THE MAINTENANCE AND RELIABILITY INITIATIVE AT TECK
FOCUSBING ON THE MINE MAINTENANCE DEPARTMENT AT HIGHLAND
VALLEY COPPER PARTNERSHIP

by

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Abstract

There is significant opportunity to drive value by improving maintenance in mining. Maintenance represents approximately 20% of a mine’s operating costs, and influences production and capital spend. Teck has begun a coordinated Maintenance and Reliability Initiative (MRI) across seven mines. The MRI was begun at each mine with a year of accelerated change to maintenance processes and systems facilitated by a consultant. This paper focuses on Mine Maintenance at the Highland Valley Copper (HVC). Year one accomplishments are reviewed. Lessons learned are recorded that could be applied to another mine contemplating an MRI. Direction is recommended for the next two years, focussing on finishing change already begun, expanding the role of Reliability and upgrading the Enterprise Resource Planning system. Recommendations include how to measure and audit long-term maintenance performance improvement.

Keywords: Maintenance; Reliability; Maintenance Planning; Maintenance Scheduling; Short Interval Management; Change Management; Performance Management
Dedication

This paper is dedicated to my wife, Esther, who has encouraged and supported me during my MBA studies, including shouldering an additional parenting load for our young family.
Acknowledgements

I would like to acknowledge and thank those who have contributed to this program and to this paper. First, the staff employees in Mine Maintenance who have expended so much effort in implementing the changes included in this program. None of our accomplishments would have been possible without your hard work and professionalism. Secondly, John Ritter who is my supervisor and the Teck sponsor for this paper. Thirdly, Lotfi Maroizy, Tom Burke and the rest of the consulting team involved with the project. Lotfi has been the consultant’s direct contact with the Mine Maintenance group for the majority of the program and has skilfully guided external expectations, listened attentively to internal feedback, and conducted himself professionally in his work. Tom has provided constructive feedback on the paper. Finally, Ian McCarthy, who is the Simon Fraser University faculty member assigned to be the first reader for this paper and has provided sound guidance.
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1: Introduction

Teck has embarked on a coordinated Maintenance and Reliability Initiative (MRI) across seven mine sites. This paper explains what the MRI is, why it is necessary, and what has been accomplished to date. This paper is written at the conclusion of approximately a year of accelerated change to maintenance processes and systems, which was facilitated by a consultant. Direction is recommended for the next two years.

Teck is Canada’s largest diversified mineral processing and metallurgical company, which owns or has interests in eight mines in Canada, as well as a metallurgical complex in Canada, and five mines in the USA, Chile and Peru. Maintenance represents approximately 20% of each mine site’s operating costs, with a combined annual spend at mine sites of approximately $700 million. Teck’s maintenance function employs approximately 2,500 people and directly impacts the availability of production equipment, thus impacting productivity and the need for capital spend. (See Appendix A)

Teck has contracted a consulting company to assist with the MRI at seven of its Canadian mines. The consultant is a global consulting company currently operating in a wide variety of industries in 38 countries. The consultant brings knowledge of best practices, experience in change management, and additional resources to the mines to enable change.

The Mission Statement of Teck’s maintenance group is: “Doing the right thing – every time. We will lead our industry in having the right equipment availability, at the right time, and at the right cost.” The associated Vision statement (see Appendix B for full version) identifies the key areas of focus in “Doing the Right Thing - Every Time”:

1. Maintenance and Operations taking joint responsibility for equipment and working together to get things done
2. Using best practices in the core maintenance functions with a focus on planning and scheduling identified work
3. Applying reliability tools and techniques using proven systems such as Reliability Centered Maintenance (RCM), Root Cause Failure Analysis (RCFA), Condition Based Maintenance (CBM) as well as setting critical standards for maintenance and operations
4. Sharing knowledge and learning from others to drive improvement including using knowledge and resources from outside the mining industry

The MRI will address all of these areas of focus, but the initial phase concentrated on maintenance process and systems. This phase was called the Maintenance Enhancement Program (MEP) at HVC and had other names at other mines. The implementation of reliability tools and techniques (point 3 above) was largely out of scope in the MEP, and will be a major focus of the next two years. The MEP that took place in the Mine Maintenance group at Highland Valley Copper (HVC) took 44 weeks. It is now considered complete.

Key accomplishments of the project include:

- Understanding of the building blocks of an effective maintenance program
- Improvement in planning and scheduling processes
- Clarification of roles and responsibilities
- Use of standardized process for work order flow
- Improvements in meeting effectiveness and reporting
- Control of backlog
- Short Interval Management
- Rationalization of preventative maintenance routines
- Improvement in materials management to support the maintenance function

Although much was accomplished in those 44 weeks, the MEP is only the first phase of Teck’s MRI. Some future advances to maintenance process and systems lead logically from the MEP that will require time and the integration of new staff to accomplish. Once these employees are integrated, and both old and new employees become proficient in their new roles, then what was accomplished can be extended further into the maintenance organization. The reliability program requires further development and more time to show results.

Some lessons were learned in the MEP that can be applied at HVC or at other Teck sites that are contemplating an MEP. One of the key lessons is that gaps in staffing should be determined prior to the start of a project. The paper will apply this learning to a discussion of HVC’s anticipated upgrade to its Enterprise Resource Planning (ERP) system. Another key lesson learned is that there is significant potential to improve communication between Teck sites. This paper postulates that there is significant potential in sharing reliability learning between sites, and for sharing knowledge of ERP installation.

There are a number of initiatives proposed or underway which are driven either by Teck corporate or at the site level. To employees busy with their normal duties, these initiatives can
appear as a burden and an interruption, particularly when they do not fit well with established systems and processes. These initiatives include reliability engineering, human resources and information technology initiatives. These initiatives make more sense when one looks at them collectively, and in the context of the MRI.

The structure of this paper is as follows. Chapter 2 explains the opportunity and need to improve maintenance in HVC’s Mine Maintenance group and across Teck. Chapter 3 reviews the accomplishments of the MEP in HVC’s Mine Maintenance group, assesses cost/benefit, and discusses sustainability. It also describes lessons that were learned that would be useful for HVC going forward or for another Teck mine that was contemplating an MEP. Chapter 4 introduces a number of initiatives driven either by Teck corporate or at the site level and reviews their fit with the MEP. Chapter 5 provide direction for the next two years and discusses implementation of those next steps. Chapter 6 is the conclusion of the paper.
2: Teck’s Maintenance and Reliability Opportunity

This chapter describes why Teck needs to improve its maintenance program, and then proceeds to describe the opportunity in HVC’s Mine Maintenance department. It does so by describing the magnitude of maintenance spend, and the impact of physical availability on capital spend and production. Then it presents the results of the consultant’s initial audit, which was called a diagnostic. The results of the diagnostic were considered in justifying the project. A synopsis is provided for how the project is structured and controlled.

As stated in the Introduction chapter of this paper, maintenance represents approximately 20% of each Mine Site’s operating costs, with a combined annual spend at mine sites of approximately $700 million. Teck’s maintenance function employs approximately 2,500 people. As such, maintenance represents a significant opportunity for cost control. Maintenance can also significantly affect mine productivity or the need for capital expenditure. The amount of machinery available for production is often the bottleneck in generating additional revenue at minimal marginal cost of production. Improvements to equipment physical availability (percentage of time available for production) will result in fewer equipment purchases, or in more production. Teck’s 2010 Q4 Quarterly Financial Report (Teck, 2011: 9) shows that 2010 revenues from the seven mines included in the MEP totalled $CAN5.22 billion. There is significant potential to reduce costs or increase revenue by focussing on maintenance. “The ultimate performance of any piece of mining equipment is primarily dependent upon three critical factors: the design of the product, the application that it is used in, and the maintenance that it receives during its time in service... Maintenance is the factor that offers management the best opportunity to influence and control the resultant performance of its equipment” (Caterpillar, 2005: 2)

Maintenance self-assessments completed at mine sites in 2008 and 2009, and past internal audits, indicated several areas requiring improvement. (Appendix A) Teck has recognized that there is significant opportunity to establish common best practices across sites, and has initiated a project call the Maintenance and Reliability Initiative (MRI) across many of its sites. Enhanced business guidelines and procedures are being incorporated into day-to-day
maintenance operations to provide preferred standards and best practices to the maintenance process. Expected results from this focused effort include:

- Standardized processes and data at all Teck Sites and an opportunity to implement company-wide best practices
- Increased communication between operations and maintenance
- More reliable and timely information management which facilitates better analysis, planning, and decision making
- A shift in employee effort toward more value added activities – more analysis, more automation, and less administration. (Teck, 2010: 4)

Teck has chosen to begin this project with its seven open pit mines in Western Canada because they are all wholly managed by Teck, have a long remaining mine life, have geographic and cultural proximity and have similar equipment and operations. As such, there is significant opportunity to apply and share best practices across these sites.

A similar project was performed at Shell’s Muskeg River Mine, during which several root causes of low truck availability were identified including:

- Urgency to fix broken equipment at the expense of preventive activities perpetuating low equipment availability
- Weak planning process for ensuring completion of preventive maintenance (PMs)
- Lack of active management on the floor (Consultant (a))

These are also areas of opportunity within Teck’s maintenance function.

2.1 The Maintenance Diagnostic at Highland Valley Copper (HVC)

Each site began with a visit from the consultant’s diagnostic team. This section will introduce the diagnostic and present its findings in a way that will provide a compelling case for change at HVC.

Four team members visited HVC and were on site for a period of ten days in November of 2009. During their time on site, the team job shadowed employees, analyzed data supplied by the mine site, attended and evaluated meetings, conducted employee surveys and assessed the clarity of roles and responsibilities.
2.1.1 Job Shadowing

The diagnostic team spent time with a cross section of maintenance staff employees (management). This was called a ‘Day In The Life Of’ or DILO. The DILO provided a snap shot of how the employee spent their workday. The figure below is taken from the diagnostic presentation, and breaks down the time spent in various functions. The key observation from these DILO’s is that supervisors and planners were spending less than half of their time actively supervising, planning or scheduling.

![Figure 1: 'Day In Life Of' Results for Foreman and Planner (Source: Diagnostic Presentation)](image)

2.1.2 The Maintenance Pyramid

The Maintenance Pyramid was a product of a Teck task force that included representation from the copper, zinc and coal business units and from the Teck corporate office. Together the task force identified the building blocks of a maintenance system. The diagnostic team conducted interviews with twenty staff employees to identify areas for improvement. As demonstrated in the figure below, improvement was required in nearly all areas.
2.1.3 Summary of Findings

At the end of ten days, the diagnostic team presented their findings, summarized as follows:

Planning

- Long term reliability data is not utilized effectively
- Planning responsibilities are not clearly defined between supervisor and planner and there is a lack of clarity of roles and responsibilities with respect to planning, scheduling and job execution responsibilities
- Time allocated to planning (job preparation) is not adequate
- Not all scheduled jobs are prepared in advanced
- Required supporting assets are not identified in the planning process
- Lack of coordination for supporting assets causes work delays
- Lack of defined processes for planning/scheduling and continuous improvement
- Right parts are not in the right place at the right time

**Scheduling**
- Weekly and daily schedules are not sufficiently loaded
- Conversion of the weekly plan to a daily schedule happens too late

**Supervision and Execution**
- Trades time is lost due to job preparation, parts and tools issues
- Frequent schedule breaks prevent the execution of planned work and increase inefficiency

**General**
- The pyramid interviews show that employees have differing views on reliability processes and tools implemented
- Basic maintenance Key Performance Indicators (KPI's) are not used to drive maintenance operations

The diagnostic team presented financial data for both the Mill and Mine Maintenance departments (Figure 3) to categorize the opportunities to reduce annual maintenance costs.
The diagnostic team then proceeded to set targets for reductions in maintenance costs in each category and project annual savings ($CAN millions) available if the project proceeded. As seen in the table below, the cost reduction opportunity is dominated by the labour and repair parts/supplies categories.
Table 1: Summary of Potential for Annual Maintenance Cost Reduction (Source: Diagnostic Presentation)

<table>
<thead>
<tr>
<th></th>
<th>Maintenance Labor</th>
<th>Repair Parts &amp; Supplies</th>
<th>Consumables, tools, vehicles, fuel etc</th>
<th>Contractors</th>
<th>Maintenance Staff/OH</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASELINE COSTS (AVG 08-09 FCUS)</strong></td>
<td>$46.2</td>
<td>$69.5</td>
<td>$4.2</td>
<td>$3.2</td>
<td>$13.2</td>
<td>$138.3</td>
</tr>
<tr>
<td>Impact</td>
<td>Min Max</td>
<td>Min Max</td>
<td>Min Max</td>
<td>Min Max</td>
<td>Min Max</td>
<td></td>
</tr>
<tr>
<td>Reliability Improvement (RCM, RCA, CBM, PM focus, reduce unscheduled downtime)</td>
<td>$2.3 $4.6</td>
<td>$2.6 $4.9</td>
<td>$0.2 $0.4</td>
<td>$0.2 $0.2</td>
<td>$- $-</td>
<td>$5.3</td>
</tr>
<tr>
<td>Planning and Scheduling (PM planning, more planned work, schedule adherence)</td>
<td>$2.3 $4.6</td>
<td>$- $-</td>
<td>$0.2 $0.2</td>
<td>$0.2 $0.2</td>
<td>$- $-</td>
<td>$2.7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$4.62 $9.23</td>
<td>$2.64 $4.86</td>
<td>$0.42 $0.63</td>
<td>$0.32 $0.32</td>
<td>$- $-</td>
<td>$8.0</td>
</tr>
<tr>
<td><strong>Mine</strong></td>
<td>$3.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$5.0%</td>
</tr>
<tr>
<td><strong>Mill</strong></td>
<td>$4.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.0%</td>
</tr>
</tbody>
</table>

A key observation from this table is that improved planning and scheduling will reduce only labour costs, while improved reliability will reduce both labour and repair parts/supplies costs. The benefits section of the paper will explain that it will take a further two years to see significant improvements from reliability efforts.

2.2 Implementation of the Maintenance Enhancement Program (MEP) at Highland Valley Copper

The diagnostic results were agreed by Teck as justification for an implementation of the MEP at HVC, which began in June of 2010. This section of the paper will describe the implementation in enough detail to give the reader an understanding of the MEP so that the reader will be able to follow the following chapters of the paper. This chapter will include the organizational structure for the project, and the process and timeline used for implementation.
2.2.1 Project Organization Structure

The project is overseen by a Steering Committee made up of HVC’s General Manager, other senior management within Teck and senior consultant representation. Four of the members are on the Steering Team for all seven mines that are implementing an MEP. The remaining two are involved in just this implementation because they are directly responsible for this particular site. Together this group is responsible for ensuring that the implementation is on track and properly resourced. They also serve to coordinate the project between mines.

The Site Project Management Team oversees the MEP, tying the Mine and Mill together and managing the site’s implementation. The Mine and Mill Maintenance teams have parallel structures that are responsible for doing the work. Each area has a full time consultant resource.
continuous through the 44 weeks of the project. During the installation phase, an extra consultant resource is supplied to each area to help with the increase in coaching that this phase brings. Each area requires a full time team lead to work closely with the consultant lead. The area task force is a diverse group of approximately eight employees including representation from Operations and Materials Management. These employees are expected to work approximately 20% of the time on the project. Their responsibility is to assist the consultant and HVC team leads in providing direction for the implementation and helping with the rollout of new methods and practices to the rest of the maintenance organization. The Superintendents are responsible for giving the task force and team leads direction and ensuring that they receive the support that they need from the rest of the maintenance organization.

2.2.2 Project Process and Timeline

The project has a 44-week timeline, beginning in June 2010 and ending in April 2011. Each eight-week segment has a set of milestones and finishes with a presentation to the Steering Committee. A shorter presentation is provided to the Steering Committee half way through each milestone, showing progress towards the milestones. The milestones have clearly defined exit criteria. The first eight weeks of the project are intended to allow the consultants an opportunity to become familiar with the organization they are tasked with changing, and to work with the HVC team in designing the future state of the maintenance organization. That includes tailoring the processes, metrics and standard practices to work at HVC. Weeks nine through 24 are the installation stage of the project. This is the most difficult and time-consuming portion of the project and requires the extra consultant resource. Weeks 25 through 40 are the sustainability stage, in which the previously installed processes are coached to a fully functional and sustainable level. The project was extended an additional four weeks to assist with integration of new employees and address some gaps identified at the end of the 40 week period.
Figure 5: Project High Level Timeline (Source: Steering Team Presentation)

The milestones are further broken down into weekly Steps To Milestones, and weekly status reports are prepared and reviewed with the mine and mill project teams. Processes and Systems are agreed with the client and then developed, coached and monitored until they are sustainable.
3: Review of the Maintenance Enhancement Program

This chapter will list and review what was accomplished in the MEP, assess the cost/benefit of the accomplishments and evaluate the sustainability of the accomplishments. The chapter concludes by describing lessons that were learned through the implementation. These lessons learned will be useful for HVC going forward or for another Teck mine that is contemplating an MEP.

3.1 Accomplishments

3.1.1 Final Maintenance Pyramid Survey

The initial pyramid survey was repeated at the conclusion of the MEP, and the results are shown in the figure below. The circled boxes are those that focus on reliability, while the uncircled boxes are focused on work management. For the most part, the uncircled boxes were within the scope of the MEP, while the circled boxes will be the focus of the next two years.
Figure 6: Final Maintenance Pyramid Survey

Comparing this pyramid with the one from the diagnostic (See Figure 2), one can see that significant progress has been made, particularly for the lower tiers of the pyramid, and for those that were within the scope of the project.

3.1.2 Key Performance Indicator (KPI) Trends

Prior to the MEP, HVC focused on lagging indicators such as physical availability and compliance to budget. Focussing on lagging indicators is like driving your car using the rear view mirror. There was a lot of information available on performance, but very little of it was useful for managing the work. “Most companies’ operational and management control systems are built around financial measures and targets, which bear little relation to the company’s progress in achieving long-term strategic objectives.” (Kaplan & Norton, 1996: 152) “You cannot manage what you cannot control, you cannot control what you cannot measure, you cannot (or at least should not) measure without a target, and, without a target you cannot improve”. (Caterpillar, 2005: 3) “...many mines tend to collect mountains of data … some of which they use, much of which they do not. Furthermore, much of the data that is used is not used in such a way that it actually helps improve the operation. For the most part, the data that is
collected is presented in the form of purely informational reports that present little more than a historical perspective ... Metrics should help us make sense of our situation and through their use we become smarter and gain some degree of control over the outcome.” (Caterpillar, 2005: 5)

The MEP has provided metrics that are leading indicators. These KPI’s provide greater and timelier visibility into issues, which in turn enables control. Examples of these KPI’s are Preventative Maintenance (PM) Schedule Attainment, Schedule Loading, Schedule Attainment, % Unscheduled labour, % Scheduled Downtime and Efficiency. Heavy Duty Shop (haul trucks & major support equipment) examples are included in this report. Additional trends for Field Mechanical (shovels & drills) and Mine Electrical are shown in Appendix C.

**PM Schedule Attainment** is the weekly percentage of scheduled Preventive Maintenance (PM) hours that were completed. Poorly functioning maintenance organizations often struggle to complete their Preventative Maintenance because they are focused on completing breakdown maintenance, but the key to breakdown reduction is a functioning PM program. Such maintenance organizations find themselves caught in a vicious cycle that requires tremendous discipline to break. PM Schedule Attainment has improved through the MEP in each of the three major areas in Mine Maintenance.

![Haul Trucks & Support Equipment PM Attainment](image)

Figure 7: Heavy Duty Shop PM Attainment  (Source: Week 39 Milestone Presentation)

**Schedule Loading** is the weekly percentage of the available resource hours (manpower) that were scheduled. Schedule loading has increased in all three areas as well. Schedule loading targets are typically set between 80% and 100% depending on the work area. Work areas that can
have days without unscheduled work should be loaded more highly than those areas that always
have some level of unscheduled work.

Figure 8: HD Shop Schedule Loading (Source: Week 39 Milestone Presentation)

Schedule Attainment is the percentage of the weekly scheduled work that was
completed in the week. % Unscheduled Work is the percentage of total hours worked that was
spent on unscheduled work in the week. The higher the schedule is loaded, the more difficult the
schedule is to attain, but Schedule Attainment numbers have also risen through the MEP.
Scheduled work is always more efficient than unscheduled work. (Wireman, 2004: viii)
(Sheremeta et al, 2008: 87) At the beginning of the project, people did not believe that the
schedule could be loaded above 60% or that unscheduled work would average less than 40%.
Unscheduled work results in delays due to looking for parts, tools, coordinating trades and space,
etc. Often unscheduled work causes an uneven workload which results in equipment delays due
to inadequate manpower or space to work on all of the down equipment. Since Loading and
Attainment numbers have risen through the MEP, it follows logically that % Unscheduled work
has gone down during the same period, which can be seen in the Figure below.
% Scheduled Downtime is a percentage of total fleet downtime that is scheduled in advance, i.e. included in the weekly schedules. Since this metric was recorded prior to the MEP, it provides a baseline against which later performance can be compared. The design, installation, and sustainability phases of the MEP and a line of best fit are included on the chart to help illustrate the effect of the change program on the metric. “Data collected from mine studies has shown that the average downtime for unplanned / unscheduled work is up to eight times greater than the downtime for planned / scheduled activity. Aside from MTBS, % Scheduled Downtime is the most important measure of equipment maintenance management performance ... Mines with highly effective equipment management processes in place are able to execute 80% of its maintenance and repair downtime activity on a scheduled basis.” (Caterpillar, 2005: 22)
Efficiency is a measure of actual hours versus estimated hours spent on a task. When actual and estimated hours do not correlate well, either the task was not planned and executed well, or the estimate was poor. Efficiency is most useful when used at the work order or daily level, and cannot be meaningfully trended over time because task estimates are continuously being revised. Long-term labour productivity can be trended by the Maintenance Ratio, explained in Section 3.2.2. Efficiency was tracked, but not meaningfully used prior to the MEP. Now the KPI is used in daily meetings to identify issues, which are usually gaps in work preparation. “The primary reason for low wrench time (productive maintenance time) is that they are not provided the necessary resources by management.” (Wireman, 2004: viii)

3.1.3 Establishment of a Management Operating System

A Management Operating System consists of meetings held at suitable intervals and with appropriate attendees and reporting. During those meetings, key performance indicators are reviewed to find root causes of variances from plan and actions taken to recover the plan.

“Diagnostic control systems work like the dials on the control panel of an airplane cockpit, enabling the pilot to scan for signs of abnormal functioning and to keep critical performance variables within preset limits. Most businesses have come to rely on diagnostic control systems to help managers track the progress of individuals, departments, or production
facilities toward strategically important goals.” (Simons, 1995: 81) Diagnostic controls allow a manager to see if he is getting to his target, but have little value in helping him get to that target. HVC tracked nearly all of the KPI’s noted in the prior section prior to the MEP, but did very little with the information. Through the MEP process, these control systems have shifted to ‘Interactive Control’ Systems.

‘... Interactive control systems are the formal information systems that managers use to involve themselves regularly and personally in the decisions of subordinates’ (Simons, 1995: 86) Interactive control systems have four characteristics that set them apart from diagnostic control systems. First, they focus on constantly changing information that top-level managers have identified as potentially strategic. Second, the information is significant enough to demand frequent and regular attention from operating managers at all levels of the organization. Third, the data generated by the interactive system are best interpreted and discussed in face-to-face meetings of superiors, subordinates and peers. Fourth, the interactive control system is a catalyst for an ongoing debate about underlying data, assumptions, and action plans. (Simons, 1995: 87)

In the past, reports were written to provide basic information to upper management rather than to identify problems or to drive actions and priorities for problem management. “The real “meat” of any good report are the conclusions made from the “picture” of the data provided by the graphics and the resulting action plans that are developed to address problems that are identified.” (Caterpillar, 2005: 6)

Meeting effectiveness training was one of the most important contributions of the consultant team. “Meetings have a high level of impactability (potential for improvement) due to a common lack of organization and process”. (Consultant (c): 7) With the Consultant's help we developed a ‘Terms Of Reference’ (TOR) for all meetings. This communicated the meeting objectives, inputs/outputs, standing agenda and attendee list for all meetings in a standard format. Each meeting now contains an action log as both an input and an output.

3.1.4 Clarification of Roles and Responsibilities

During the MEP, all staff employees and all clerks provided a breakdown of their regular duties in the form of an Activity List. The activities were divided into categories.

Consistent with the diagnostic findings, the activity lists demonstrated that planners were not ‘planning’ enough. Too much of their time was spent doing clerical and scheduling work, leaving them without sufficient time to plan. There are two ways to fix that. The first is to
reduce the non-planning workload by eliminating or streamlining clerical and scheduling processes. The second is to shift that work to others. Most experts agree that better use of planners provides one of the largest potential areas for cost savings in maintenance (Wireman, 2004: viii), yet maintenance organizations very commonly place responsibility for too many craft technicians on planners. (Wireman, 2004: 106) “The Planner position is one of the most critical in the Maintenance Organization, but planners are frequently tasked with multiple job responsibilities including helping with emergency or unscheduled work.” (Warmack, 2009: 2)

The Activity Lists also demonstrated that supervisors were doing a significant amount of clerical and planning work, particularly ordering and expediting parts.

Companies should take a closer look at supervisory activities to determine which portions of the day can be altered to make more effective use of their time. This means examining specific roles and ensuring that the right employees are performing the right tasks; loosely defined roles, undefined expectations, and ineffective practices create a chaotic and frustrating daily work experience with a great deal of lost time. Implementing a simple architecture with clear accountabilities is the first step in breaking this cycle, and each new role must be aligned with measurable expectations and supported with the tools necessary to achieve them. (Consultant (c): 4)

The following were significant steps to increasing active supervision, planning and scheduling.

- Developed a scheduling role in both the Heavy Duty Shop and Field Maintenance areas, and added an employee for each. In a recent survey of maintenance managers, over 40% of the respondents indicated that scheduling was their biggest problem. (Wireman, 2004: 105) Adding schedulers focuses on that challenge and gives the planners more time to concentrate on planning. In addition, for someone doing both planning and scheduling, the urgent always wins out over the long-term, so planning suffers. Separating the roles eliminates that problem.

- Provided 7 day/week planning coverage in the Heavy Duty Shop

- Developed job descriptions and a RACI matrix for planners, schedulers, clerks and supervisors. A RACI is a matrix that identifies which function is Responsible, Accountable, Consulted or Informed for a particular task. A common pitfall for planners is that they are pulled into helping with emergency work. (Warmack, 2009: 2) Similarly, supervisors are often pulled into planning work because plans are not adequately prepared. Clear accountabilities have reduced duplication of efforts and allowed work to
be systematically shifted from supervisors to planners and from planners to schedulers and clerks.

3.1.5 Use of Work Order Status Flow

Prior to the MEP, the originator of a work order often completed all steps required to bring the work order to the execution stage. Delineation of planner, scheduler and supervisor roles required disciplined use of Work Order Status Flow. Movement of a work order between statuses now is an effective hand off from one function to the next, and clearly identifies whether a work order has been planned, whether parts have been ordered, whether parts have arrived, and whether the work order has been scheduled. In the past, work orders often were executed without having gone through the necessary planning and scheduling steps.

3.1.6 Maintenance and Operations Commitment and Interaction

Even prior to the MEP, HVC had a high-level of cooperation between Maintenance and Operations. The MEP increased visibility of whether equipment was released for Maintenance according to the schedule and how it was released. Explanations for deviations from the shovel and drill schedule are now reviewed at the weekly Schedule Commitment meeting. Operations is accountable for preparing an adequate work area and moving the shovel for each down. Maintenance is accountable for returning the shovel to the active face and checking all motions at the end of each day. Similarly, any deviations from the truck or support equipment schedule are reviewed daily at the shop Short Interval Control meeting and weekly at the Schedule Commitment Meeting. These improvements have contributed to the gains in PM Compliance and have reduced coordination delays.

3.1.7 Backlog Control

Improvements in Roles and Responsibilities and in Work Order Status Flow have enabled an accurate maintenance backlog. Together with equipment Delay information and overtime levels, the backlog is a useful tool in determining whether manpower levels are adequate to support the workload. The backlog is also useful in reviewing whether schedulers and planners are making good decisions in filtering and prioritizing the work and whether supervisors are appropriately moving work to the planning and scheduling process.
3.1.8 Short Interval Control for Safety and Delay Reduction

Short Interval Control (SIC) is the discipline of measuring a process at the shortest appropriate time frame in order to identify variations and take corrective action. Benefits of Short Interval Control include:

- Provides focus
- Identifies small problems before they become larger
- Enables a more detailed understanding of process degraders
- Engages those closest to the process (Teck, 2010: 50)

SIC requires tracking the current status of work in progress in a short enough time span that safety or productivity issues can be identified and fixed. This requires tracking delays and can be enabled by a whiteboard or by using a tracking sheet on a clipboard. Either way, the key is for the supervisor to have regular interactions with his crew and to be available when they need help or guidance. The MEP has resulted in increased time spent in meetings. The supervisor’s time lost in attending meetings has been offset by improved planning, scheduling and materials sourcing and by reduced time spent in adhoc meetings.

3.1.9 Materials Management

Sourcing parts and materials is a time consuming and disruptive activity for a maintenance department. When a job is unscheduled, that burden falls directly on the supervisor. During the MEP, the percentage of work that is scheduled has increased, and a channel for supervisors to defer work to the planning process has been provided. Improvements in kitting and staging and the handling of non-stock parts orders have provided more time for supervisors to actively supervise.

3.1.10 Haul Truck Pre-PM

The Pre-PM is done seven to ten days ahead of the Preventative Maintenance (PM) event. It takes about one hour, during which time a mechanic takes fluid samples, reviews a list of operator complaints with the operator, and performs basic checks. The benefits of a Haul Truck Pre-PM were documented during a benchmarking trip performed by Teck Coal. (Sheremeta et al, 2008: 87) Advantages include:

- Clarification of issues identified by the operator.
• Opportunity to educate the operator on how his/her activities affect the reliability of the truck.
• Oil sample results are available prior to the PM.
• An increase in planned work during the shutdown, resulting in better parts coordination and a better estimate of the work duration.

3.2 Cost/Benefit of the MEP in Mine Maintenance

This section will estimate the cost and benefit of the MEP in Mine Maintenance at HVC. Where possible, cost and benefit will be expressed in financial terms.

3.2.1 Cost of the MEP

The cost of the MEP consists of consulting costs and the cost of HVC labour. Consulting costs were budgeted at $2.7 million. Approximately half of that amount, or $1.35 million was expended in Mine Maintenance. There were approximately 2.5 full time equivalents involved from HVC’s Mine Maintenance group for 44 weeks, which is a cost of approximately $300,000. One could argue that these wages are a sunk cost, and that the real cost of HVC labour is the opportunity cost - the value of the activities that these people would have been able to perform if they were not involved with the MEP. It is the author’s belief that the opportunity cost exceeds the actual cost. However, actual cost will be used since the opportunity cost is nearly impossible to estimate. The total cost of the MEP in mine maintenance is therefore approximately $1.65 million.

3.2.2 Benefit of the MEP

Putting a dollar value to the benefits of the MEP is more difficult. Improvements occurred gradually through the course of the MEP, gains are still being realized, there has not been sufficient time to track those gains, and there is a great deal of background ‘noise’. That background noise includes the timing of major maintenance events and the influence of other improvements. In the short term, inferences will have to be made to the financial benefit of the MEP using a sensitivity analysis. In their article ‘Using the Balanced Scorecard as a Strategic Management System’, Kaplan and Norton describe how to use a Balanced Scorecard to drive objectives that are not just financial, but also focus on our internal customers (equipment availability and reliability), on our internal business processes (schedule loading & attainment, % unscheduled) and learning and growth (continuous improvement). (Kaplan & Norton, 1996)
These metrics are widely accepted as being linked to long-term financial performance and are more easily measured. Measuring them, therefore, provides an earlier and more reliable measure of project success than directly measuring costs.

The following table summarizes and estimates the potential MEP opportunities, which are further explained in the following sections of the paper.

**Table 2: MEP Benefits Table (Source: Author)**

<table>
<thead>
<tr>
<th>Source of Opportunity</th>
<th>Annual Size of Opportunity</th>
<th>Short Term Indicator(s) / Benefit</th>
<th>Long Term Indicator(s) / Benefit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Labour</td>
<td>$22M</td>
<td>%Unscheduled Work / $700K per year</td>
<td>Maintenance Ratio / $1 million per year</td>
<td>Highly influenced by the MEP through improvements in work management.</td>
</tr>
<tr>
<td>Maintenance Materials</td>
<td>$28M</td>
<td>%Unscheduled Work / negligible financial benefit</td>
<td>Component Rebuild $/hr, $/hr by fleet by component / $1.4 million per year</td>
<td>Not highly influenced by the MEP, but with significant potential through reliability improvements.</td>
</tr>
<tr>
<td>Production increase through Availability</td>
<td>$872M</td>
<td>Reliability, PM Attainment / significant financial benefit</td>
<td>Reliability KPI’s, Availability / Effect on long term capital requirement</td>
<td>Influenced via labour productivity gains. Large short-term opportunity that is difficult to quantify.</td>
</tr>
</tbody>
</table>

### 3.2.2.1 Gains in Maintenance Labour Productivity (Maintenance Ratio)

In the short term, trends in % Unscheduled work is the best indicator of improvements in Labour Productivity. The effectiveness of planning and scheduling in improving productivity is well documented. Planned and scheduled work can conservatively be considered twice as efficient as work that is unplanned and unscheduled. (Wireman, 2004: viii; Frampton, 2001: 2) Qualitative observations about the effect of improved planning and materials management are also legitimate indicators of productivity improvements. With reference to Appendix C, approximately 10% less work is unscheduled than at the start of the MEP for the 62% of Mine Maintenance employees impacted by the MEP (See Section 5.1.2). This translates into $682,000 per year in reduced labour costs, with probable further gains. ($22 million in annual labour x 62% affected x 10% improvement in schedule work x 50% efficiency gain = $682,000 / year).
In the longer term, the Maintenance Ratio is the best metric to measure improvements in maintenance labour productivity. The Maintenance Ratio is defined as the ratio of maintenance man-hours to equipment operating hours. The Maintenance Ratio has the advantage of being independent of escalation. During labour budgeting, the total maintenance head count is often budgeted as a ratio of the operations head count. That comparison is overly simplistic because it neglects the effect of fixed positions and makes no allowance for the difference in maintenance effort for various types of machinery. See Figure 12 for trends in the Maintenance Ratio for the past decade at HVC for haul trucks. The maintenance hours include all trades. Contractor hours are negligible. Benchmarks for new and mature fleets are included in the figure. A fleet that has undergone its first round of major component rebuilds is considered mature. HVC has a fleet of 54 haul trucks. Eight trucks were commissioned in 2007, another eight in 2008, and ten in 2010. All but the ten newest trucks were ‘mature’ by the end of 2010.

Figure 11: Trending Haul Truck Maintenance Ratio (Source: Author)

The table below shows industry standards for a mature fleet of haul trucks in this class for this metric. (Caterpillar, 2005: 28)
Table 3: Industry Standards for the Maintenance Ratio

<table>
<thead>
<tr>
<th>MR</th>
<th>Assessment / Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30 to 0.35</td>
<td>Excellent; high % of scheduled downtime; Equipment Mgmt. organization is highly proactive.</td>
</tr>
<tr>
<td>0.35 to 0.40</td>
<td>Acceptable; majority of downtime is scheduled; substantial emphasis on Equipment Mgmt.</td>
</tr>
<tr>
<td>0.40 to 0.50</td>
<td>Marginal; approx. half of all downtime is scheduled; Equipment Mgmt. disciplines not fully functional.</td>
</tr>
<tr>
<td>0.50 to 0.60</td>
<td>Fair; &lt; 40% downtime is scheduled; minimal effort on Equipment Mgmt.</td>
</tr>
<tr>
<td>&gt; 0.60</td>
<td>Poor; only PM’s are scheduled; Equipment Mgmt. organization is purely reactive.</td>
</tr>
</tbody>
</table>

The haul truck Maintenance Ratio is progressing towards industry benchmarks, but could improve by a further 0.05 maintenance hours per hour of haul truck operation. Using a budget of 200,000 truck hours per year, there is potential to reduce maintenance hours by 10,000 hours per year. That would translate into a savings of $650,000 per year at $65 per hour. Similar potential in other fleets could raise the payback to approximately $1,000,000 per year.

3.2.2.2 Reduction in Maintenance Material Costs

Material costs will be reduced by improvements in planning and scheduling, but to a limited degree. “Planned purchases average 5% less than unplanned.” (Sheremeta et al, 2008: 87). As stated above, approximately 10% less work is unscheduled than at the start of the MEP. This would indicate that material costs should be reduced by approximately 0.5%. However, material costs in mobile maintenance are dominated by the cost of component rebuilds, particularly haul truck engines and shovel transmissions, which are already planned, thus further reducing the cost saving benefit of the MEP to a negligible amount.

As noted in Table 1, maintenance material costs can be impacted to a high degree by reliability improvements. Cost per hour, cost per tonne or cost per litre of fuel burned etc are suitable metrics for component rebuild costs. Fleet cost per hour broken down into the component level is suitable for looking at total cost of maintenance. All of these metrics must be adjusted for the cost of inflation. These metrics are already monitored and gains are expected from our reliability program. It is reasonable to expect the 5% improvement in parts and repair material costs in two years time, primarily due to reliability improvements which extend the life of major components. A 5% gain would correspond to $1.4 million annually.

3.2.2.3 Increase in Fleet Physical Availability

There is a direct link between increased availability (particularly for haul trucks) and revenue at HVC, particularly in the short term. 2010 revenues at HVC were $872 million, thus
any impact on revenues is likely to dominate the benefits of the MEP. It is not immediately clear whether the MEP has helped to improve haul truck availability. In fact, haul truck availability has been lower in recent months than the 2010 average. During these recent months, physical availability was reduced by mine operating conditions, level of planned component replacements, and availability of labour.

As demonstrated in the following figure, physical availability is highly correlated to delays. Regression analysis demonstrates that if delays could be eliminated, approximately 91% availability would be possible.

![Figure 12: Correlation of Haul Truck Availability to Delays (Source: Author)](image)

As demonstrated in the figure below, these delays are predominantly manpower delays. Since HVC’s Collective Bargaining Agreement prevents bringing in contract labour, improving labour productivity or hiring more employees are the only ways to reduce manpower delays.
The next figure shows monthly trends of availability, reliability and equipment delays. Again, the inverse correlation between delays and availability is evident, while reliability numbers are relatively stable and perhaps trending upwards. There has been no increase in haul truck PM Attainment during the MEP because it was 100% before and during the program.

*Figure 13: Breakdown of Haul Truck Delay Hours (Source: Author)*
It is reasonable to assume that there will be an improvement in availability due to the MEP. Proving or quantifying the improvement is nearly impossible. Because of a reduction in mining throughput in Q4 of 2011, availability will not significantly affect production for several years following completion of the MEP.

3.3 Sustainability Evaluation of the MEP

This section reviews the MEP to assess whether the changes will be permanent and continuing. It begins with a definition of sustainability and establishes the fact that changes are often unsuccessful. This is followed by an assessment of how the MEP fared through the stages of change management identified by Kotter in his paper ‘Leading Change – Why Transformational Efforts Fail’. (Kotter, 1995) The MEP should be seen as an accelerated start to a change program that is at least three years in duration. Accordingly, this section will conclude...
with an evaluation of whether and to what extent these changes will be sustained and furthered following the completion of the MEP. This section will build into the Recommendations section of the paper.

### 3.3.1 General Discussion of Sustainability in Change Management

Sustainability is the condition in which the implemented systems, processes, and behaviours are institutionalized and self-correcting resulting in continuous performance improvement. Since sustainability is the foundation for continuous improvement, it will allow the continued achievement of results long after any implementation is completed.

In the journey to sustainability, the organization will go through a series of changes in behaviour that range from the moment the need for change is identified to the time when everyone in the organization fully understands, uses and believes in the changes implemented. Sustainability is reached when the changes become the norm, and a pre-change organization no longer seems possible. Hard work, perseverance and patience are crucial for getting to this stage; in addition to a personalized, flexible implementation that ensures the changes are the most appropriate for the organization – not an imposed standard. (Teck, 2010: 8)

Many change efforts do fail. The Economist Intelligence Unit has commissioned a survey of the success of changes in a range of organizations. Their findings are that only about half of change programmes at companies in Western Europe or the US were successful.

(Consultant (b): 4)

### 3.3.2 Steps in Change Management

In the following sections, this paper will review the MEP in the context of Kotter’s paper entitled ‘Leading Change – Why Transformational Efforts Fail’. Kotter notes that corporate change efforts fall somewhere between success and failure, with ‘a distinct tilt toward the lower end of the scale’. (Kotter, 1995: 96)

The most general lesson to be learned from the more successful cases is that the change process goes through a series of phases that, in total, usually require a considerable length of time. Skipping steps creates only the illusion of speed and never produces a satisfying result. A second very general lesson is that critical mistakes in any of the phases can have a devastating impact, slowing momentum and negating hard-won gains. (Kotter, 1995: 97)

Table 5 below is a summary of these phases. Further detail on these phases is provided in the remainder of this section.
Table 4: Summary of Change Management Steps for MEP (Source: Author)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Score</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishing a Sense of Urgency</td>
<td>B</td>
<td>A slow start, but regular reporting of project progress helped create a sense of urgency</td>
</tr>
<tr>
<td>Forming a Powerful Guiding Coalition</td>
<td>A</td>
<td>Appropriate levels of management were involved. The team included people with subject matter knowledge &amp; expertise and line leadership</td>
</tr>
<tr>
<td>Creating a Vision</td>
<td>B</td>
<td>Leadership team created an effective vision</td>
</tr>
<tr>
<td>Communicating the Vision</td>
<td>C</td>
<td>Vision was sometimes lost amid other initiatives and the multitude of installations in the MEP</td>
</tr>
<tr>
<td>Empowering Others to Act on the Vision</td>
<td>B</td>
<td>Control and empowerment are not always compatible</td>
</tr>
<tr>
<td>Planning for and Creating Short Term Wins</td>
<td>A</td>
<td>Milestones were effectively broken down into weekly actions</td>
</tr>
<tr>
<td>Consolidating Improvements and Producing Still More Change</td>
<td>TBD</td>
<td>New supervisors are coming on board, future steps have been identified</td>
</tr>
<tr>
<td>Institutionalizing New Approaches</td>
<td>TBD</td>
<td>Meeting effectiveness and root cause identification are embedded</td>
</tr>
</tbody>
</table>

3.3.2.1 Establishing a Sense of Urgency

Chapter 2 described Teck’s opportunity to improve maintenance and reliability. There is significant payback to the corporation (See Table 1), but no obvious tangible benefit to employees. The first step to realizing the opportunity is to create a widespread agreement that change is necessary and urgent. According to Kotter, the required rate of urgency ‘is when about 75% of a company’s management is honestly convinced that business as usual is totally unacceptable’. Kotter has found that well over 50% of companies that he has observed fail in this first phase. (Kotter, 1995: 98)

Initially the MEP at HVC suffered from a low level of urgency. There were several reasons:
The maintenance organization considered itself high functioning. In particular, availability of machinery was relatively high. “The vast majority of organizations never become great, precisely because the vast majority become quite good - and that is the main problem.” (Collins, 2001: 1)

The maintenance group was busier than it ever had been. Resources were stretched in maintaining fleets that were considerably larger than in the previous year, and approximately double that of four years prior. There was also considerable pressure not to raise manpower levels due to uncertainty in the future mine plan. The net result was that the project was not well resourced.

Despite operational problems, company profits were high due to high Copper prices.

The MEP followed closely on the heels of a pair of other initiatives. The first was a performance management initiative facilitated by a consultant and the second was an employee empowerment initiative. It was difficult to ‘go to the well’ again.

Many of the employees had also been through similar consultancy reviews of maintenance by Proudfoot and Ryberg-Levy in decades past. These previous consultants were efficiency focused, in one notorious case even timing employees’ bathroom breaks.

‘Because there seems to be an almost universal human tendency to shoot the bearer of bad news... executives in these companies often rely on outsiders to bring unwanted information.’ (Kotter, 1995: 98) The diagnostic was used to establish the need for a change, and was partially successful. In the process of the diagnostic, employees learned more about the MEP, which also helped convey the need for change. At the beginning of the project, quick wins were identified and acted upon, which helped fuel initial enthusiasm. Clearly defined milestones and a rigorous tracking system also contributed to the sense of urgency.

3.3.2.2 Forming a Powerful Guiding Coalition

Kotter has found that “whenever some minimum mass is not achieved early in the effort, nothing much worthwhile happens... in the most successful cases, the coalition is always pretty powerful – in terms of titles, information and expertise, reputations, and relationships.” (Kotter, 1995: 98) “An executive steering team should be established to review progress and break down barriers for teams on a monthly basis. In addition, a project management team should meet weekly to measure results of the change program and report to the steering committee.” (Consultant (c): 7) The MEP is structured to include a powerful guiding coalition in the form of
the Steering Team which is updated every four weeks on progress. The regular reporting to a powerful guiding coalition is also an effective way of maintaining a sense of urgency through the MEP. On a site level, senior maintenance management is actively involved in the MEP, which is important because “groups without strong line leadership never achieve the power that is required”. (Kotter, 1995: 98)

3.3.2.3 Creating a Vision

“In every successful transformation effort that I have seen, the guiding coalition develops a picture of the future that is relatively easy to communicate and appeals to... employees.” (Kotter, 1995: 98) “A useful rule of thumb: If you can’t communicate the vision to someone in five minutes or less and get a reaction that signifies both understanding and interest, you are not yet done with this phase of the transformation process.” (Kotter, 1995: 99)

Appendix B contains Teck’s Maintenance Mission and Vision. The statements are simple and written in a way to appeal to employees at all levels within the organization and serves as a ‘belief system’ control lever. (Simons, 1995) When communicated clearly, the vision allows employees to view the end goal, and find unique ways of contributing to that goal.

“Without a sensible vision, a transformation effort can easily dissolve into a list of confusing and incompatible projects that can take the organization in the wrong direction or nowhere at all ... In failed transformations, you often find plenty of plans, directives and programs but no vision.” (Kotter, 1995: 99) Since the scope of the MEP was very broad, this proved to be a very real hazard. Contributing to the danger was the fact that many of the ideas were transplanted from other Teck mines or even other industries via the consultant. Direct contact with the Teck personnel at the other mine was helpful in certain circumstances.

3.3.2.4 Communicating the Vision

Drafting and disseminating a clearly articulated vision are the first steps to harnessing the enthusiasm of the workforce. Executives should draft a statement that communicates the urgency of the situation, the financial ramifications, the need for change, and how it will impact the company. “In more successful transformation efforts, executives use all existing communications channels to broadcast the vision.” (Kotter, 1995: 100) Although the maintenance vision is clear and concise, it has not been effectively communicated. The objectives of the MEP were shared in crew presentations at the beginning of the program, and results and mission statement will be communicated again in crew presentations at the end of the program. Steering team presentations
were shared with supervision throughout the program, and relevant topics were discussed with supervision at weekly meetings.

“The easiest parts of any change programme are the technical aspects such as mobilising a project team or writing a new value statement. The hardest part, according to our survey panel, as suggested above, is “winning hearts and minds”. ... survey respondents single this out as the most difficult element of any change programme. It is one thing to get people to state their commitment to a change initiative, but if they have not truly bought into the change, the programme will ultimately fail.” (Consultant (b) : 5)

3.3.2.5 Empowering Others to Act on the Vision

“To some degree a guiding coalition empowers others to take action simply by successfully communicating the new direction. But communication is never sufficient by itself. Renewal also requires the removal of obstacles.” (Kotter, 1995: 101) In a company the size of Teck, or in a site as large as HVC (1200 employees), there are often significant barriers to change. Part of the Steering Team’s function is to assist with removing those barriers.

Part of Teck’s Maintenance Vision is an increase in the resourcing of planning, scheduling and reliability engineering, and the need for this was identified and addressed in the MEP. Other barriers at present include the limitations of our existing Enterprise Resource Planning (ERP) system, and building of office space to locate planners near supervision. Hiring the resources, building office space and in particular upgrading an ERP takes time, and will not be completed prior to the end of the MEP.

Empowerment and a powerful guiding coalition are sometimes at odds. While a powerful guiding coalition can help remove barriers, it also has the potential to add new barriers by exercising control at too low a level. “A fundamental problem facing managers... is how to exercise adequate control in organizations that demand flexibility, innovation, and creativity.” (Simons, 1995: 80) “Effective managers empower their organizations because they believe in the innate potential of people to innovate and add value... To unleash this type of potential, senior managers must give up control over many kinds of decisions and allow employees at lower levels of the organization to act independently.” (Simons, 1995: 88) “With KPIs outlined, front line teams should also enjoy autonomy to investigate the best path to reach them. This approach spreads risk, intellectual investment, and ultimately confidence in the process, and by design it encourages teams to test their theories and discover what works and what needs redirection.” (Consultant (c): 7)
While at times the workstream teams were hampered by a lack of empowerment, this was a necessary sacrifice in order to ensure consistency in the project.

3.3.2.6 Planning for and Creating Short Term Wins

“Real transformation takes time, and a renewal effort risks losing momentum if there are no short-term goals to meet and celebrate.” (Kotter, 1995: 102) The process designed by the consultant includes steps to milestones, and does a good job of dividing the MEP into bite size chunks. That process is particularly powerful when the local workstream has input to both the milestones and the steps to milestones, and can tailor them to the unique needs of each site or group within the site. “Creating short-term wins is different from hoping for short-term wins. The latter is passive, the former is active.” (Kotter, 1995: 102)

Short term wins are particularly important because it is often difficult to see the complete path to a destination from the outset of the journey. “It took Einstein ten years of groping through the fog to get the theory of special relativity, and he was a bright guy.” (Collins, 2001: 114) The MEP was particularly effective in creating short term wins.

3.3.2.7 Consolidating Improvements and Producing Still More Change

‘While celebrating a win is fine, declaring the war won can be catastrophic.’ (Kotter, 1995: 102) In many cases, a change is acknowledged to be complete, and then dies out over time. HVCP is approaching the end of the 44 week MEP, and at this point the structured management of change that is facilitated by the consultant will end. During the MEP, some resources and structure were put in place to accelerate change. At the end of the MEP, it will be important to remind our employees that change will continue, particularly since some of the resources required to meet our long term goals are just coming into place. Section 4 describes some future steps in Mine Maintenance.

3.3.2.8 Institutionalizing New Approaches

“Until new behaviours are rooted in social norms and shared values, they are subject to degradation as soon as the pressure for change is removed.” (Kotter, 1995: 103) Mine Maintenance is better prepared for future change. Even before consultant has left the site, new skills and tools have been used to change things that are outside of the scope of the MEP. In particular, we have used the meeting effectiveness training to improve meetings that are shared with other departments. These meetings now include a Terms of Reference and Action Log. All
maintenance meetings have better structure and better enable us to identify root causes of issues. Meetings have been added that better enable continuous improvement, and the role of reliability is better understood. Most importantly, the resources are in place or will be in place shortly to sustain these new approaches.

### 3.4 Lessons Learned

One of the staples of project management is to review lessons learned. Ideally this is logged throughout the project, but a minimum this should be done at the project’s conclusion. “Those who cannot remember the past are condemned to repeat it” (Santayana, 1905). Commonly, people focus on the things that did not go well, but it is equally as important to remember and repeat successes, as it is to avoid repeating failures. It is also important to be positive and constructive and avoid casting blame. This section of the paper describes lessons that were learned through the implementation that would be useful either for HVC going forward or for another Teck site that is contemplating an MEP.

#### 3.4.1 Ensure the project is adequately resourced by the client

As with all projects, the MEP was begun with a budget of manpower required for both the consultant and the client. The client’s commitment for the Mine Maintenance portion of the project was approximately 2.5 full time equivalent positions, or approximately 10% of its staff employees. This requirement existed at a point when approximately 30% more mining equipment was being maintained than in the prior year and approximately double that of four years prior. Lengthy absences of some key employees and staff retirements during the project exacerbated the project staffing shortage. We were reluctant to hire those additional people because of the potential for a precipitous drop in workload if a mine life extension was not approved. If we had to do it all over again, it would make sense to hire in advance for staff attrition, and perhaps even hire additional resources in preparation for a higher standard of planning and scheduling. Industry standards of planner to trades ratios could have been used to predict the need for those additional staff.

While the focus of the MEP is on establishing process, the success of the project hinges on people. Here are some quotes to back up that statement.

Those who build great companies understand that the ultimate throttle on growth for any great company is not markets, or technology, or competition, or products. It is one thing above all others: the ability to get and keep enough of the right people. (Collins, 2001: 54)
At Teck, we recognize that our ability to achieve our objectives is directly tied to the talents, skills and commitment of our employees. The main focus of our human resources strategy is to recruit and support employee development, to enable people to fulfill the expectations of their jobs and to have employees who are strongly motivated, highly competent and successful. (Teck Website)

If I were running a company today, I would have one priority above all others: to acquire as many of the best people as I could. I'd put off everything else to fill my bus. Because things are going to come back. My flywheel is going to start to turn. And the single biggest constraint on the success of my organization is the ability to get and to hang on to enough of the right people. (Collins, 2001: 51)

The MEP identified the need to hire three additional resources for scheduling and supervision. In addition there were three staff retirements to fill, creating a need to find six new staff employees in a short period. We no longer have the luxury of being able to fill all first level staff positions internally. Filling internally is good for moral, and provides a candidate that has relevant site experience and easily adapts to a new position. “In determining "the right people,” the good-to-great companies placed greater weight on character attributes than on specific educational background, practical skills, specialized knowledge, or work experience.” (Collins, 2001: 51) Filling positions externally can provide a healthy infusion of new competencies and ideas, but requires a longer training and orientation process. Bringing these new employees up to speed is a key objective for 2011, and is a continuation of the MEP.

Recommendations to another site just beginning the process would be to increase staffing in advance of the project, targeting a skill set or attitude over experience, and allow them several months to integrate with the rest of the workforce prior to the MEP. Similar to an engineering consultant, a performance management consultant requires strong owner representation to achieve the desired outcome. Hiring several months in advance of the project start date would ensure that new employees are in place to free up a full time team lead with the experience and influence to be effective. Much effort was expended during the project in finding the right new staff employees, which was equally as important as completing the project goals, but removed capacity from the project.

A higher level of client involvement in the MEP has three benefits. First, client labour is less expensive than that of a consultant. Second, the MEP is a significant learning opportunity for the client. Greater client involvement would result in greater retention of this learning with the client. Finally, increased client involvement improves buy-in to the change. On the other hand, change can be difficult using internal change agents. People can be reluctant to challenge the status quo for fear of jeopardizing their relationship with their peers.
3.4.2 Drive more value from the diagnostic

The diagnostic was focused on demonstrating the need for the MEP. As a result, it focused on convincing a decision maker to proceed with the program rather than on understanding the client and preparing the client for the upcoming program. Further, the information gathered during the diagnostic was not used in the implementation. The diagnostic should have been used as a planning tool to prepare the site for the implementation. For example, the diagnostic might have identified a need for an ERP resource, a need for a scheduling function and tools or basic computer training for supervisors.

3.4.3 Learn From Other Sites

The MEP was an opportunity to share information, successes, best practices and failures between the seven mines carrying out the project concurrently. Much of the Steering Team is common to all seven sites, and the consultants had a weekly conference call between sites. These venues were helpful in passing along information. It was even more useful to provide direct communication between appropriate people at two different sites. This was done effectively at several points during the MEP, but could have been done more often. Learning from other sites can continue following the conclusion of the MEP. Suggestions for the future include:

- Building a list of key contacts for each site
- Sharing Steering Committee presentations between sites
- Interaction through reliability efforts including joint participation in Reliability Centered Maintenance (RCM) and Root Cause Failure Analysis (RCFA) and the annual reliability conference
- Bring Teck team leads and maintenance superintendents together at the conclusion of the program in a forum similar to the annual reliability conference or perhaps at that conference

3.4.4 Focus on Communication

Some basics about the MEP were communicated to the crews early in the program, but that was not followed up through the program other than through their supervisors. The crews observed some frustration on the part of supervisors and noticed a reduction in supervisor availability at times during the program. An effort is being made to communicate results to
employees at the end of the program, starting with supervisors, but it would have been best to communicate that information regularly.

The MEP should have had a communication plan that included an article in the company newsletter, a written communication to staff employees at each milestone, and a one-page update for hourly employees at each milestone. The one-page updates should be discussed with the crew by the supervisor and perhaps with the general foreman and superintendent.

3.4.5 Involvement of Information Technology, Materials Management and Operating Groups

The MEP was focused on the maintenance function. Involvement with other groups was in scope only to the extent that those groups interacted with maintenance. The reality is that IT, materials management and operations are tied very closely with maintenance. Early in the project, a multi-disciplinary task force was very effective in training and communicating. The task force dissolved as the program proceeded and initiatives became more targeted. There was no IT representative on the task force, but there were representatives for the materials management and operations groups. These two individuals continued to play an active role in the MEP. The materials management lead and the maintenance lead also continue to meet weekly and report to a steering team of sorts on progress of materials management issues.

Leads for these complimentary groups should be identified early in the program. Senior personnel from IT, materials management and operations should be included in Milestone and/or Steering Team meetings. The most significant missing resource during the MEP was an IT lead with a strong ERP background and knowledge of maintenance processes and systems. This remains a gap on the site, which is a concern given our expected transition into a new ERP system in the near future.
4: Relevant Further Site and Corporate Initiatives

There are a number of initiatives proposed or underway which are driven either by Teck corporate or at the site level including reliability engineering, human resources and information technology initiatives. To employees busy with their normal duties, these initiatives can appear as a burden and an interruption, particularly when they do not fit well with established systems and processes. The conclusion of the MEP is a good point in time for a high level review of these initiatives.

4.1 Maintenance Functional Audits

Teck corporate will carry out audits of mine sites as a follow up to the MEP. “The audit will review, benchmark and evaluate the policies, practices, processes and key controls that support the Company’s Maintenance function; and, look at opportunities for business simplification and further process improvements where applicable.” (See Appendix A) The audit scope matches the MEP’s scope to a high degree, and such audits are recommended by the consultant.

Follow-up is also key in making sure the changes implemented are sustainable ... Audits will demonstrate the leadership’s continued commitment to the changes and will be helpful for the taskforce to identify new areas for improvement. (Teck, 2010: 13)

One of the stated objectives of the audit is to look for opportunities for business simplification. That goal is often missed in implementations, and should be kept as a focal point for the audit.

The audit makes sense if implemented well, and should be repeated regularly. Audits are typically focused on finding gaps, but since the same audit team will audit multiple sites, the audit team also has the potential to identify sites that are functioning well in a particular area and identify those sites as a resource to other sites which are lagging in that area. The key will be to include qualified, knowledgeable people, who engage the sites in a manner that provides assistance for the maintenance function.
4.2 Reliability Coordination within Teck

Teck is working at coordinating reliability practices and sharing knowledge between sites. This appears to be furthest advanced at the coal sites. There is tremendous value to including HVC in that effort. In the fall of 2010, a group of reliability professionals and maintenance management assembled for the first annual Reliability Conference in Fernie, BC. This is a valuable networking opportunity, and a chance to share successes and best practices with colleagues. Sharing of reliability studies, failure analysis, rationalized or optimized PM’s, and materials management strategies, has the potential to reduce the workload of the reliability teams at each site. A centralized support group for the coal sites is located in Sparwood, and provides the resources to maintain a Sharepoint site. There may be further opportunity to tie relevant information from other industry events such as the Canadian Institute of Mining (CIM) local branch and national events, and the annual Western Mine Maintenance Association (WMMA) meetings.

4.3 Building Strength With People (BSWP)

Building Strength With People is a Human Resources initiative that ties Performance Management, Employee Development, Career Development and Succession Management. The MEP initiative is relevant to the Performance Management portion of BSWP. The MEP provides objective, measurable indicators of performance that can be used to determine whether annual objectives have been met. A balanced set of measures and targets allows a better link between short-term actions and long-term strategy than strictly financial measures. (Kotter, 1995)

4.4 HVC Performance Management Project

An initiative was started in July, 2010 to enable the transformation of performance management practices at HVC. In a nutshell, the HVC Performance Management Project involves collecting the performance metrics that are currently scattered in various software systems and reports and gathers them into a central dashboard. That dashboard will allow managers to drill down for information at low levels in the organization to investigate performance variances.

Phase 1 is focused on setting direction for the project. Phase 2 is focused on implementing the project to go live in the fall of 2011. Phase 3 will be focused on sustaining and enhancing the implementation.
According to the project charter, the Performance Management Framework will not replace the current daily, weekly and monthly reporting system, but is intended to provide a focused and interpretive view of the underlying data to manage performance. However, in the process of developing the dashboard, departments will have the opportunity to review their regular reporting. This is an opportunity to review the information required from corporate in the Functional Audit to make sure it is readily available for the audit team. It is also an opportunity to consolidate new KPI’s required for reliability engineering.

4.5 Upgrade to Enterprise Resource Planning (ERP) System

HVC is considering a replacement of its ERP system, which would include the Computerized Maintenance Management System (CMMS) module. HVC’s existing ERP system is a version of JD Edwards that is approximately 20 years old. From a maintenance perspective, the system’s chief drawbacks are the lack of a work-scheduling module, that it is not user friendly, and that it is moving towards a lack of support due to age of the system. Modern systems allow easier filtering and sorting of information and have enhanced reporting capability. They are also more efficient, which reduces time spent using the system. They allow attachment of files, and importing and exporting to and from other software. The lack of a work scheduling and tracking module is a significant drawback to the existing ERP system. This results in reliance on spreadsheets which results in inefficiencies, data integrity issues, and poor collection of history.
5: Recommendations and Implementation for 2011 & 2012

This chapter is split four sections. The first describes the next progression of what was started in the MEP. The second describes HVC’s reliability program goals and direction for the next two years. The third describes recommendations for implementation of an ERP upgrade. The fourth section presents a timeline for the changes and describes some change management challenges.

5.1 Progression of Maintenance Enhancement Program

The MEP was an accelerated period of change to work management processes, but change is continuous and much of what was introduced in the MEP can be expanded into other areas as new employees are integrated. Much of what was begun in the MEP will build into the fledgling reliability program in Mine Maintenance.

5.1.1 Integrating New Employees

The MEP identified a need for three additional full time resources for scheduling and execution of work. In addition, three vacancies were opened due to retirements. These six positions were all filled late in the MEP or will be filled shortly following the completion of the project. Training these people in their new responsibilities will be a focus in the 2nd quarter of 2011.

5.1.2 Expanding the Program

At the conclusion of the MEP, 62% of Mine Maintenance employees have been directly impacted. These crews are guided by a daily loaded weekly schedule, their performance is monitored using KPI’s, they are beginning to see improvements in job preparation, and they have resources in place for reliability improvements. These areas were targeted because they involve large crews, directly affect the availability of production equipment, and consume high cost repair parts and materials. A further 11% of employees occupy fixed positions. That is to say they perform a similar function each day and there is no requirement to plan or schedule their work. The remaining 27% of employees represent an opportunity for further installation of some or all
of the improvements made in MEP. The figure below illustrates that breakdown, differentiating between areas installed, fixed positions (no opportunity) and areas of further opportunity.

*Figure 15: Breakdown of Employees Impacted by the MEP in Mine Maintenance (Source: Author)*

The table below shows a further breakdown of the areas identified as a future opportunity, and notes whether there are opportunities in Short Interval Management, Materials Management, Reliability and Scheduling.

*Table 5: Summary of Future Opportunities (Source: Author)*
<table>
<thead>
<tr>
<th></th>
<th>No. Employees</th>
<th>Short Interval Management</th>
<th>Materials Management</th>
<th>Reliability Opportunity</th>
<th>Scheduling Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld Shop</td>
<td>24</td>
<td>Yes</td>
<td>Some</td>
<td>Some</td>
<td>Yes</td>
</tr>
<tr>
<td>Light Vehicle</td>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>Some</td>
<td>Yes</td>
</tr>
<tr>
<td>Washbay</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Component Shop</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>Some</td>
<td>Yes</td>
</tr>
<tr>
<td>Tire Shop</td>
<td>6</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Building Mtce</td>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### 5.1.2.1 Weld Shop

Approximately a third of the weld shop’s work is included in the daily and weekly schedules of the major equipment fleets. The rest of the scheduling and the majority of the planning of the weld shop work is handled directly by the weld shop supervisor. The shop would benefit from a more formalized scheduling process. The weld shop supervisor actively and regularly manages his crew during the shift, however, there is some opportunity for greater transparency in expectations between supervisor and crew (Short Interval Management). There is little in the way of parts procurement in the weld shop, but there is potential to improve the planning of materials. Reliability opportunities will be exploited in the process of reviewing opportunities with the major fleets.

### 5.1.2.2 Light Vehicle Shop

Similar to the weld shop supervisor, the light vehicle shop supervisor has regular contact with his crews, but there is opportunity for a more visible communication of daily assignments. Materials Management is a large concern in the Light Vehicle Shop, and opportunities include rationalizing inventory, improvement of parts lists, and better management of bought-in parts. The light vehicle shop has a weekly schedule, with PM’s assigned to each day, but the schedule is not loaded with manpower requirements, nor is it practical to do so. Unlike the major equipment fleets, a predictive or elaborate preventative maintenance program is not justified. There is potential for some basic reliability improvements in the light vehicles shop, beginning with a focus on buying the right equipment for each application, and providing feedback on operation of the equipment. There is also potential to review maintenance intervals and to revise maintenance strategies for specific units with recurring failures.
5.1.2.3 Tire Shop, Component Shop, Building Maintenance & Wash Bay

These areas are each provided with a weekly schedule of work, but not a daily loaded schedule. Further work is identified by their supervisor and managed on a daily basis. More formalized Short Interval Management is required to ensure that priority work is done in a timely manner. A review of PM’s in Building Maintenance would be of value. Wash bay opportunities include standardizing wash procedures and improving equipment and technology.

5.2 Expanding the Reliability Program

This section will describe the key initiatives of HVC’s reliability program and highlight the interaction with the MEP at HVC. “Management should view unscheduled shutdowns as potential failures of the equipment management system rather than just as failures of the equipment...What distinguishes the successful site from the less successful one is the organization that is in place and how it deals with problems when they arise.” (Caterpillar, 2005: 4) The MEP has focused on building closed loop processes for identifying, resolving and verifying solutions to problems. The work management processes established in the MEP will enable reliability processes. For example, effective PMs are the first step to reliable operation of equipment.

An effective reliability program over a number of years is the key to decreasing unscheduled work, yet only about 10% of all companies perform any failure analysis on their breakdowns. (Wireman, 2004: x) Without such a program, we can expect a ‘glass ceiling’ on fleet reliability, availability and levels of unscheduled work. Accordingly, a reliability focus is the logical progression to the work begun in the MEP. The following areas of focus have been identified for the next two years. (THVCP, 2011)

5.2.1 Equipment Criticality

Identifying critical equipment is one of the basic building blocks of the Maintenance Pyramid. This will be further developed into identifying critical components. Each component is ranked with a risk probability number which is the product of the consequence of a failure, the probability of a failure and the probability of detection of a failure. ‘Bad Actors’ (chronic failures) will be identified for critical equipment first, and Reliability Centered Maintenance (RCM) and Root Cause Failure Analysis (RCFA) efforts will be focused on critical equipment and components.
5.2.2 Revision of Reliability KPI’s

HVC has tracked reliability for the last ten years. The metric currently used is a measure of interruptions to the daily schedule, but the metric is not well understood, and not used in a systematic way. Mean Time Between Shutdowns (MTBS) is the average operating time between machine stoppages. It is the single most important measure of equipment maintenance management performance (Caterpillar, 2005: 11). Mean Time To Repair (MTTR) is the average duration of downtime events. (Caterpillar, 2005: 15). These metrics are accepted in industry and easily benchmarked. They are most useful when trended monthly, and used in tandem.

5.2.3 RCM (Reliability Centered Maintenance) & RCFA (Root Cause Failure Analysis)

An RCM is a session that typically lasts several days and is used to develop a complete maintenance strategy for critical equipment, components or systems. A cross-functional team is assembled, which analyzes failure modes of components and develops a complete maintenance strategy. An RCFA is used to determine the root causes of a failure and to develop and implement recommendations to mitigate or prevent the failure in the future. During the MEP, employees were trained to expose the root cause of all events. An RCFA is more formal, and typically involves cross functional teams and spans several days. One RCM and one RCFA are targeted for each quarter over the next two years.

5.2.4 Lubrication Program

Lubricants are the life blood of a machine. Effective management of lubricants will have a significant effect on reliability. It also affects maintenance costs by increasing component life. Over the next two years, there will be a focus on contamination control, with the goal of improving scores on 3rd party lube audits. There will also be a focus on training, and improving procedures and handling.

5.2.5 PM Rationalization

Preventative Maintenance routines are key to equipment reliability. PM Rationalization is a method to improve the efficiency of PM execution in order to increase equipment availability. It involves analyzing existing PM activities to identify redundancies and inefficiencies for elimination, compiling best-practice methods from the personnel most knowledgeable about the work, and ensuring accurate detail on required tasks, parts, and support equipment. The process
of PM rationalization was begun during the MEP, and will be extended to a minimum of eight PM’s in 2011.

5.2.6 **Condition Based Maintenance (CBM)**

CBM is the regular monitoring of equipment in order to identify a developing failure. Examples include oil analysis, vibration analysis, thermography and running checks. Planning and scheduling of work is a major focus of the MEP, but is only possible if the need for the work can be predicted. Scheduling work to happen at a fixed interval rather than condition can result in unplanned failures or the costly early replacement of components. CBM has the potential to dramatically improve the scheduling of work without replacing parts before they are truly worn out.

5.2.7 **5S Program**

5S is a way for work teams to arrange work areas in the best manner to optimize performance, safety and cleanliness. The 5S’s are as follows:

- Sort – Organization – What is needed, what is not
- Simplify – Orderliness – Find a place for everything
- Sweep – Cleanliness – Clean it and keep it clean
- Standardize – Maintain and monitor the first three S’s
- Sustain – Exercise self-discipline – Stick to the rules

Workplace organization affects safety, productivity and morale. These improvements will be a very visible change at all levels in the organization.

5.2.8 **Reliability Management Operating System**

The reliability group has regular meetings with defined agendas and action logs similar to general maintenance group. Maintenance meetings will provide inputs for the reliability meetings, such as identification of Bad Actors and PM’s that need review. The takeaway from the figure below is that there is a structured system of meetings and reporting that will ensure the group stays on course.
5.3 Upgrade to ERP System

HVC is a relatively high-level user of its existing system. A new system will enable a higher level of functionality, but it will take time and resources to achieve that functionality. ‘Many companies have to make big bets because they haven’t sent out sufficient numbers of “search parties.”’ (Beinhocker, 1999: 54) A large number of IT projects fail, most end up behind schedule and over budget, and MIS systems rarely deliver a strategic advantage unless they enable a different and better way of doing business.

Overall, replacement of the system will not provide a significant competitive advantage, and will not radically change maintenance processes at HVC. A modern ERP does have the potential to reduce administrative work in the planning, scheduling and tracking areas, and eventually an upgrade will be required due to system obsolescence. HVC should tread cautiously, leveraging the experience of its sister mines and the knowledge of their IT staff and waiting for them to optimize the installation of their new system.

This paper recommends that a resource be hired for the HVC site or assigned to the site from corporate IT. This person could be an IT professional with ERP experience who could spend several months in the maintenance group learning to understand maintenance. He or she
could also be an engineer currently working in a planning or reliability function in maintenance who has very strong computer skills. In either case, this employee should be thoroughly versed in Teck Coal’s AX system and be thoroughly exposed to HVC’s maintenance groups prior to taking a lead role in implementing the ERP upgrade.

5.4 Implementing the Change

This section will provide a high-level timeline for the 2011 and 2012 plan, and describe some of the change management challenges with the plan.

5.4.1 Timeline

The table below is a proposed timeline for the recommendations described in this chapter.

<table>
<thead>
<tr>
<th>Task</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ERP Replacement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hire and Integrate ERP Resource</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design and Development Implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5S Implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contamination Control upgrades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCFA, RCM, PM Rationalizations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relief Planning and Supervision</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Expanding on the MEP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training new Employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidating Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expansion to Other Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Functional Audits</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Timeline for 2011 and 2012 (Source: Author)

It will take a minimum of 6 months to expose a new ERP resource to existing maintenance systems. An extensive design and development period is recommended prior to installation.
The 5S implementation is the most visible reliability effort, and Contamination Control provides the highest payback. Accordingly, these two areas of focus are recommended as priorities through the end of 2011. Since our reliability professionals are relatively new to the organization, it is recommended that they gain knowledge, acceptance and respect by filling a short-term need for relief planning and supervision in mid 2011. Since our reliability professionals are relatively new in their role, we will need to invest heavily in training and expose them to reliability professionals at other sites.

Training new employees will be a focus in 2011 Q2. Once trained, new employees will further optimize their jobs and both new and existing employees will be ready to take on the challenge of making improvements in the welding shop, gas shop, tire shop, wash bay and component shop starting in the fall of 2012.

The first Functional Audit is currently scheduled for January 2012.

5.4.2 Managing Recommended Change

Many of the changes recommended for 2011 and 2012 are understood because they have been introduced in the MEP. The role of reliability is also increasingly understood, but there is a low level of understanding of the pending ERP upgrade. The table below is a summary of Kotter’s eight change steps, and identifies the challenges that will be faced in this timeframe.
<table>
<thead>
<tr>
<th>Step</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishing a Sense of Urgency</td>
<td>These objectives will be included in objective setting with BSWP. As a result, they will be formally reviewed twice per year. Achievement of objectives in BSWP will form the basis of annual bonus calculations.</td>
</tr>
<tr>
<td>Forming a Powerful Guiding Coalition</td>
<td>All levels of management can see objectives and confirm that they are aligned. Reliability efforts are championed at a high level in the organization. They will be included in annual Functional Audits.</td>
</tr>
<tr>
<td>Creating a Vision</td>
<td>While the reliability vision has been developed, the vision for the progression of the MEP and for the ERP upgrade will need to be focused and communicated.</td>
</tr>
<tr>
<td>Communicating the Vision</td>
<td>Communication of the reliability vision to senior staff is complete. Annual crew presentations are an effective way of broadly disseminating the vision, and in particular, 5S efforts are very visible to all levels.</td>
</tr>
<tr>
<td>Empowering Others to Act on the Vision</td>
<td>The department organizational structure has been modified to provide the reliability team considerable freedom to carry out their goals.</td>
</tr>
<tr>
<td>Planning for and Creating Short Term Wins</td>
<td>The reliability vision has been effectively broken down into measureable and discreet goals. Similarly, the progression of the MEP can be reduced to discreet objectives. The ERP upgrade, however, is a relatively unknown commodity.</td>
</tr>
<tr>
<td>Consolidating Improvements and Producing Still More Change</td>
<td>An effective maintenance and reliability management operating system is the key to having a Plan/Do/Check/Act loop to ensure steady progress towards goals.</td>
</tr>
<tr>
<td>Institutionalizing New Approaches</td>
<td>We are building a culture of high achievement.</td>
</tr>
</tbody>
</table>

*Table 7: Change Management Steps for 2011 & 2012 (Source: Author)*
6: Conclusion

The MEP has produced gains in the planning, scheduling and execution of work. This has been achieved by building process and systems, clarifying roles and responsibilities, and training and hiring to build planning and scheduling capacity. The most significant learnings from the MEP are that initiatives must be adequately resourced, that there is potential to learn from other sites, that communication of vision to all levels in the organization is important, and that success is often dependent on involvement with complementary departments.

In the next two years the focus will be on expanding work management processes begun during the MEP, on reliability engineering and on the implementation of a new ERP system. Our experiences in the MEP have taught us to consider resourcing before starting any new implementation. The reliability team has been adequately staffed and this paper proposes to invest in their development through training, through exposure to other sites and through planning and supervision experience. Resourcing of the ERP installation is identified as a gap in this paper. This paper proposes to fill that gap by hiring a IT resource or a maintenance person with strong IT skills. Regardless, that person should be exposed to maintenance people and systems at HVC and to the ERP installation at Teck Coal prior to beginning the installation at HVC. This paper also proposes metrics to be tracked, audited and shared between sites for reliability (MTBS, MTTR, % Scheduled Downtime), labour productivity (Maintenance Ratio), and equipment maintenance costs (Cost Per Hour, component rebuild cost per hour). These metrics should be common between mine sites and shared between sites running similar fleets.
Appendices
Appendix A – Functional Audit

The document contained in this appendix was issued by Teck Corporate to the mine sites in December, 2010.

Audit & Operational Review and Business Improvement Groups

TECK RESOURCES LIMITED

MAINTENANCE FUNCTIONAL AUDIT

SCOPING DOCUMENT
CONTENTS

1. PROJECT PERSPECTIVE & SCOPE

2. PROJECT APPROACH & INFORMATION REQUIREMENTS
**PROJECT PERSPECTIVE**

This project is a part of the Five Year Audit Plan for 2007 - 2011 approved by the Audit Committee of the Board of Directors and by senior management and is being conducted jointly with the Business Improvement Group.

Maintenance is included in the five year audit plan as it:

- Represents approximately 20% of each site’s operating costs with an annual spend of more **$700 million** (excluding Antamina) or nearly **$4 billion over 5 years**.

- Employs more than **2,500 employees** worldwide.

- Directly impacts the **availability** of production equipment.

Maintenance self assessments completed in 2008 and 2009, and past internal audits, indicated several **areas requiring improvement** and periodic audits to measure performance and identify additional opportunities are an **essential part of the continuous improvement process** and of Teck’s Maintenance and Reliability Initiative.
PROJECT SCOPE

Taking into account the Teck Maintenance and Reliability Initiative that commenced January 2010, the audit will review, benchmark and evaluate the policies, practices, processes and key controls that support the Company’s Maintenance function; and, look at opportunities for business simplification and further process improvements where applicable.

The project scope includes (not exhaustive):

- Maintenance & Reliability Initiative: project status, implementation, achievements, and pending items.
- Organization: roles and responsibilities, training, coaching, and sharing of information.
- Maintenance System(s): performance, support, training, functionality, module integration with other systems, reports and controls.
- Maintenance Planning: maintenance programs (preventive, predictive, emergency, shutdowns, etc.), short-term and long-term planning, scheduling, backlog control, work order process, coordination with Operations and Supply Management departments.
- Maintenance Execution: preventive maintenance compliance, overview of supervision and control of labour and overtime, non-maintenance work (construction, projects, etc.) and safety performance.
- Maintenance Facilities: overview of facilities for maintenance activities, parts and supplies.
- Maintenance Contractors: tendering, selection, contractor management, and contract administration and compliance.

The project will commence with a request for information (see next page) and the timing of site visits will be agreed with the operations.

The project will start in April 2011 with target completion by the second quarter of 2012.

The project will be led by Graham Harris and Shehzad Bharmal. The Team Lead will be Richard Au supported by Audit & OR members and potential seconded staff. Liaison with stakeholder departments will be sought.
PROJECT INFORMATION REQUIREMENTS

To commence the project, soft copies (where possible) of the following information requirements are requested from the respective operations.

i. Organization chart for Maintenance Departments (mine, plant, other, etc.)

ii. Latest month-end Maintenance report(s) including backlog reports

iii. Key Performance Indicators (3 year trend, if available)

iv. Equipment list or basic fleet information

v. Annual maintenance costs by department (mine, plant, etc.) and by type (labour, parts, contractors, etc.) for the last 3 years

vi. Maintenance & Reliability Steering Committee presentation and agreed actions, by site

vii. Most recent Improvement (“MPI”) Action Log

viii. Progress log for addressing identified “Bad Actors”

ix. List of maintenance contractors with greater than $1 million annual spend

x. List of reliability or maintenance engineering projects

xi. Maintenance & Reliability Initiative team organization chart

xii. Initiative reports and updates to Business Unit heads
Appendix B - Maintenance Mission and Vision

<table>
<thead>
<tr>
<th>Teck</th>
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<tbody>
<tr>
<td>Doing the Right Thing – Every Time.</td>
</tr>
<tr>
<td>▪ We will lead our industry in having the right equipment available, at the right time, and at the right cost.</td>
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</tbody>
</table>

The key areas of focus in “Doing the Right Thing - Every Time” include:

▪ Maintenance and Operations taking joint responsibility for equipment and working together to get things done
▪ Using best practices in the core maintenance functions with a focus on planning and scheduling identified work
▪ Applying Reliability tools and techniques using proven systems such as Reliability Centered Maintenance (RCM), Root Cause Failure Analysis (RCFA), Condition Based Maintenance (CBM) as well as setting critical standards for maintenance and operations
▪ Sharing knowledge and learn from others to drive improvement including using knowledge and resources from outside the mining industry

“The equipment arrives when it should. It is clean. We are not looking for parts. We return it to Operations when we said we would.”

– Jeff Etue, Reliability Engineer, Elkview Operations

Benefits of “Doing The Right Thing - Every Time”

These practices have proven successful for other organizations. Companies which use Reliability Tools and Techniques and where Teamwork, Communication, and Core Maintenance Functions are working well, report the following benefits:

▪ Stress goes down
▪ Productivity goes up
▪ People have higher job satisfaction
▪ Systems function better
▪ Equipment availability and reliability is improved
▪ The Operation runs smoother and safer
Sources of Maintenance Inefficiencies and Frustrations:

- Parts not available or incorrect; difficulty finding the right parts
- Unanticipated work steps and skill requirements
- Support requirements not coordinated
- Unanticipated safety concerns
- Equipment not available / turned away by operations
- Equipment not prepared and work permits not available
- Required tools not available; required manpower not available
- Poor work coordination between trades
- Job stops and starts due to emergencies and break-ins
- Poor coordination with other site activities

| Planned and scheduled work is safer, more efficient, and more effective. Re-aligning maintenance resources and activities to focus on these activities will greatly improve maintenance effectiveness. |

Critical First Steps to Improving Maintenance Execution:

- Dedicate resources to work planning and preparation
- Set clear standards for work preparation and only schedule work that is prepared accordingly
- Prioritize work to ensure non-emergency work can be prepared and coordinated prior to execution
- Dedicate resources to develop integrated maintenance schedules with operations and other site functions
- Measure schedule attainment and include operations in reviewing and addressing causes of variability and break-ins
- Identify and address “bad actor” equipment driving emergency/break-in work
- Identify critical equipment to aid in work prioritization and focus reliability efforts
- Assign and dedicate reliability resources to optimize predictive and preventative maintenance routines
Appendix C – Key Performance Indicator Trends

PM Schedule Attainment – The weekly percentage of scheduled Preventive Maintenance hours that were completed.

Field Mechanical PM Schedule Attainment

Haul Trucks & Support Equipment PM Attainment

Mine Electrical PM Schedule Attainment
Schedule Loading – The weekly percentage of the available resource hours (manpower) that were scheduled.
Schedule Attainment – The percentage of the weekly scheduled work that was completed in the week.
Unscheduled Work – The percentage of total hours worked that was spent on unscheduled work in the week.

Field Mechanical & Welding Schedule Attainment and Unscheduled Work

HD Shop Schedule Attainment and Unscheduled Work

Mine Electrical Schedule Attainment and Unscheduled Work
Reference List


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