

STRATEGIC ASSET MANAGEMENT INTL. LLC

25 NEW BRITAIN AVENUE
UNIONVILLE, CT 06085
+1 (860) 675-0439
WWW.SAMICORP.COM
INFO@SAMICORP.COM



Reliability 2000+: A Maintenance Initiative

Jean-Guy Paulin

Noranda Brunswick Mines

Bathurst, New Brunswick, Canada

Dave Army

Strategic Asset Management

THE COMPANY

Noranda is a leading international mining and metals company with operations and offices in 20 countries. One of the world's largest producers of zinc and nickel, Noranda is also a significant producer of copper, primary and fabricated aluminum, lead, silver, gold, sulfuric acid and cobalt. In addition, Noranda is a major recycler of secondary copper, nickel and precious metals.

For over 30 years, the Brunswick Mining Division of Noranda has been extracting and processing ore from one of the world's largest massive sulfide deposits. The Mine is located in Northern New Brunswick some 35 kilometers southwest of the city of Bathurst. It is a major producer of zinc and lead. The mine also produces small quantities of silver and copper. Production from the mine to-date is in excess of 80 million tonnes with an average daily production of 9,000 tonnes per day.

The mine employs approximately 900 personnel spread out over three functional areas, which include:

- Underground
- Plant Services
- Concentrator

WHY MAINTENANCE?

In 1998, after several attempts to improve maintenance internally, Noranda Brunswick Mines undertook a search for firms to help them achieve their goals for excellence. One of those firms, Strategic Asset Management, Inc. (SAMI), was selected to help a select Team of mine employees realize their goals of:

- Improved Equipment Reliability
- Improved Materials Management – more closely aligned to Maintenance requirements
- Better Utilization of Mine and Contractor Resources

The management of the mine realized that Maintenance continued to be a major contributor to the cost of operating the facility. In fact, in the year previous, the total direct and indirect maintenance costs were \$62 Millions. This amount represents 40% of all operating costs. (Figure 1.) This represented a significant opportunity to reduce operating costs and bring more profits. It was anticipated that by implementing a site wide maintenance and reliability improvement initiative, yearly savings of over \$2.5 Millions per year (Canadian) could be realized. These modest projections would be broken down as follows: Along with cost savings, it was anticipated that the initiative would lead to increased production, and improved material recovery. This would ultimately lead to revenue enhancement (more dollars to the bottom line).

Justification		Savings
50% OT reduction	=	\$1.1 million
5% material reduction	=	\$1.2 million
Inventory reduction	=	\$0.2 million
Total	=	\$2.5 million

The only question remaining was how to accomplish these objectives in a timely manner.

Both mine management and SAMI agreed that before any real gains could be realized, basic, or Stage 1 Work Management (Figure 2.), processes needed to be strengthened. In some cases, those processes required re-design. Stage 1 processes include:

- Preventive Maintenance
- Work Initiation & Prioritization
- Planning & Scheduling

- Work Execution/Review
- Materials Management
- Computerized Maintenance Management System (CMMS)

Plans were made to conduct a detailed assessment of the site's maintenance practices, and then conduct a design phase, followed by a pilot implementation. Only then would the new processes be rolled out to the site population.

THE ASSESSMENT

The assessment started in February 1999 and took place over six weeks. The responsibility of the assessment rested on the shoulders of a team of consultants and BMS project liaison personnel.

It was extremely important that worker viewpoint were included in the assessment. In order to achieve this goal, a "Brown Paper" Fair was held to ensure that workers had the opportunity to make their thoughts known about how the process worked or, more importantly, didn't work.

For the Brown Paper Fair, the Assessment Team created a model of the "as is" work management process on sheets of Brown Wrapping paper. The paper was taped on a large wall and people were asked to comment on the process. Participants were given "sticky" notepads and wrote down their comments, good, bad, or indifferent, and attached them to the brown paper.

The Brown Paper Fair was a tremendous success and provided much needed input from the workforce. Furthermore, it allowed the workforce to play a direct role in the assessment and subsequently the design stage of the work management process.

The Assessment accomplished the following:

- Interviews – 46 Employees
- Surveys – 68 Maintenance Practice Surveys
- Brown Paper – 215 craftsmen, foremen and 2nd line supervisors
- CMMS evaluation
- Benchmarking
- Reliability Assessment
- DILO (Day In the Life Of)
- Downtime analyses
- Business Case Justification of Path Forward
- A Preliminary Design Model

During the assessment, a "preventable maintenance" exercise was conducted to identify various reliability issues. In order to conduct this exercise, a group of assessment team members, along with plant maintenance and operations personnel, reviewed completed corrective maintenance work

orders to determine the causes of failure (Figure 3). Consequently, it was determined that 59% of the work orders reviewed were preventable.

The assessment also identified organizational strengths and opportunities for improvement:

Strengths

- Highly skilled and knowledgeable workforce
- Resourceful personnel capable of meeting production demands
- Extremely knowledgeable about equipment and its repair
- Possession of universal CMMS skills
- Excellent at Fire-fighting

Opportunities

- Better identification of work
- Stabilization of priorities
- Improvement of schedule compliance
- Better utilization and coordination of planning activities
- Reducing the impact of parts delays
- Improving the status of Preventive Maintenance

At the end of the assessment, the team concluded that the mine Maintenance Organization was performing at a "low performing" Stage 1 level (Figure 4.). Clearly, if improvements were to be made and goals realized changes to basic maintenance processes would have to be made. Armed with this information, and with a business case to back it up, management decided to proceed with design and implementation of an improved maintenance process.

PROCESS DESIGN

The design process started with the selection of members for the Design Team. In order to maximize the benefits during the design, members were selected from both a vertical and horizontal slice of the plant community. This meant that Team members were not only selected from both management and bargaining unit ranks, but also from the affected plant organizations. Looking for an identity for their activities, the Team selected the name "Reliability 2000 Plus" (R2K+) for the project. The selection of a name gave the project immediate visibility.

Armed with information gathered from the assessment, the Team set forth to attack the following issues:

- Low PM Performance
- Unacceptable Levels of High Priority Emergency Work
- Few Planned Activities
- No Long Range Planning (Greater than One Day)
- Poor Schedule Performance

Before development of the new process design started, the Teams were subjected to several days of Team building training. They learned about team dynamics, change readiness, process design methodologies and other techniques that would prepare the members for the task ahead. Using the model developed by SAMI, team members focused on Stage 1 elements. Their High Level design model (Figure 5) addressed:

- Work Identification
- Prioritization
- Planning & Scheduling
- Work Execution & History
- Measures and Follow-up
- Variance
- Reliability, Failure Analysis, Preventive and Predictive Maintenance
- Backlog Management
- Materials Management

Information gathered from Plant personnel during the “Brown Paper” exercise was used as baseline data for the design of a new and revised process. Use of “Brown Paper” feedback ensured that all identified issues were addressed as part of either revised or new processes.

Using classical process mapping techniques as their tools, the Team concluded their activities during June 1999 after many hours of hard work. The result of their dedicated labor was a detailed, integrated work management process that has been tagged the “White Paper.” After internal review and challenge, the “White Paper” was approved for implementation.

PILOT IMPLEMENTATION

The decision for which area to pilot the implementation of the “White Paper” was not an easy one. First, there were at least five areas from which to choose from. These distinct operating areas ranged from conventional above ground industrial milling to underground mobile repair at 3250’. Secondly, the types of maintenance and operations activities varied widely. After some discussion, the Team selected the Concentrator (milling) area to pilot the “White Paper.”

The concentrator is the area of the plant where roughly crushed ore is finely ground, treated chemically, processed hydraulically, and turned into a highly concentrated material (zinc, lead, copper and silver), hence the name, “concentrator.” It is comprised of heavy mechanical equipment, subjected to a harsh chemical and abrasive environment and, therefore, prone to failures. Failures of concentrator component lead to poor concentrate quality, lowered production rates and elevated maintenance costs.

The concentrator was generally more accessible and the Team felt it had a better chance for successful implementation. Furthermore, two individuals from the Design Team were members of the Concentrator Maintenance Staff.

Pilot implementation commenced in June and was keyed to address:

- Work Identification
- Prioritization
- Planning & Scheduling
- Work Execution
- Measurement

Reliability, materials management, and long-range scheduling were not included at this time.

In the June through July 1999 timeframe, Implementation was initiated; Work Orders and Preventive Maintenance activities were reviewed for duplication and cleaned up.

Training in “White Paper” methodology was started at this time. Training included presentations to all members of the production and maintenance staff. Members of the Design Team gave most of the training. During this period, daily and weekly scheduling of maintenance activities started.

Concurrently, two major initiatives, changes to existing behaviors, were at the core of the initial activities. The first initiative was the reduction of high priority, emergent work (P-1). These items had been causing havoc with any attempts to schedule maintenance activities. P-1’s were referred to as “Schedule Breakers,” and were considered Enemy #1. The second was the re-establishment of effective communications between maintenance and production personnel. The control of P-1’s was tightened, and formal daily scheduling meetings were started, complete with agendas.

In August and September timeframe, Key Performance Indicators (KPI) for maintenance were created and monitored. More formalized weekly scheduling meetings were kicked off. Personalized coaching was conducted with all key members of the production and maintenance staff. An implementation Team, created to identify and address key implementation issues, was initiated. Finally, a Site Steering Team was started with the objective of identifying any key implementation issues, resource constraints or items of common interest that could possibly affect R2K+ implementation across the site. Members of the Steering Team included the Manager responsible for the project, area process champions, the SAMI consultant and key members from the Design Team.

During the months of September through November a detailed process “Preparing Of Equipment For Maintenance” (POEFM) was rolled out. This process formally notifies production personnel of the time and date when specific equipment will be needed for maintenance. This communications tool is needed since most equipment needs labor intensive cleaning prior to any maintenance activity. POEFM allows maintenance to directly communicate that need to production and, more importantly, allows maintenance and production to successfully coordinate their resources.

As we all know, in order for any work management process to be successful, close coordination, teamwork and integration is required between maintenance and production supervision. Throughout the initial implementation period, it became clear that this was not taking place. Even with POEFM, the barriers were still raised. To combat this trend, management initiated meetings between maintenance and production supervision, with the intent to identify and resolve the issues between the two groups. These meetings continue to this day.

Two other important steps were undertaken at this time. First was an expansion from daily scheduling to two weeks look-ahead scheduling. The second was the initiation of a Reliability Team to address the lubrication system that supported an element of a critical plant system.

EXPANSION TO SITE-WIDE IMPLEMENTATION

Recognizing success with the Concentrator pilot implement, the Steering Committee decided to expand implementation to other areas of the plant. The next areas for implementation were the Surface shops and Material handling. Later, underground mobile and electrical were added.

These implementation activities are still underway, but are following the lessons learned and the steps used in the Concentrator.

QUANTIFICATION OF BENEFITS

In the Concentrator, we had targeted the following objectives for achievement during implementation:

- Performance of more PM activities, as scheduled
- Improve work planning skills and plan more work
- Improved schedule compliance
- Reduction of the impact of emergent (schedule breaking) work
- Reduction of the overall cost of maintenance (overtime, cost/work order, etc.)

Why did we focus on these objectives? First, it was felt that by showing proficiency in these areas, we would set the foundation for establishing a “World Class” maintenance program. Second, getting “good” at Stage 1 maintenance is a prerequisite for entering Stage 2. Third, Stage 2 (Pro-Active Maintenance) will lead to incremental cost savings by:

- Improving reliability – less downtime
- Improving process performance – increased revenue
- Improved resource and material utilization
- Reduced inventory – reliability driven

Initial indicators have shown that R2K+ implementation has been successful in the Concentrator. The indicators demonstrate that:

- More work activities are being planned and scheduled (Figure 6.)

- More hours are being applied to scheduled work (Figure 7.)
- Emergent Work Activities (Schedule Breakers) have decreased (Figure 8.)
- The percentage of total hours spent on Preventive Maintenance has increased (Figures 9 & 10)
- Maintenance labor costs have decreased since implementation began (Figures 11 & 12)

Note: Labor cost saving includes indirect benefits from the introduction of new equipment.

Armed with these results, it was felt that limited reliability initiatives could now take place. A team of resident experts was chosen from the ranks of management and union in the concentrator. A methodology for optimizing PM activities was developed and the team trained in the methodology. Using the Mill Lube Oil System as the pilot, the team was able to develop an improved maintenance strategy within 6 weeks.

The Lube Oil System was chosen for the following reasons:

- It had contributed to an estimated revenue loss of approximately \$1.4 Million per year.
- It had 9 documented causes of Mill shut downs in a 5 month period
- It was chosen as a 6-? initiative
- It was felt that it could be performed with “plant experts” and not a team of outside analysts.

The analysis yielded the following benefits:

- Several engineering issues were identified for resolution
- Several material issues were identified
- Several previously unknown critical components and failure causes were identified
- Several Lube Oil System specific maintenance activities (predictive maintenance) were created
- Performance indicators were developed to track success

The reason for this success is clearly attributable to the overall success of Phase One R2K+ implementation. Now that we can be assured that work can be planned, placed on a schedule, and executed according to that schedule, were are confident that a maintenance strategy can be identified and implemented.

CONCLUSIONS

We have concluded that Stage One R2K+ pilot implementation has been successfully completed in the Concentrator. The reasons for this conclusion is as follows:

- Process indicators are going in the correct direction
- Roles and Responsibilities have been identified and clearly communicated

- Local Management has taken charge of the process
- Two reliability initiatives have been concluded

From the decision to improve overall maintenance performance to the assessment, through the design and throughout pilot implementation phases, the R2K+ initiative has been a success. We feel that the primary reason for its success is the involvement of plant personnel at all levels within the process. With the plant community as part of the design teams, it was extremely easy to convert them into champions of the process. They became the communication vehicles for the project and were among the first to point out changes along the way and participated directly with implementation efforts.

R2K+ implementation in the Concentrator has achieved new levels of competency within the organization (Figure 13). At the beginning of the project the organization was (Figure 14):

- Excellent at fire-fighting
- Reactive to emergent work – constantly changing assignments
- Poor at schedule compliance
- Not concerned with PM (discretionary activities)
- Poor at coordination and planning between organizations (maintenance and production)

At the end of implementation the following had occurred:

- Work is planned at two weeks out – stretching to three weeks
- High priority, emergent work is under control
- Maintenance costs are dropping
- Interdepartmental coordination and communications have improved
- KPIs are routinely used to identify process weaknesses
- Two reliability projects have been completed
- Schedule compliance is up

With all the activity that has taken place, what have we learned?

First, we found that without long-range planning in place, it was difficult to develop meaningful daily schedules for the workers. Initially, daily schedules were produced. We found that there was more time spent in filling in the daily schedule than in identifying relevant activities. Current emphasis on the long-range plan allows us to plan work far enough in advance to reflect plant needs.

Resource requirements to implement the process throughout the organization weren't as minimal as first envisioned. Implementing this process takes constant attention and follow-up.

It is easy to underestimate the need for full maintenance and production collaboration. Often it is thought that the solution to maintenance issues resides only within the maintenance department. However, without the full understanding, cooperation and participation of production personnel, all efforts would be increasingly difficult.

We found that it was important to clearly define roles and responsibilities, both organizationally and individually.

The "White Paper" has served as an important communications tool. Even now, when we are working on difficult implementation, we go back to the "White Paper" to regain our perspective.

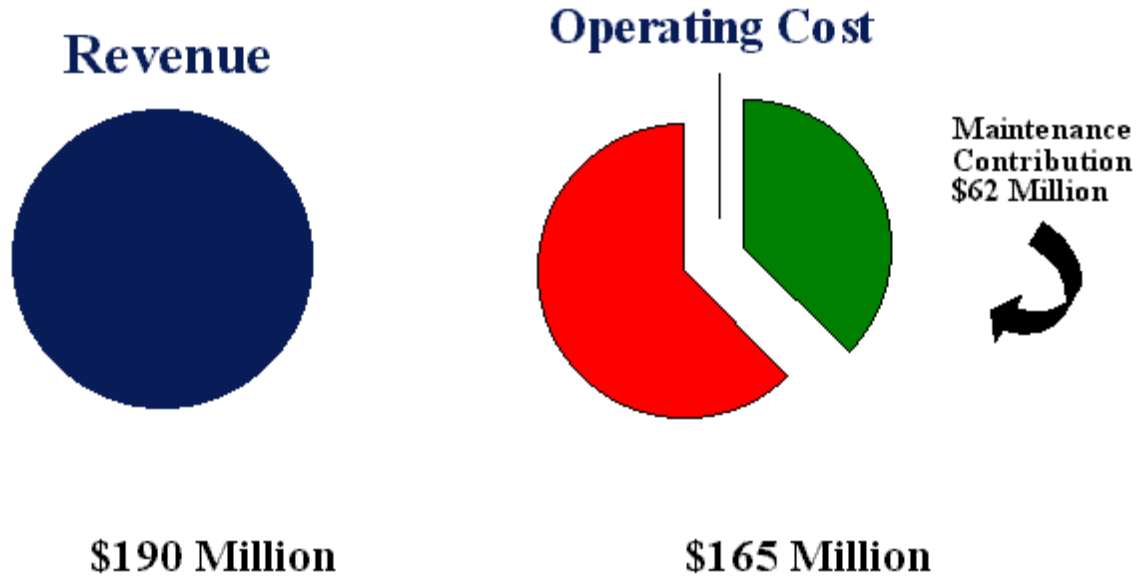
Participation from all levels of the organization was critical in making the process stronger during the design phase. Management couldn't have developed this process in a vacuum. Furthermore, they couldn't have assured its successful implementation.

Finally, scoring and measuring the project success through KPIs communicates progress throughout the organization. We found out that by focusing on key indicators, elements of the process would improve without major intervention on the part of management. The downside to the problem solving side of performance trending is not to let the problem take on a people aspect. Repeatedly, we have found that issues are primarily process related. Once we identify and remove process barriers, we find that the indicators improve. We found that we didn't have to fix people but we did have to fix processes.

Continued success remains in the hands of Brunswick Mines.

- Management must not lose its focus and commitment
- Communications must continue at all levels (management and union)
- We must expect changes and embrace them
- We must continue to monitor implementation and be ready to adjust to meet changing conditions

We have only begun the journey. The pilot is complete and movement into Phase Two started in fall of 1999. Furthermore, implementation into other areas of the facility necessitates the commitment of several people within the organization. Lessons learned cannot be discarded and we feel that the effort will be well worth the ultimate gain.

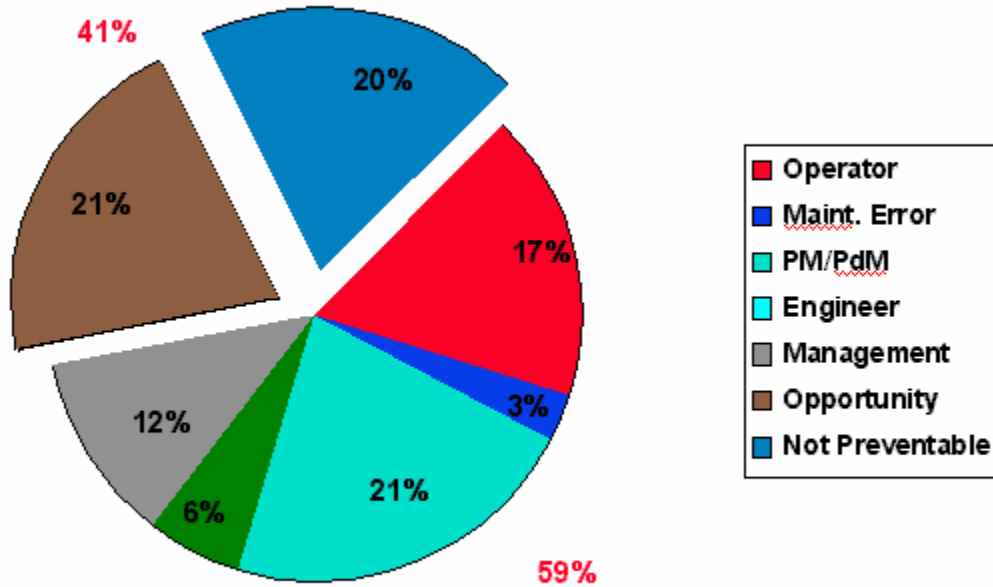


Direct & Indirect maintenance cost \$62 million or 40% of yearly operation cost.

Figure 1: Maintenance Cost Contribution



Figure 2: Stages of Maintenance Excellence



59% of the Work Orders Hours Analyzed Were Preventable

Figure 3: Reliability Issues Identified During the Assessment

Stage	Class	Low Performing	Competent	High Performing
Stage 1 Daily Maintenance		<ul style="list-style-type: none"> "Fire" determine priorities Breakdowns frequent Maintain as equals to repair No work orders, plans, controls Stores as r/c as low as possible Poor operator/maintenance relationships Poor customer service levels 	<ul style="list-style-type: none"> Most work planned, scheduled Preventive maintenance implemented Trade competent at most repairs Computerized work order system Stores as r/c as low as fair Operator prep for repairs Expedited and are infrequent 	<ul style="list-style-type: none"> All work prioritized PM hours and W/O exceed repairs Stock mgt. system utilized, integrated with purchasing, stores JIT stores; 2X minimum turns Operator inspect, create W/O's Turnarounds well planned, executed
Stage 2 Proactive Maintenance		<ul style="list-style-type: none"> Condition monitoring equipment purchased, installed Little analysis performed on data No preventative action taken No analysis done to identify candidate equipment Benefits tracking anecdotal 	<ul style="list-style-type: none"> Condition monitoring equipment installed, readings taken regularly Information as ahead, work orders created Candidate equipment has high value to production Rational cost/benefit analysis 	<ul style="list-style-type: none"> Conditions monitoring intervals based on risk analysis Predictive techniques minimize repair, out-of-pocket as r/c as cost and time Proactive techniques employed (e.g. high quality filtration) PdM data integrated with CMMS
Stage 3 Organizational Excellence		<ul style="list-style-type: none"> Training emphasis disconnected from real work practices Quality program ineffective in changing work behaviors "Team" implementation creates chaos Anarchy replaces hierarchy 	<ul style="list-style-type: none"> Natural Work Teams perform most daily maintain and effectively Operator perform TPM activities Some program integration (e.g. Quality, PSM, EPA, ISO, CMMS) Costs flexibility high priority MX philosophy adopted (e.g., TPM) 	<ul style="list-style-type: none"> Work teams flexible, self directed Continuous improvement process embraced, understood, working Programs rationalized, integrated Reward/recognition support best results Skills proforma over functions All staff systems compliant
Stage 4 Engineered Reliability		<ul style="list-style-type: none"> RCM implementation creates confusion, increased downtime Functional divisions prevent successful pooling of talent Pedantic rigor creates paralysis through analysis Vendor reduction — lower service levels 	<ul style="list-style-type: none"> Failure analysis a routine activity High value production processes assessed via RCM techniques Maintenance routines changed to increase value impact Reliability becomes focus — not maintenance 	<ul style="list-style-type: none"> Contract engineering employed to ensure lifecycle, maintainability Reporting systems tie reliability to financial results through OUE Completed equipment histories are used to trend and predict failures Vendor participates in reliability
Stage 5 Operational Excellence		<ul style="list-style-type: none"> Executive and plant management fail to align and implement goals Market pressures make short-term decisions predominant Union stewardship makes high performance organization impossible 	<ul style="list-style-type: none"> Clear organizational alignment Operational reliability is cross-functional responsibility. Reliability built into purchasing, production, engineering Activity-based management implementation Market impact of reliability valued 	<ul style="list-style-type: none"> Monitoring, process control, and information systems integrated Automated self-coordinating process equipment Life cycle cost analysis, life style extension engineering done Automated, demand-driven plant production balancing implementation

Figure 4: Assessment Conclusions



Figure 5: R2K+ Top Level Process Model

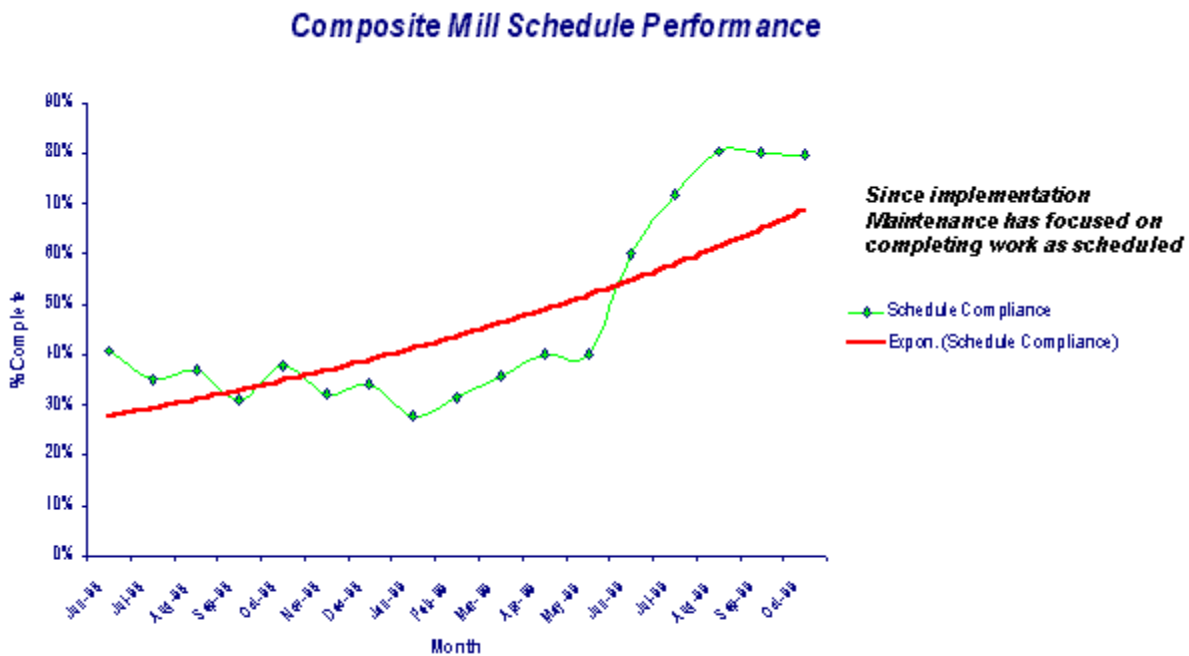


Figure 6: Schedule Performance

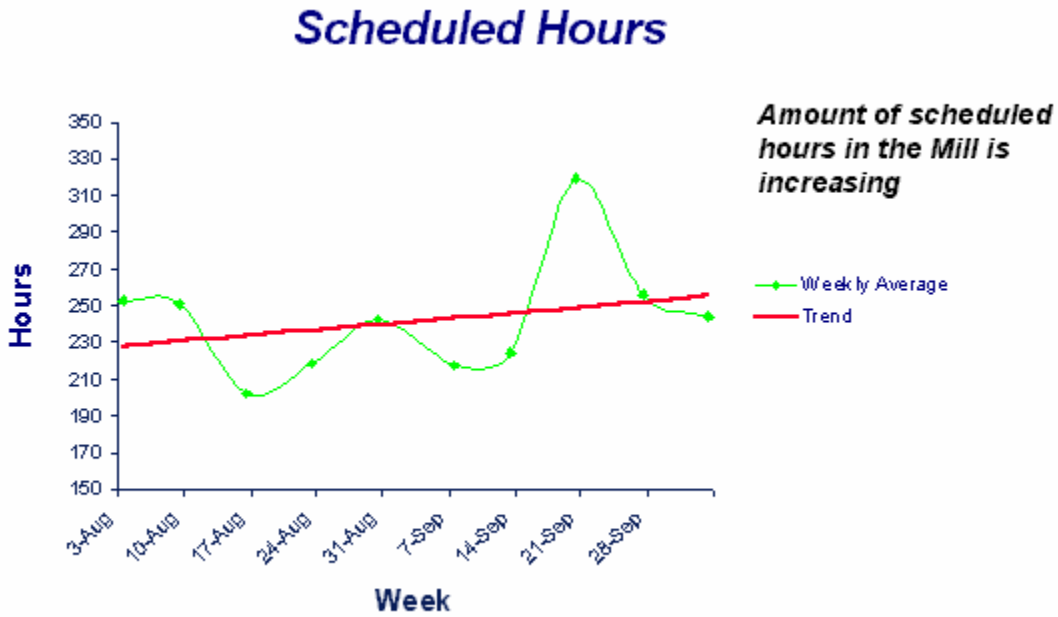


Figure 7: Scheduled Hour Increase

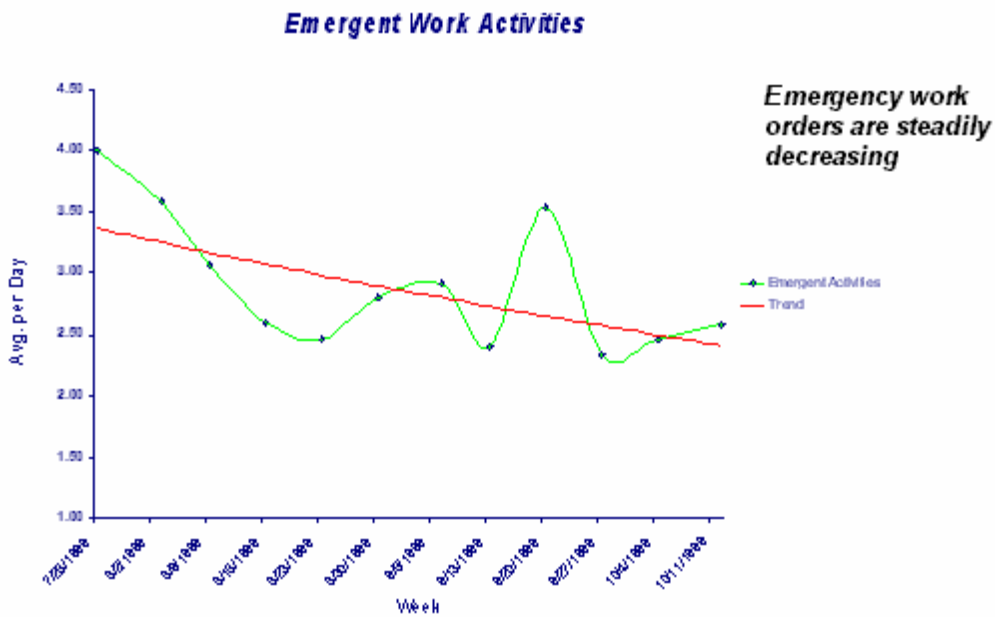


Figure 8: Trend of Emergent (High Priority) Work

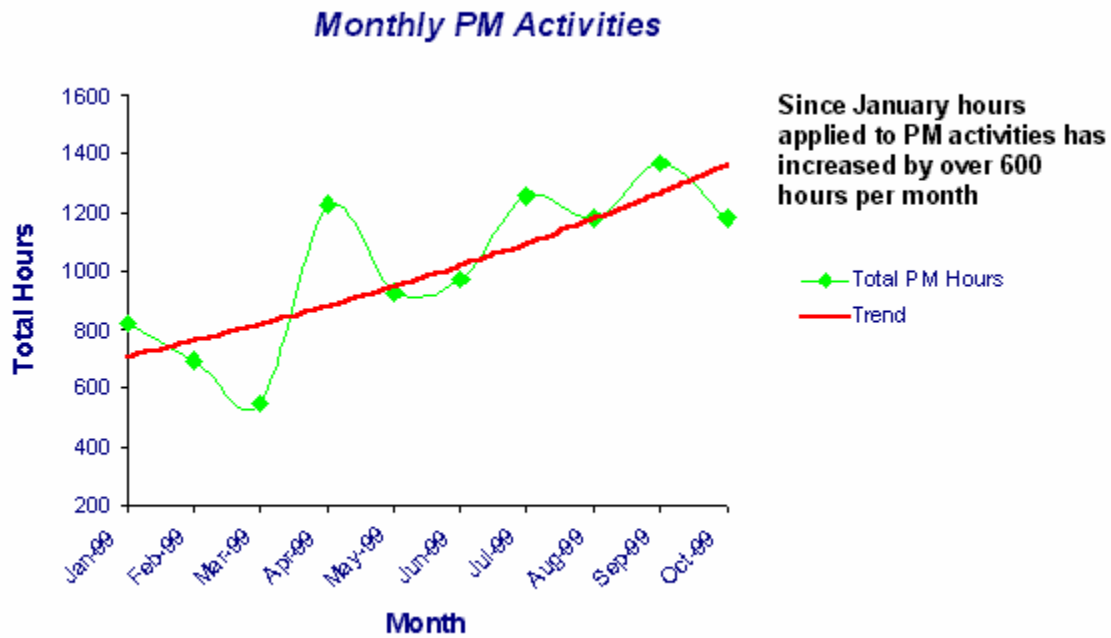


Figure 9: Hours Applied to PM Activities

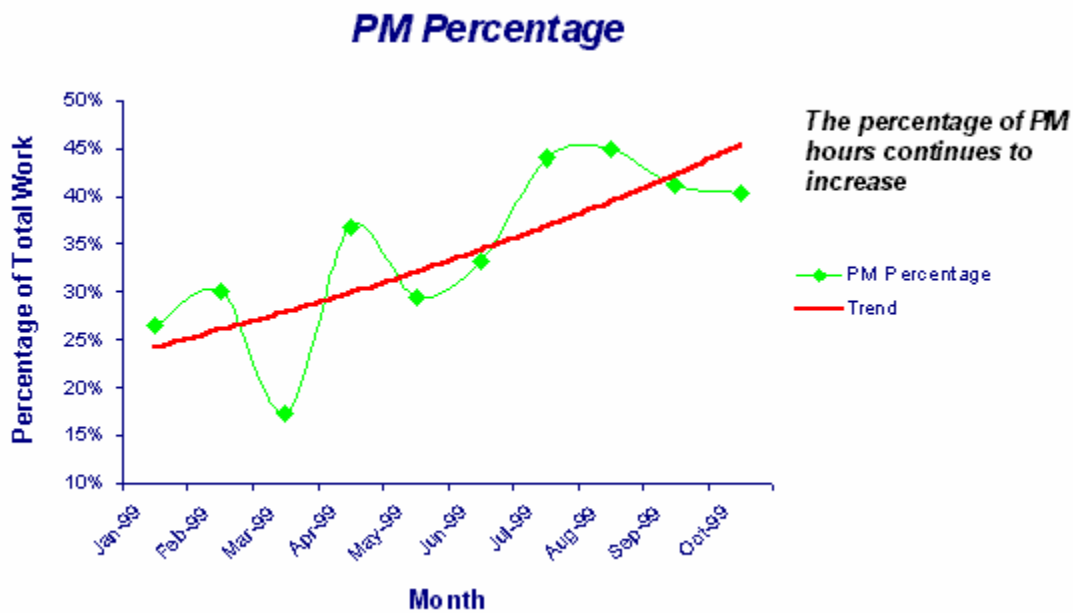


Figure 10: PM Percentages

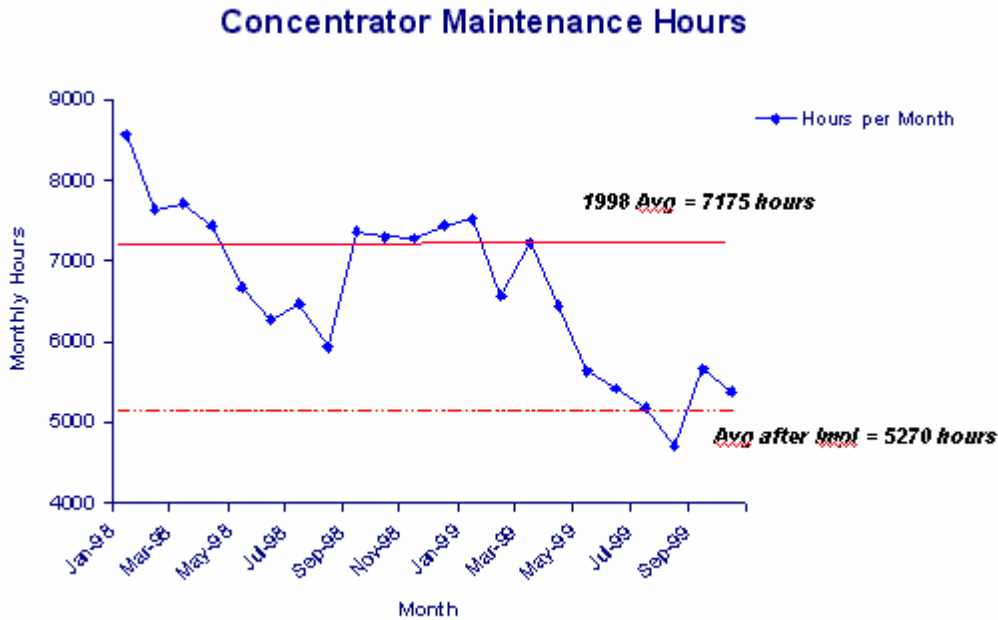


Figure 11: Reduced Maintenance Labor Hours

On an Annualized Basis, Maintenance Costs in the Concentrator Have Been Dramatically Reduced

	Year 1998	June-Oct '99 Annualized Costs	Differences
Total Hours	86102	63234	22868
Overtime Hours	8061	5009	3052
%O/T	9.4%	7.9%	1.5%
Total Labor Costs	\$3,565,005	\$2,604,496	\$960,509
O/T Costs	\$443,277	\$275,497	\$167,708

Figure 12: Annualized Maintenance Savings

Stage	Class	Low Performing	Competent	High Performing
Stage 1	Daily Maintenance	<ul style="list-style-type: none"> "Fire" dominates priorities Breakdowns frequent Maintenance equates to repair No work orders, plans, controls Stores service levels low Poor operator/Maintenance relationships Poor customer service levels 	<ul style="list-style-type: none"> Most work planned, scheduled Preventive maintenance implemented Trade competent at most repairs Computerized work order system Stores service level fair Operator prep for repairs Expedited orders infrequent 	<ul style="list-style-type: none"> All work prioritized PM hours and cost exceed repairs Reliability mgmt. system utilized, integrated with purchasing, stores JIT stores; 2X minutes in turn Operator inspect, create cost Turnarounds well planned, executed
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Figure 13: New Levels within the Organization

Over Time the Concentrator Organization Has Evolved

Prior to June

- Excellent at firefighting
- High priority work changing hourly impacts worker assignments
- Schedule compliance at 30%
- PMs are low priority
- Poor coordination and planning



November

- Planning work at two weeks out
- High priority work is under control
- Maintenance costs are dropping
- Inter-departmental coordination on scheduled activities
- Using KPIs to identify weaknesses
- Two reliability projects in progress
- Schedule compliance is up



Figure 14: Concentrator Evolution

“Think of R2K+ as a “Wheel of Inertia” – While it continues to revolve, it needs periodic lubrication and a push to keep it going. Only then will you reap the benefits.”

Brad Peterson

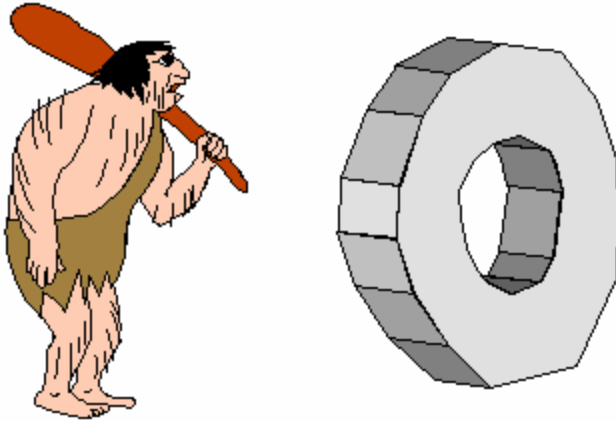


Figure 15: The Final Word