Optimized Maintenance, a Roadmap to Excellence

Roop Lutchman, P.Eng
Vice President, Utility Management Solutions
CH2M HILL
255 Consumers Road Suite 300
Toronto, Ontario M2J 5B6
Canada
rlutchma@ch2m.com

ABSTRACT

Maintaining assets is a key business process in any municipal operations. When done effectively it can result in optimal asset performance, reliability and maximize the overall return on investment in the asset. Indeed, maintenance is a key enabler of many municipalities’ vision of sustainability. Unfortunately, most Utilities still struggle at the maintenance function and many would rate their maintenance function as reactive and a sinkhole for precious dollars. Is the idea of being in control of maintenance an elusive dream? The answer is no, private companies have been able to successfully master this business process and maintain a competitive edge as well as sustainability of their businesses. Many companies (including some Utilities) have been able to take control and achieve the right mix of reactive and proactive maintenance – this optimal point is termed Optimized Maintenance. These companies are on the road to excellence and are reaping the benefits of reliable, high performance assets at a minimum overall cost of ownership. There is no magic bullet to achieve an optimized maintenance environment. It requires a clear vision of what this would look like, understanding of your current situation, implementation strategies and a road map to achieve the vision. This paper provides a structured approach and practical ideas to help Utilities develop and sustain an Optimized Maintenance environment necessary for a high performance O&M department.

KEYWORDS

Work Order Process, Work Order Types, Maintenance Dashboard, Planning and Scheduling, Preventive Maintenance (PM), Reliability Centered Maintenance (RCM), Predictive Maintenance (PdM), Total Productive Maintenance (TPM), Optimized Maintenance, Computerized Work Management Systems (CWMS)
INTRODUCTION

A quick look at the typical asset life cycle reveals that the planning, design and construction phases add up to approximately 10% (or less) of the overall asset life. Operations and maintenance can have stewardship of the asset for up to 90% of the asset life. O&M groups can therefore have a major role to play in maximizing asset reliability, meeting performance standards/service levels and keeping overall life cycle costs to a minimum. Unfortunately, in the utility industry, the typical work environment is a reactive one with many Utilities being a long way from maximizing asset reliability and minimizing overall costs. The goal of many Utilities is to take control of the maintenance function and move away from a reactive work environment. The challenge for many of these Utilities is how do they pull themselves out of the downward spiral, get to the right balance of reactive and proactive work and be able to sustain the resulting optimized maintenance environment.

Optimized Maintenance

As most O&M practitioners are aware, there are some assets that you can run to failure (reactive maintenance) and there are some that you must work on before they fail (proactive maintenance). There is an optimal mix of reactive and proactive maintenance that provides maximum reliability and performance as well as minimum cost of ownership. The optimal mix is usually around a 25% reactive to 75% proactive split. Note that in the utility industry most Utilities find that their maintenance is usually reversed with a 75% reactive and 25% proactive. Optimized Maintenance is focused on achieving this optimal point through various maintenance concepts: planning and scheduling, preventive maintenance optimization, reliability centered maintenance, predictive maintenance, total productive maintenance and the maintenance dashboard. It is possible to realize a 30% to 40% reduction in O&M costs when you are in the zone. Fig 1 shows a graphical representation of this concept. The following five step methodology (Fig 2) provides a robust and systematic approach to implementing Optimized Maintenance:

1. Taking Control using a practical Work Order Process
2. Develop the enabling Integrated Technology Solution
3. Do the Right Maintenance Tasks at the Right time
4. Monitoring Asset Health - set up a Predictive Maintenance Program
5. Sustaining the Optimized Maintenance environment
Optimized Maintenance Management Seeks to Find the Optimal Mix of Proactive and Reactive Work

![Graph showing the level of work executed in advance of asset failure with cost of work, proactive work, and reactive work]

Fig 1 Optimized Maintenance

Optimized Maintenance is a Five-step Process

![Five-step implementation process with steps: Taking Control, Technology Enablers (CWMS), Right Tasks at the Right Time, Monitor Asset Health, Sustainability]

Fig 2 Five-step Implementation Process
Step 1 Taking Control
This requires a good understanding and practice of the maintenance (or work) management process – Fig 3. O&M practitioners must master the key practices for each step in the process: Work Initiation, Planning, Scheduling, Execution, Closeout, History and the last but very important step, Evaluation.

Work Initiation - work can be initiated in many ways. This can be from equipment failures (identified by operations or maintenance), facilities and equipment upgrades, safety or environmental concerns, preventive maintenance (PMs) that are due, customer requests or aesthetic improvements etc. It is expected that the work requester indicate verbally or in writing what is required (describing the asset, the problem, the account to charge), an attempt at diagnosing the problem, how important the request is and how soon it should be addressed.

Work Planning - The request created by the initiator eventually finds its way to the person who is responsible for planning the work order task. Workflow parameters would dictate how quickly the request reaches its final destination and how quickly it sees some action. At this stage, the planner can either plan the work order task from scratch or as is usually the case in most industries use a previous work order task as a template. This is the stage where the work request becomes a work order. The planner needs the details on the asset to be worked on (criticality, specifications, safety/environmental (permit) requirements etc.), work methods applicable to the asset, spares and services typically used in repairs. The detailed tasks, based on the work methods, can then be developed with the appropriate labor, material (materials, tools and special equipment) and services needed.
to execute the task. At the same time, all materials are ordered through stores check out requests (or material requisitions) for items stocked in the stores. Any non-stores or services items are ordered through purchasing system.

*Work Scheduling* - scheduling of work orders is the process of identifying which work order tasks will be done, when they will be done and by which crew and (or) employees. A work order can be scheduled to be done on a specific day and time with a hundred percent (100%) surety only if all scheduling elements are in place. For this phase to be effective it is important that all materials, services, tools, special equipment, labor (commonly referred to as net capacity) are available together with the availability of the asset for work to be done on it. If any of these scheduling elements are not in place then the work order or task cannot be done and there will be consequential non-value added time associated with waiting while efforts are made to resolve the problem.

*Work Execution* - once a work order is scheduled, workers can proceed with the execution phase by collecting materials, tools and equipment, arranging “lock out and tag out” or other permitting requirements and proceed with doing the various tasks. During the actual work execution there be a need to access information that was not provided (e.g. assembly drawings, clearances, torque values etc.) or different spares, add or modify the tasks based on new information that become available. Noting work progress, completion and the crew’s observations, findings during the repair or overhaul process is an important aspect of the execution phase.

*Work Closeout* - any completion details, crew’s comments etc. are either not recorded or is limited to employee time charged the work order. This is the component of the work management process that enables the optimization of work by providing an opportunity to capture value work history in addition to task detail and cost. The reason for failure, follow on work, descriptive details on failed components, photographs, videos etc. are some of the ways to capture what happened.

*Work History* - all the data/information created directly or indirectly from the preceding components of the work management process can be valuable history for use in the evaluation phase. Generally this information is stored as files that can be paper or electronic.

*Work Evaluation* - the work evaluation component of the work management process is essential to provide feedback in the planning and scheduling components. On a day to day basis the planner needs to know if the right job plan was put together with accurate determinations of resources and time to do the actual task. It is always a good practice when planning and scheduling work to check on previous work done to identify failure trends and program upgrade or improvement type work orders instead of repeating the same repair work as in the past.
Work Order Types

It is important that work order types are fully understood in order to capture work related information in the right categories. In order to track progress towards an optimized maintenance work environment, it is necessary to categorize and track all open and closed work orders in a consistent manner. The following break down fully captures the concepts of Reactive, Proactive and Optimized Maintenance:

- **Reactive** (maintenance staff not in control)
  - *Emergency* – work done to contain an emergency and protect life and assets – unplanned
  - *Break down* - work done on assets that have failed – planned

- **Proactive** (maintenance in control)
  - *Preventive* - routine work on assets that is time or statistic triggered – planned
  - *Upgrade* - major work on assets that is time or statistic triggered – planned

- **Optimized** (seeking the optimal mix)
  - *Predictive* - regular tasks (time based) aimed at ascertaining asset health - planned
  - *Corrective* - work that originates from predictive type activities - planned
  - *Corrective from Continuous Improvement (CI) activities* - work that originates from continuous improvement initiatives, could be modifications or upgrades - planned

Step 2 Technology Enablers (develop and implement the enabling Integrated Technology Solution)

Verbal or manual work processes are inadequate and cannot effectively deal with the large number of work orders that are create on a daily basis in Utilities. Technology can be helpful in eliminating non-value added steps, improve productivity, capture key asset data and support decision making. Systems such as Computerized Work Management Systems (CWMS), Asset Management Systems (AMS), Supervisory Control And Data Acquisition (SCADA) and Financial Information Systems (FIS) are critical to the maintenance process and must all be linked to each other to ensure the smooth flow of data. The CWMS is the core system to support the work management process. All of the CWMS software products that are on the market today are modeled after the standards work management process discussed above. There are two key types of data that must be captured and monitored in the course of doing work: *work order history* and *work order cost*. The CWMS as a stand alone solution can provide work order history and estimated cost. In order to capture true cost of doing work interfaces must be built to the Financial Information System (FIS) so that actual costs can be posted back to the specific performance center or asset. In addition, there are significant benefits to be gained through interfaces with the Customer Information System (CIS) and Geographic Information System (GIS) especially in a linear asset network. Obviously, integration of key business systems is important in minimizing transactions, eliminating non-valued activities and sharing of data. All
Utilities should give serious consideration to the idea of an Integrated Technology Solution. The resulting ITS (Fig 4) is also an asset that should also be managed in a proactive manner to keep it current. The idea of keeping the ITS current by following the System Development Life Cycle (SDLC) process has proven successful for many companies. Success using technology as an enabler of practices also requires an effective selection and implementation process to ensure that the right systems are procured and the right business partnerships with vendors are established.

Integrated Technology Solution is derived from the Asset Life Cycle

Fig 4 Integrated Technology Enables the Work Order Process

Step 3 Doing the Right Tasks at the Right Time.

It is clear to most maintenance professionals that you can run some assets to failure and for others there need to be rigorous preventive maintenance. Typically, maintenance professionals determine maintenance tactics for assets based on manufacture recommendations and their collective experience on similar assets. The objective is to do the right maintenance task at the right time. A more scientific and rigorous process for developing maintenance tactics is called the Reliability Centered Maintenance (RCM) process – Fig 5. This rigorous, but very value added methodology, helps determine the right maintenance tactic that should be done on the various assets. It is a six-step process that focuses on:

1. Defining all the functions of the asset together with the desired performance standard for each function
2. Identifying possible functional failures where each of these functions no longer meet the user’s performance standards
3. For each of the possible failures associated with each function it is necessary to identify the failure mode

4. Consequences for each failure mode must then be defined

5. Failure management policies (or maintenance plans) will be the output from the process (these can be either: Run to Failure, Time Based Maintenance, Condition Based Maintenance or Re-design)

6. The final step this implement the choices (right maintenance task at the right time) – maintenance plans can now be developed for each asset and condition based tasks can be set up as PMs in the CWMS

Reliability Engineering: Doing the Right Tasks at the Right Time

**Fig 5 Reliability Centered Maintenance**

**Step 4 Implement a Predictive Maintenance (PdM) Program**

The output from the RCM process and experience of practitioners would dictate that a PdM program is essential to knowing the health of your critical assets at any time and making the right maintenance interventions at the right time. This requires an understanding of how assets fail and the potential failure interval based on asset deterioration curve (Fig 6). The idea is to track relevant statistics and take the asset out of service as close to the failure point as possible. The PdM program (Fig 7) requires decisions on use of internal or external resources, predictive techniques and instruments, skilled resources to continuously interpret data and a feedback loop to validate the accuracy of the process. Once the predictive PMs and frequencies are determined (either subjectively or from the RCM process, it is necessary to determine the predictive
technique and suitable resourcing (internal or external). The predictive PMs should then be set up in the CWMS and condition based data captured on a regular basis when the PMs are triggered. This data should be tracked, trended and interpreted to identify suitable maintenance interventions. The subsequent corrective work order should be completed following the standard work management process. It is important the PdM loop is closed with a feedback process to the person evaluating the predictive data to ensure that there is validation and quality control.

![Asset Deterioration Curve](image)

*Fig 6 Asset Deterioration and the Potential Failure Interval*
Components of a PdM program

**Fig 7 The Predictive Maintenance (PdM) Process**

**Step 5 Sustainability**

Steps 1 to 4, if implemented fully, will help any Utility achieve that elusive goal of Optimized Maintenance. Many people find that this “sweet spot” is a moving target due to changing business drivers. There are two key concepts that Utility must master to stay the course: continuous scanning of the business environment for changing drivers and the continuous improvement process. Changing drivers can influence the impact of maintenance. Being aware of potential challenges or new business drivers can allow decisions makers to develop and implement suitable mitigation strategies. For example, many North American Utilities are facing retirement of skilled resources in the next 5 years that can potentially decimate the workforce. This will not only limit the maintenance department’s ability to do the work they need to do on a timely basis but also could result in a significant loss of knowledge that is critical to the sustainability of the operations. Staying in the optimized maintenance zone requires the development of a culture of continuous improvement. In this type of environment, staff routinely capture key data on the maintenance process, review this data, identify and implement improvement initiatives. This approach will lead to maximum asset reliability, minimum maintenance and operating costs and satisfied asset operators. The CI process is shown in the following graphic (Fig 8).
Continuous Improvement (CI)

Data & Transactions From The ITS

Define
Measure
Control
Analyze
Improve

Fig 8 Continuous Improvement Process
CONCLUSIONS

The five step approach described above is a structured and proven method for Utilities to take control of the maintenance management function and find the right balance of Reactive and Proactive maintenance. It also helps Utilities develop a culture of continuous improvement that ensures that they can lock their radar on the elusive Optimized Maintenance goal and stay there in the face of changing business drivers. The benefit of this approach is a high performance O&M organization that consistently displays excellence in the maintenance management area. Tangible savings can be in the region of 30% to 40% of O&M budgets based on where the utility is starting from in the Reactive/Proactive continuum. Intangible benefits are also significant and important, these include: improved safety and environmental record, corporate knowledge retention, improved skills, culture of continuous improvement, improved O&M staff morale and improved company image resulting from consistently high quality service levels.

REFERENCES