completed on a specific date, and status updates if plans must change. This level of transparency ensures business partners and customers will be satisfied that formal or implied service levels are met.

A few CMMS vendors offer advanced features that help provide transparency for customers and business partners. Those software packages include service level agreements, contract management, help desk and a full-service management module optionally accessible by the customer. Each of these features helps set expectations and track actual results for maintenance and its customers.

Mobile transparency is for technicians on the move. The increase in popularity of portable, connected devices extends transparency toward technicians, wherever they might be. Mobile devices and related software allow them to download all sorts of useful data that gives visibility into the location, status, equipment histories, as well as providing various analysis tools that help to diagnose problems.

Technicians can upload data such as root cause and remedy codes, time taken to complete the work order, spare parts used, and inspection measurements taken relevant to completing the work order. This provides transparency that allows planners and management to know whether work was completed to plan or, perhaps, that the job plan was unrealistic and requires modification.

Some CMMS integration points, including GIS, bar code and RFID capability, can increase the visibility potential of mobile solutions. GIS capability allows users to access maps on mobile devices, determines which assets are within a user-defined polygon drawn on the map, redlines assets that have been installed or mapped incorrectly, and many other features. This gives transparency, for example, as to what assets lie underground before work at a given location commences.

A bar code or RFID reader integrated into a mobile device allows technicians to scan equipment on a route and quickly and accurately identify them, which, in turn, triggers the downloading of work order history and other relevant information. Although somewhat controversial with technicians, some managers can gain visibility into the whereabouts and productivity of technicians in the field. The technology applies automatic date and time stamping when technicians scan the assets and enter work order information.

Even more contentious are managers who track the movement of technicians using GPS devices in their vehicles or mobile devices, or simply monitor the coordinates of assets scanned or reported as visited.

Transparency drives decision-making by exposing areas that are a priority for improvement. Many things drive the business. Examples include identifying opportunities for greater asset reliability, reducing energy consumption, greater product consistency, and a host of other possibilities. In general, visibility into maintenance operations helps find ways to reduce the total cost of ownership for every asset and increase the quality and quantity of output from operations.

Regardless of your business, transparency provides technicians, their supervisors, maintenance planners, and other stakeholders in operations and maintenance with a means to make more insightful decisions. The key is to pick a few high-priority measures that truly drive your business, and configure your CMMS to collect, analyze and report on any variances from expected results. Ultimately, the onus is on you, not the CMMS, to take timely and appropriate action that reaps the rewards of greater transparency.

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The changing role of the CMMS vendor

You should expect more than a shrink-wrapped box of software from your supplier.

By David Berger, P.Eng., Contributing Editor, Plant Services

CMMS vendors have seen a lot of change during the past 30 years, including many start-ups and wind-downs, a plethora of mergers and acquisitions, several generations of new technology, a roller coaster of economic activity, and ever-changing demand from a growing customer base. But one of the most significant trends from your perspective as the customer is that CMMS vendors are no longer simply purveyors of software. As CMMS software becomes more sophisticated and mission-critical, the dependence on your vendor increases. It's therefore important not only to choose a CMMS package that is right for you, but a CMMS vendor with whom you can partner over the long term.

In moving from a supplier of software licenses to a full strategic partner, the CMMS vendor has amassed a number of products and services that can help you manage your growing investment in assets.

Best practices

One noteworthy change in the relationship between you and your CMMS vendor is the increasing reliance on vendor knowledge of asset-management best practices. This stems from the common assumption that because a given vendor has sold CMMS software to hundreds or even thousands of companies, it must have acquired considerable knowledge that it can transfer to its customers. The more savvy vendors have picked up on this supposition, and are offering many of the following products/services:

Industry-specific software: As competition increases, CMMS vendors are looking for more marketable competitive advantages such as deep knowledge of a given industry. This includes software features that ensure compliance with industry-specific legislation, as well as more intimate understanding of industry practices. Some vendors have hired experts with extensive experience in a given industry to help develop relevant product and service offerings.

Standard data: A handful of CMMS vendors have standard data to sell or provide free of charge when customers purchase their software. Standard data can include job plans, standard operating procedures (SOPs), preventive maintenance routines, estimated or standard hours to complete tasks and coded field options (e.g., problem and cause codes). Data can be specific to an asset type or classification, such as data for electrical devices. As well, it can be industry-specific, for example, data relevant to pulp and paper mills.

Process mapping: CMMS vendors can further demonstrate their knowledge of best practices by facilitating process improvement during the software implementation. This typically involves drafting process maps reflecting the current state, and comparing them to future-state processes that incorporate the appropriate CMMS functionality. The gap between current and future states must be addressed carefully in terms of configuration of software, training on processes, project management and, most importantly, change management to ensure CMMS users buy into the new processes.

Configuration: The flexibility of modern CMMS software is demonstrated by the ease with which it can be tailored to your needs, such as configuring menus, data entry screens, reports, alerts, approvals, equipment hierarchy and workflows. In years past, this often required customization, a term synonymous with a large, upfront investment in time and money, and a costly upgrade path. Today's software is easy

to configure to a wide range of business process options, regardless of company size, industry, competitive strength, level of sophistication or organizational readiness. Configuration takes little time and the cost is minimal compared to customization. Because the source code isn't altered, there is little or no effect on the upgrade path.

Training: Once best practices are embedded in procedures through process mapping and baked into the software via configuration, users must be trained in the new processes and supporting systems. The CMMS vendor plays a critical role, especially if industry experts are available who can better gain the trust and confidence of nervous users and skeptics. Training should be just-in-time and comprehensive to facilitate retention, employing multiple tools and techniques such as classroom, on-the-job, video-based and online training.

Consulting: If you have gaps in the capabilities or availability of specialized resources in your company, the CMMS vendor can fill them in with its consultants. For example, a vendor might have specialists who are familiar with best practices in implementing process, system and organizational change, as well as technical areas like call centers, reliability-centered maintenance, linear assets or calibration. Although CMMS vendors might not be 100% third-party objective, they usually can be relied upon to conduct surveys on organizational readiness before implementation and stakeholder satisfaction following implementation. Vendors also can assist with benchmarking other organizations.

Web site: Another tool that's fast becoming a preferred source for best practices is the CMMS vendor's Web site. Users can search for and download information such as white papers, technical bulletins and conference proceedings that cover a host of relevant topics. In addition, some vendor Web sites provide opportunities for users to share tips and traps, solve problems in chat rooms, and conduct surveys.

Fee for results

One option (that admittedly hasn't yet gained much momentum) is to pay the vendor an amount based on long-term results. This can dramatically increase the probability of a successful implementation for both you and your CMMS vendor if:

- Objectives are well documented and communicated to everyone, including the performance targets that define success
- Payment is in the form of a bonus, not built into the vendor's base fee
- Users also will receive an equally meaningful bonus for meeting the same objectives
- Targets are achievable

Software as a service

An option that has received a lot of attention in the past few years, software as a service (SaaS), is a rebirth of a concept popular in the days of early mainframe computers more than 30 years ago. Although CMMS vendors don't yet define SaaS consistently, there are some common threads. At a minimum, vendors that offer SaaS charge a monthly subscription rate that covers at least software licenses and maintenance fees, for example, $30 per module per user per month. At the other end of the spectrum, some SaaS providers bundle absolutely everything into the subscription price, including software, hosting infrastructure on your site or that of the vendor, maintenance, unlimited support, all the training you want, and whatever implementation services are required. The pricing might be, say, $200 per 100-hour block of use, regardless of the number of named users or modules accessed.

Users have jumped on the SaaS bandwagon because of the reduced burden on cash flow, the appeal of paying only for what is used, and the flexibility to scale up or down quickly in terms of functionality or the number of users. Although some companies argue about the economics of SaaS compared to traditional pricing, there's no way to tell without crunching the numbers.

Formal long-term partnership

The most intimate relationship possible between you and your CMMS vendor is some sort of formal, long-term contract such as a joint venture or outsource arrangement. Although many CMMS vendors offer hosting services for their CMMS, there are very few that have ventured as far as taking responsibility for maintaining any of your assets. Most are happy to work with a third-party contract maintenance company and supply the CMMS, but are reluctant to supply and manage the maintenance technicians or their managers. Perhaps this will eventually change if CMMS vendors continue on their current path of transformation, from CMMS software supplier to asset-management services provider.

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