AN IMPROVED IMPLEMENTATION STRATEGY FOR THE TECK MAINTENANCE PROGRAM

by

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Abstract

Open pit mining is simply about large machinery moving large amounts of material. The optimal operation and maintenance of these machines is critical to business success. In 2010, Teck operations initiated a journey to develop and implement a "World Class" maintenance program across Teck.

Five years into the journey, I examine the effectiveness of the implementation of the program on the mining fleets in the coal business unit. I use a series of academic tools to evaluate the successes and shortfalls in achieving the original objectives of the program in the time expected. I then recommend a renewed vision and implementation strategy defined in a focused activity map. The new target value is smaller than the original program but more clearly defined.

Keywords: asset management; maintenance management; mine maintenance; reliability; change management; haul truck; equipment performance; equipment availability; equipment cost; reactive maintenance; maintenance culture

Executive Summary

Teck Resources Ltd. has been working to implement a well-defined "World Class" maintenance program across all mine sites for a period of five years. The targeted value of the original program was \$100 to \$200 million annually across Teck in reduced costs and increased revenue. In this paper, I evaluate the effectiveness of the implementation of the program to the mining equipment across Teck's six coalmines with the objective of recommending improvements to the implementation strategy. I use tools from the Teck Executive MBA program including blue ocean strategy, cause and effect mapping, cost analysis, evaluation of culture and assets, activity mapping, and finally, an evaluation of the implementation effort to date. The 2014 maintenance cost for mining in coal is \$470 M. A partial estimate of savings from the program to date is in reduced annual maintenance costs of \$14.2 M and reduced capital costs to date of \$32.4 M.

The primary recommendation for a renewed implementation strategy is to depart from the original objective of a whole scale application of new processes to all maintenance work with the resultant cultural change, to a targeted application of specific activities to specific fleets to achieve the greatest returns in the shortest period. This renewed strategy is achievable through site and business unit leadership without external consulting costs. The establishment of these core islands of new processes and culture is expected to expand by example throughout maintenance to achieve the original goal.

The maintenance initiative adds shareholder value through reduced operating costs, reduced capital spend, increased equipment capacity, and reduced business risk. In the current market downturn, the renewed implementation strategy achieves reductions in costs of \$30 M, reductions in capital of \$13 M, improved equipment availability of 3% and reduced business risk. There is longer-term potential to reduce maintenance costs by an additional 30%. The new vision is described in terms of five best practices:

- <u>High value field inspections prior to performing major preventative maintenance (Pre-P.M.s)</u> that effectively identify work requirements for planning, scheduling, and efficient execution of pro-active maintenance.

- Rapid turnaround on P.M.s, P.M. repairs, and component changes for primary production fleets.
- Effective Work Control Teams – Operations, engineering, and maintenance effectively manage the overall effort to reduce reactive maintenance work and assure effective development and execution of pro-active work.
- Effective Supervision achieves timely and quality completion of the work schedule by providing active leadership in setting expectations and removing barriers for a skilled and motivated team. It requires manageable supervisor to trades ratios.
- Effective central (Sparwood) and site work reduction teams- The effective application of data based decisions to minimize reactive work by extending component life, optimizing P.M.s, improving maintenance and operating practices, and engaging vendors to drive engineered equipment improvements.

In addition to the five best practices, there are the additional core activities of Operator Driven Reliability, Standardization of Haul Truck Fleets, and Equipment Criticality Assessments that are required to move towards the greater longer-term benefits.

Transforming organizational cultural change is a long-term journey that typically takes 5 to 10 years (Kotter 1995). This paper provides an analysis of the journey to date with an achievable vision for the path forward.

Dedication

This paper is dedicated to the pioneers of pro-active maintenance within Teck. The individuals with the passion and vision to see what the future can be.

Acknowledgements

I acknowledge and thank each of the instructors involved in the Teck EMBA program for their demonstration of passion for their respective subjects and the integration of academic excellence with business application. I especially recognize Ian McCarthy as a personal inspiration.

I acknowledge and thank the multitude of Teck employees who contributed to the content of this paper through "talks on the floor", formal engagements, and analyses.   The contributors include every walk of work from wash pad attendants to senior executives, from every site and the Sparwood office. I personally recognize the contribution of Justin Cvetko Lueger, the Teck Coal Reliability Lead for his keen sense of observation and practical insight into implementing complex processes.

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Glossary

Five Why's	A simple methodology of applying the question "why?" five times to the analysis of a problem to quickly identify a root cause. Typically identifies breakdowns in work processes.
Planning	The identification of resources required to complete the work including parts, labour, tools, facilities and job standards.
Pre- P.M.	Field inspections of mobile equipment prior to performing major preventative maintenance to identify corrective maintenance work for planning, scheduling, and effective execution as part of scheduled P.M. work.
P.M.	Preventative Maintenance – scheduled inspections and servicing completed as part of a fleet's maintenance program.
P.M.O	Preventative Maintenance Optimization – a facilitated cross-functional team exercise of maintainers and operators to review existing P.M.s to remove non-value adding work and add or improve pro-active work
R.T.A.	Rapid Turnaround- Application of a three day facilitated exercise involving workers and observers completing a scheduled routine maintenance task. The first day, the activity is tracked. The second day, the observations are analysed to develop an improved sequence of activities. The third day, the new sequence is validated by repeating the activity with the new processes. The result is a reduction in task duration and man-hours.
Scheduling	The coordination of equipment, labour, tools, and materials at a point in time to effectively and efficiently complete the work.
Work Control	The management and supervisory functions to control maintenance and related operating activities. Assures effective planning, scheduling, execution, management of break in work, and work reduction (reliability).
Work Control Team	Employees who attend daily meetings with representation from operations, maintenance, and mine engineering to manage the objectives of work control.
Work Reduction	The reliability effort and cumulative result of data based decisions, root cause analysis, component management strategies and improved operating and maintenance practices. The result is a reduction in work with failures that no longer happen and extensions to component and asset life.
World Class Maintenance Program	A business's asset management program that is in the upper quartile for work processes and results when benchmarked against similar businesses.

Introduction

Teck Resources Ltd. is Canada's largest diversified resource company, committed to responsible mining and mineral development producing materials essential to the quality of life of people around the world – copper, steelmaking coal, zinc, and energy.

Headquartered in Vancouver, Canada, Teck owns, or has an interest in, 13 mines in Canada, the United States, Chile and Peru. Teck also operates a large metallurgical complex, is a partner in a wind power facility, and is a significant producer of specialty metals such as germanium and indium. Teck is actively exploring for copper, zinc and gold in the Americas, Asia Pacific, Europe and Africa.

Teck has been working to implement a well-defined "World Class" maintenance program across all sites for a period of five years. The targeted value of the original program was $100 to $200 million annually across Teck in reduced costs and increased revenue. In this paper, I examine the effectiveness of this implementation for mining equipment across Teck's six coalmines. The motivation is to understand causes for the program implementation being slower than planned and make recommendations to rejuvenate and fast track key value added components. The structure of my thesis will be as follows.

In Chapter 1, I introduce the reader to what a "World Class" maintenance program can accomplish. I will introduce companies with successful programs. I will paint a picture of the culture involved in making these companies successful. I will highlight some challenges with applying a program to mobile equipment compared to fixed plant equipment where best practices have been the most established. I will show by data and examples where Teck Coal is on the journey from current state to a "World Class" program. The key objective of this chapter is for the reader to understand that implementation of the new maintenance program is a journey with significant cultural change. It also identifies challenges that have affected progress to date. The outcome of this paper must be an improved strategy that recognizes where we are and progresses this journey.

In Chapter 2, I apply blue ocean strategy (Kim & Mauborgne 2005) to identify the key deliverables of a maintenance program to a publically traded company. The objective is to answer the question "What does a shareholder (corporation) look for in a company's maintenance program?" I will compare Teck's current state to a competitor and the intended future state. The comparison will be relative, and will establish reduced cost, improved equipment performance, reduced capital expense, and reduced business risk, as the four primary objectives forming the foundation of this paper.

In Chapter 3, I apply cause and effect mapping to pull the key activities from the maintenance manual that have the most direct influence on achieving the four primary deliverables identified in the blue ocean exercise. The objective is to identify the activities that are measurable and achieve bottom line results.

In Chapter 4, I complete a detailed work order cost analysis across the six sites to identify the size of spend in the different activities and fleets and the potential for improvement. The size of potential improvement is estimated by considering the maturity of new processes on specific fleets and the results achieved to date on comparable fleets or sites. The exercise also identifies the leading metrics required to drive results in each of the activities. The objective of this chapter is to define a more detailed activity based business case with measureable results to replace the general case previously used.

Chapter 5 is a summary of a brain storming exercise to identify the significant differentiators of Teck from competitors. The exercise identifies Teck's advantages and disadvantages. The objective is to identify the assets, resources, policies, culture, and processes that would significantly influence the outcome of any major change management initiative in maintenance. These items will be included in developing a more complete activity map in chapter 6.

In Chapter 6, I create an activity map linking the value proposition to Teck's assets, capabilities, and values. This map's objective is to highlight the critical activities that will become the focus of a new implementation plan for effective implementation.

In Chapter 7, I evaluate the change effort to date and recommend changes to the implementation plan considering the eight common causes of failed initiatives identified by John Kotter in "Leading Change – Why Transformation Efforts Fail" (Kotter 2007). The primary change in the strategy will be moving from a broad application of new processes to all maintenance work, to a targeted application on specific fleets. The expected dollar value outcome will be less than the original objective with a smaller scope that is more effective in achieving results in a shorter period. It is expected that as the new processes become sustainable in these key applications, the resultant cultural change will expand by example to all aspects of the business.

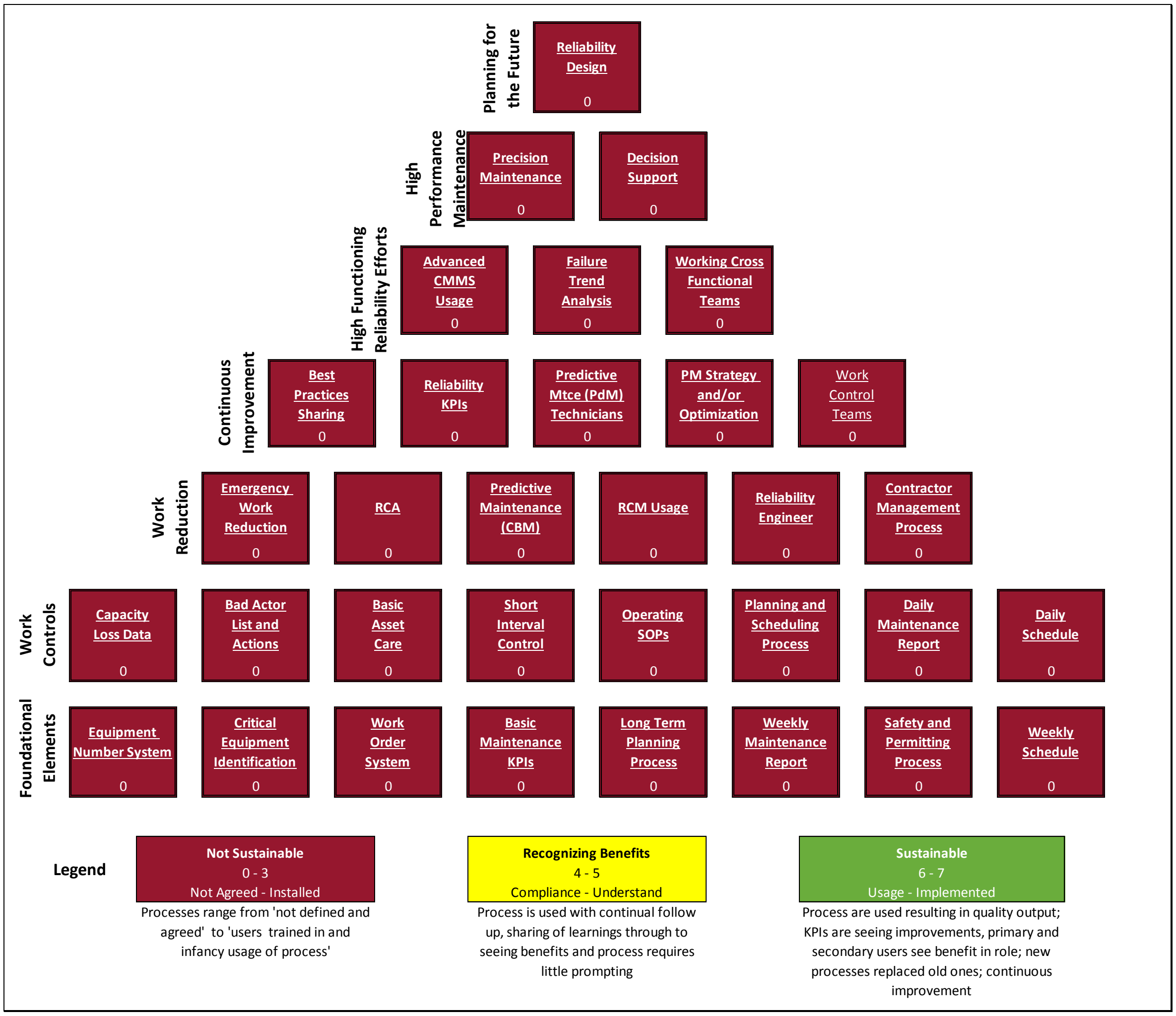
1: The Journey to Improved Asset Maintenance

As outlined in the Introduction, the objective of this chapter is to introduce the reader to what a "World Class" maintenance program involves and where Teck is in relation to the journey from current state to future state. The chapter also identifies challenges or barriers for consideration in an improved implementation strategy.

1.1 Industry Current State

For several decades, the practice of maintenance management has been transitioning from a reactive or necessary expense process to a pro-active process that creates additional equipment production hours at lower cost and risk. A typical "World-Class" maintenance program is a matrix of related activities that can achieve annual maintenance costs of 2.5% of total asset replacement value with high availability and asset utilization. The following "Pyramid" is the Teck representation of a world-class program.

Figure 1.1 Teck Maintenance Pyramid – matrix defining the maintenance program



Source: Teck 2013 Reliability and Maintenance Manual, May 2013. Unpublished
http://groupapps.teck.com/sites/ReliabilityandMaintenance/

The Teck pyramid representation of best practice in Fig 1.1 was developed over a period of several years and it is the accumulated knowledge of internal subject matter experts, engagements with different consultants and other companies, presentations from maintenance conferences, and publications. A partial list of key references is in the reference section and the reader will recognize many aspects that are common in maintenance literature.

The pyramid activities are the responsibility of a multitude of positions with "success" being achieved when the organization reaches a critical mass or "tipping point" in process and culture changes that result in a step change in organizational results. This "tipping point" is achieved when a critical mass of employees adopt "reliability" thinking or decision-making. There is a long list of companies with early failures in changing employee behaviour and results. The cultural change is significant.

Dofasco, Alumux, and Scottish Power are examples of successful organizations that have appeared in many maintenance publications and conference presentations. According to the executive overview by Ivara and Amorgroup, the following results were achieved at a ScottishPower coal fired plant:

> "In only two years, ScottishPower successfully established the asset management and process safety framework that has led to improved plant reliability. As a result, they have improved performance and transparency of key processes, as well as experienced fewer unplanned outages and breakdowns with significant cost savings:
>
> - 20% reduction in operations and maintenance costs
> - 22% increase in plant availability
> - 25% reduction in plant forced outage rates
> - 10% reduction in insurance premiums
>
> As a high reliability organization, ScottishPower now produces its product consistently over long and sustained periods of time. The proactive culture established is one that has a chronic sense of unease and lacks any sense of complacency. Employees act strongly to weak signals and set their threshold for intervening very low, given the understanding of the condition of their assets.
>
> Senior management has visibility of core operational processes. This has increased confidence and assurance from Board to plant level. The result has been improved cooperation between leadership, workforce, and regulatory bodies and the drive to deliver a 'high reliability organization'."

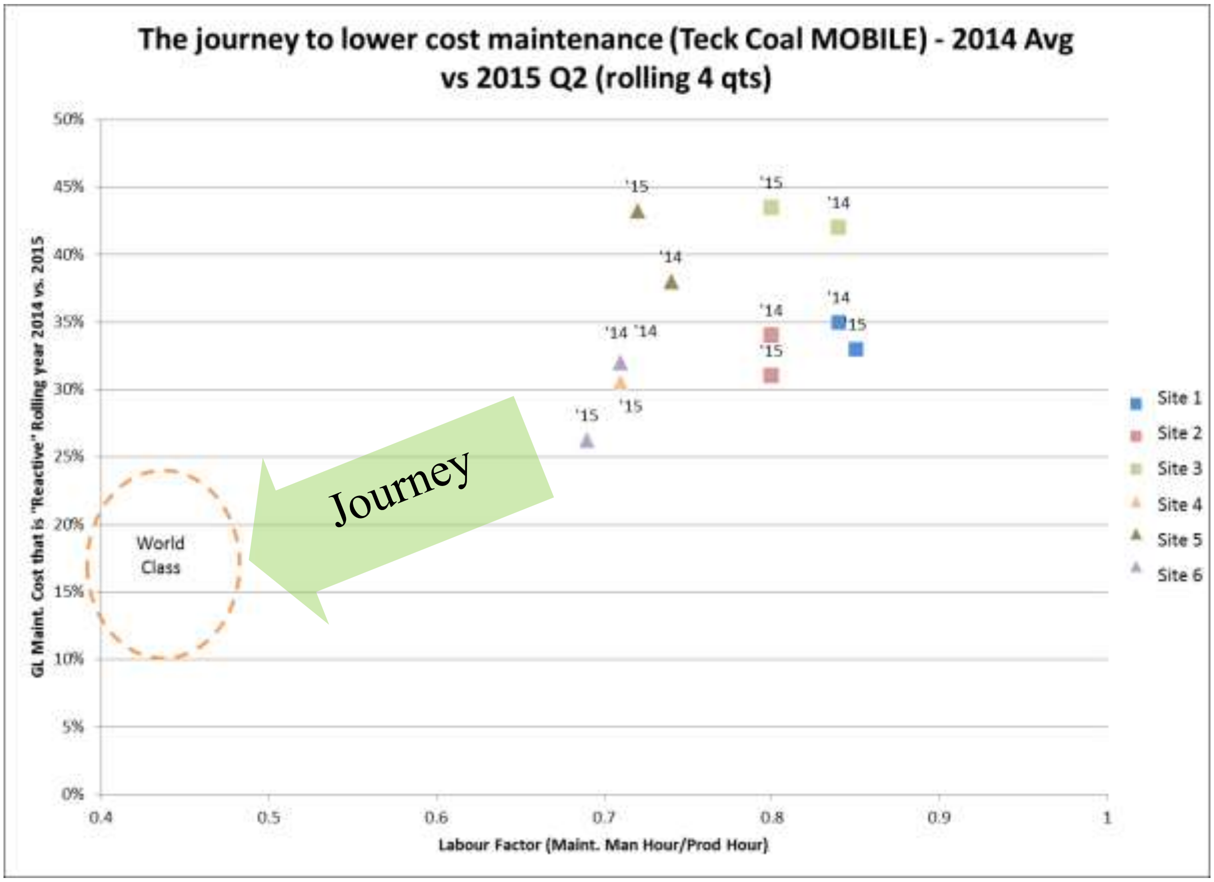
In a reactive culture, everyone readily responds to the consequence of a failure. A significant difference in a pro-active culture is that employees have a heightened sense of unease and awareness of leading indicators of equipment problems that initiates an early response so that the failure event never occurs. These behavioural characteristics also contribute to improved safety records.

Barrick Gold and Rio Tinto are the primary mining peers that Teck compares with. Barrick is at a similar place in their journey and Rio Tinto is several years ahead with their Kennecott Copper mine being their best example of success. The acceptance of new processes and results vary across individual mine sites in all three mining corporations.

Pro-active maintenance practices in literature have historically developed in fixed equipment applications and are relatively new to the mobile mining environment. Mobile mining equipment is complex in that a single engine can have more moving parts and failure modes than a small plant, and monitoring and predictive maintenance technologies are limited compared to a fixed machine such as a paper machine. Mobile equipment also varies significantly from electric shovels to haul trucks to dozers and a variety of auxiliary equipment down to small forklifts, each of which requires a similar but unique maintenance program. Even within standard fleets there can be significant differences related to model years, modifications, or different engines. Upgrades are difficult in that a product improvement on 930E haul truck fleets at Teck requires replication on 114 individual trucks. Although the technical sophistication of mobile equipment makes site improvements more difficult than fixed equipment, there is a higher level of support from the Original Equipment Manufacturer (OEM) for product improvements that can be leveraged through OEM competition for new equipment sales and OEM hunger for credible site data. Maintenance personnel interactions with a haul truck are often limited to one scheduled event every 2 months or when the truck is dysfunctional. Haul truck operators are typically entry-level positions with the highest site employee turnover. Mining typically has a culture that operators operate, and maintainers fix, mostly independent of one another. The understanding of operator driven reliability and maintenance programs intended to keep equipment operating is limited. Although management and workers generally accept the benefits of a pro-active maintenance program, it is difficult to develop credible bottom line value models.

The following diagram compares the current Teck Coal position with that of the best performing site of a competitor.

Figure 1.2 Showing comparison of maintenance performance of Teck Coal Sites to a competitor from quarterly site maintenance review meetings



Source: Teck Coal 2015 2nd Quarter Maintenance Report

In Figure 1.2, the % reactive cost is estimated from work order information and includes all site mine maintenance costs. The maintenance man-hours per production hour are determined by the total active hourly labour man-hours of the maintenance department including all trades, laborers, servicemen, and support staff divided by the total production hours of equipment tracked in the dispatch system. The values are a rolling 12 month average to smooth noise from month to month variances. The legend of the numbered sites portray the spread of the individual mine sites. The definition of world class is a best estimate from external observations of a competitor's fleet size, equipment utilization, and crew sizes. The competitor is a major North American mine with similar equipment. The % reactive maintenance costs and the total hourly maintenance man-hours per production hour are used as a high level comparison of maintenance performance between sites and a competitor. There has been positive progression at Teck sites since 2012 but a significant gap compared to the competitor. Note that performance metrics are better at the smaller sites suggesting that the larger sites have not adequately adapted organizational practices as they have expanded.

The mining industry generally lacks good examples of success that have been the catalysts for organizational change in other industries. Mobile mining also has the additional complexities referred to in section 1.1. Teck is entering a relatively new frontier.

1.2 Teck Current State

In 2009 - 2011 Teck contracted a consulting firm and initiated engagements at nine sites with the objective of fundamentally changing “how we do maintenance”. The consulting effort was successful in engaging individuals at sites to recognize that there were improved alternatives for maintenance. Awareness was achieved in the application of management control reporting systems, but too many metrics were attempted and the planning and scheduling processes were inadequately defined and implemented. The consultant lacked an understanding of best practice in planning and scheduling and reliability methodologies. At that point an external audit of processes identified that ratios of planners, schedulers, and supervisors, were inadequate compared to world best practice, planning and scheduling processes were not well defined, and management work control was inadequate. An improved program was developed with detailed work processes, job roles, facilitation guides, and an overarching policy booklet. This was implemented in part at all sites with the most effectiveness at the smaller operations of Coal Mountain and the Green Hills plant. A proposal to engage a more knowledgeable consulting firm for a Phase 2 engagement at all sites was developed but not acted on due to financial constraints and a poorly defined value proposition. As an alternative, VPs and GMs approved a document of 66 minimal corporate requirements in June of 2013 to facilitate an internal effort. Gap analyses and one-year implementation plans were developed at sites but implementation met with limited success. The complexity of the pyramid, requirements document, and manual, and the lack of a definitive value proposition contributed to the limited success.

1.3 Current Gap Analysis

Best industry practice typically states a target of 80% planned and scheduled work and an annual maintenance expenditure of 2.5% of Replacement Asset Value. These targets were developed in fixed equipment industries. Teck Coal mobile equipment is presently at 35% reactive work across six sites with annual maintenance spends of 10% to 20% RAV by fleet type for mobile equipment. “Best Practice” of these metrics for mobile equipment has yet to be established by industry.

Important for understanding this paper, planning is the identification of resources required to complete the work, and scheduling is the coordination of resources at a point in time to effectively and efficiently execute the work. Data from engine change outs on haul trucks across several sites indicate that an unscheduled failure takes three times longer in duration and two times the man-hours than a planned and scheduled change out. It is recognized that complex equipment has multiple failure modes of which many are random, therefore not all jobs can be scheduled prior to failure using the best available condition monitoring methods.

Teck is transitioning from a group of independent mines with a measure of success related to the personal abilities of our employees to a mid- sized mining company with common processes across sites. Teck sites have been successful in implementing new processes such as the "No Idle" policy for reducing greenhouse gases and fuel consumption when the objective can be easily defined and implemented. Porter represents well our current corporate development status as "Over the past decade, managers have been under increasing pressure to deliver tangible, measurable performance improvements." (Porter 1996) There is ongoing pressure for managers to complete multiple new initiatives, many of which are not production requirements, but "License to Operate" requirements of local stakeholders.

1.4 Summary of Teck's Maintenance Journey

It is a challenging cultural change in management thinking to transition from reactive decision making to the multitude of smaller pro-active decisions required for a successful pro-active maintenance program. Teck Coal is still new in this journey. Efforts to date to engage line management in leading change has been at different times either too general, or too complex to be effective. The application of "World Class" asset management is relatively new to mobile mining equipment fleets and will require adjustments to targets and some work processes. An improved strategy must consider the transitory state of our organization.

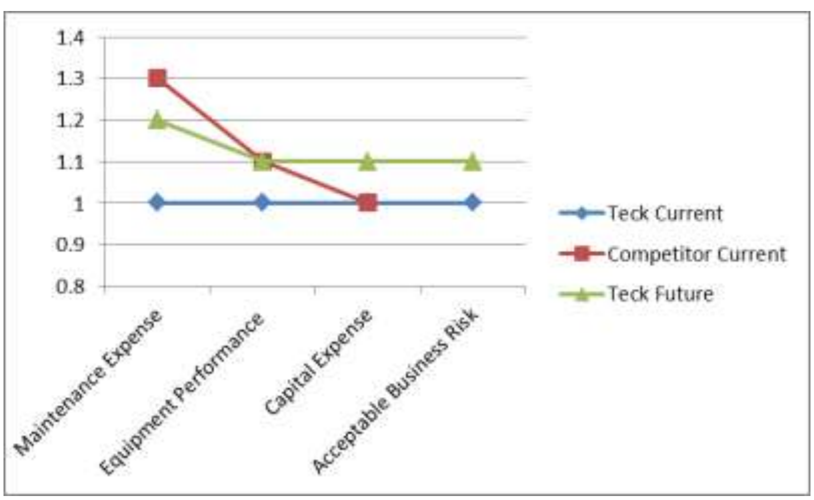
2: Blue Ocean Analysis

In this chapter, I apply blue ocean analysis (Kim & Mauborgne 2005) to identify the high-level key deliverables of a maintenance program to a publically traded company. The objective is to answer the question "What does a shareholder look for in a company's maintenance program?" The blue ocean objective to identify ways to simultaneously lower cost while increasing value will provide guidance to identifying the key shareholder values. I will compare Teck's current state to a competitor and the intended future state. The blue ocean analysis is normally applied from a consumer's perspective but here it finds value in application from a shareholder's perspective at a high level.

2.1 Value Proposition

Open pit mining is simply about large machinery moving large amounts of material. The business output is totally dependent on machines, making the performance of these assets critical to the business's success. The strategy canvas is shown as:

Figure 2.1 Blue Ocean Strategy Canvas



Source: Developed by author

The competitor current is a large North American open pit mining operation with similar equipment to Teck Coal. Their relative position was pieced together from publically available information and Teck employee observations. An index of 1.0 defines Teck current to create a relative scale. Values over 1.0 indicate a positive relative improvement. The competitor and Teck future are estimated using judgement of relative differences in application. The factors of competition on the bottom axis portray what a shareholder might consider when choosing investment in one of the companies.

The strategy canvas is both a diagnostic and action tool. A personal review of the multitude of maintenance activities in the program through the eyes of a shareholder looking for higher returns on investment in the mining sector reveals value in a strategy that simultaneously reduces costs and capital while improving equipment performance and reducing risk. The application of the blue ocean, four actions framework of: eliminate / reduce / raise / and create, reveals that "raising" value of the first three factors of competition of the factors would be an advantage and the "creation" of reduced risk as the 4th factor in a manner visible to shareholders would be a good strategy. The "reduce" strategy is notably absent in the graph but could represent high cost and high-risk initiatives such as unproven technologies that may not improve performance while reducing costs.

2.1.1 Maintenance Expense

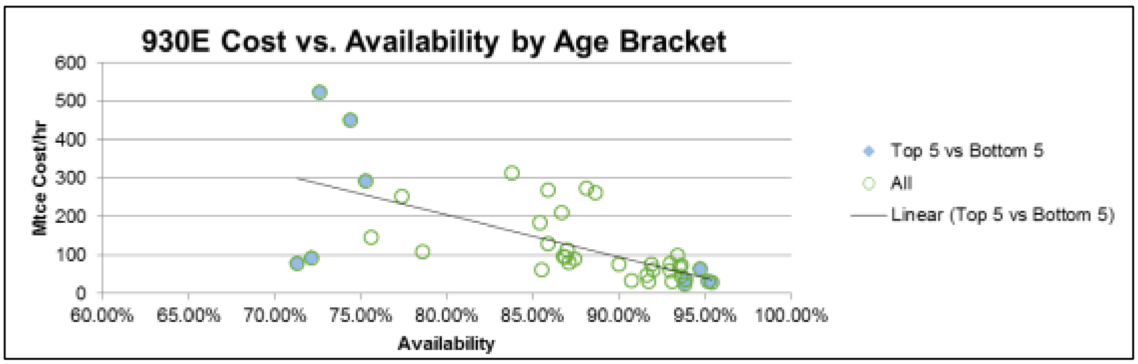
Numeric comparisons are not available for the competitor so an estimate of maintenance man-hours to production hours is used. The estimate is formed by considering fleet sizes and maintenance crew sizes. Total maintenance costs are proportional to the amount of labour hours and the equipment hours making this metric a good measure of relative total costs. This metric has been used by Teck Coal for several years and proven as a good measure for comparison between different sizes of sites and measuring performance improvements. With some adjustment for fleet ages and mining conditions, the competitor is estimated at 0.45 compared to 0.70 for our best site indicating significant room for improvement. This suggests a potential reduction in maintenance costs in excess of 30%. The relative change estimated for Teck Coal's future state identifies a sizeable potential reduction in cost. The equivalent competitor cost is not considered achievable due to differences in mining geology but is an indicator of the potential for a sizable improvement.

2.1.2 Equipment Performance

Industry practice is to measure "Availability" and "Mean Time Between Downs MTBD (or Failures MTBF)" for evaluating maintenance performance. It is assumed that the implementation of the Teck Program will achieve equivalent Availability and MTBD metrics as the competitor for equipment age.

It is noted there is a mathematical relationship between higher availability and reduced maintenance costs and many of the drivers for improvement are identical. Many people believe that money needs to be spent to increase availability but reality is that an improvement to availability through reliability efforts reduces costs. If the equipment is in the shop, it is costing money. If it is maintained in a pro-active manner to increase production hours, it is reducing costs. This relationship can be demonstrated mathematically from actual data as shown in Figure 2.2 below.

Figure 2.2 Relationship between equipment costs and availability



Source: Internal presentation to site Operating Excellence groups by Sparwood reliability team Sept 23, 2014

The analysis demonstrates from historical data for 930E haul trucks across Teck coal that improved availability through reliability practices have a lower cost per hour due to work reduction and improved efficiencies that can be mathematically determined. For the 930E trucks this is a $10/hour savings in maintenance costs for every 1 percentage point improvement in availability. This effectively breaks the value – cost trade-off management thought barrier--by demonstrating from real data that improved availability aligns with lower costs if the effort to improve is driven by reliability tools. This relationship is also supported intuitively if it is considered that the prevention of an engine failure or extension in average engine life, both reduces maintenance cost and increases availability. Trucks down in the shop are costing maintenance dollars. It also validates that measuring reliability improvements by availability is an indicator of reduced costs.

2.1.3 Reduced Capital

The competitor has better availabilities and MTBD but lower use of availability of the loading units and a newer truck fleet. It is assumed that the implementation of the Teck program will maintain our higher use and achieve equivalent availability and MTBD metrics to the competitor for equipment age achieving higher shareholder value. Current Teck practice is to maximize the use of primary assets as the lowest cost alternative for operations and capital. It is recommended that this be studied in detail in the future for there are examples on secondary fleets in Coal where excess equipment availability has been utilized to reduce operating costs. There is also additional saving if the least expensive, most productive fleet runs more hours reducing operating time on higher cost secondary fleets or units. There is also value in reduced capital expense, if availability and annual production hours are increased delaying the purchase of replacement equipment. Current practice is that additional production has been the justification for new equipment at Teck as increased maintenance cost in itself does not typically provide an economic justification.

2.1.4 Acceptable Business Risk

An improved asset management or maintenance program can reduce the business risks of major and minor incidents involving environmental disasters, safety losses, and disruption to business. The Teck maintenance program aligns with the PAS 55 program and ISO 55000 standards which were developed by maintenance professionals to reduce the risk of factors that contributed to disasters such as Deep Water Horizon, Piper Alpha, BP Texas City, and Kleen Energy Middletown. Each of these events in the last decade involved multiple fatalities, environmental disasters, and major business disruptions with significant effects on the corporation's public perception and share value. Although industry consulting firms were hoping for legislature similar to SOX to legislate corporate adoption of a standard asset management program, this has not materialized. If it is determined that shareholders become knowledgeable and begin to value the ISO 55000 Standard, Teck can evaluate if certification would increase shareholder interest.

Avoidance of risk value is difficult to quantify. In the previous example from “Scottish Power Strategy for Asset Management and Process Safety” they were able to quantify the reduced risk as a 10% reduction in insurance premiums. The mining industry has relatively less risk than the examples given in the energy and chemical industries. Tailings dam, high wall, and dump failures are possibly the most significant industry risks and Teck has well developed risk mitigation strategies in these areas. At the levels of risk mitigated through the implementation of an improved maintenance program Teck is mostly self-insured so little benefit can be captured in reduced premiums. Teck’s risk consultant and insurance underwriter provide risk reduction strategies in the form of maintenance audits for critical items of production equipment. Improvements in the maintenance program has received positive recognition from external auditors for insurance and ISO quality but has not resulted in reduced premiums to my knowledge.

There is also a value to reducing risk of primary shovels going down for unscheduled maintenance which reducing the cost of delays for the trucks on that loading cycle. The building of a credible estimate of value for reduced business risk is complex and will not be attempted in the detail of this paper,

2.2 Summary of Blue Ocean Analysis

The application of blue ocean analysis from a shareholders’ perspective did not meet the highest objectives of creating uncontested market space, making the competition irrelevant, or capturing new demand. It does however, identify four levers that can align the firm’s activities and break the value – cost trade off. These four areas are reduced maintenance cost, improved equipment performance, reduced capital spends, and reduced risk. These will be used in the subsequent evaluation of the program to identify and reinforce the activities that contribute to this value. The exercise identifies that high cost initiatives to improve performance should be avoided.

This strategy could be attractive to investors for what blue ocean describes as first tier “soon to be” non-customers who are on the edge of the market waiting to jump ship, and second tier “refusing” non-customers who consciously choose against the market. Low cost, high performance and certification with ISO 55000 would align with Teck’s high profile strategy of sustainability and public responsibility to attract more conservative investors by showing reduced risk in a mining sector known for high returns in the market up cycle.

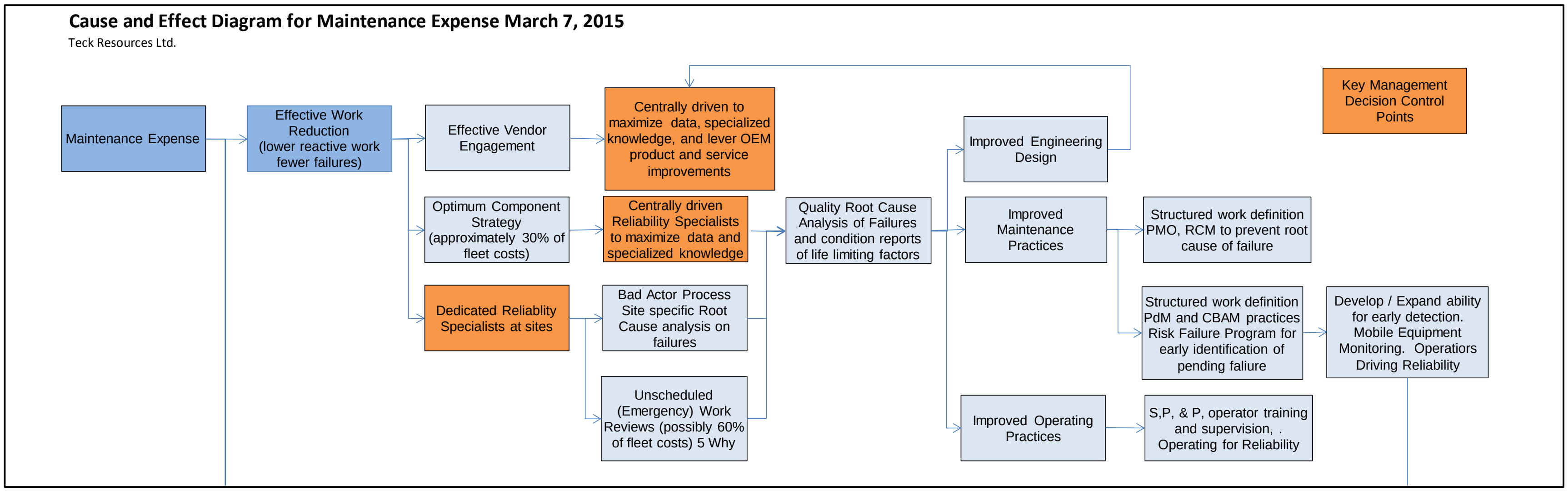
3: Identification of Key Activities – Cause and Effect Mapping

In this chapter, I apply cause and effect mapping to identify the key activities from the maintenance manual that have the most direct influence on achieving the four competitive factors identified in chapter 2. This chapter will identify the activities that contribute to bottom line results. Specific stories from individual sites will demonstrate the value of the selected activities for application to all sites.

The following maps in figures 3.1, 3.6, and 3.10 were created with input from employees familiar with the Teck maintenance program to highlight the specific activities that contribute to the values identified in the blue ocean strategy. The result is a simplified portrayal of the work processes in the manual.

3.1.1 Maintenance Expense

Figure 3.1(a) Cause and Effect Tree for Maintenance Expense, Part 1 of 3



Source: Summary of white board exercise for this paper

Figure 3.1(b) Cause and Effect Tree for Maintenance Expense, Part 2 of 3

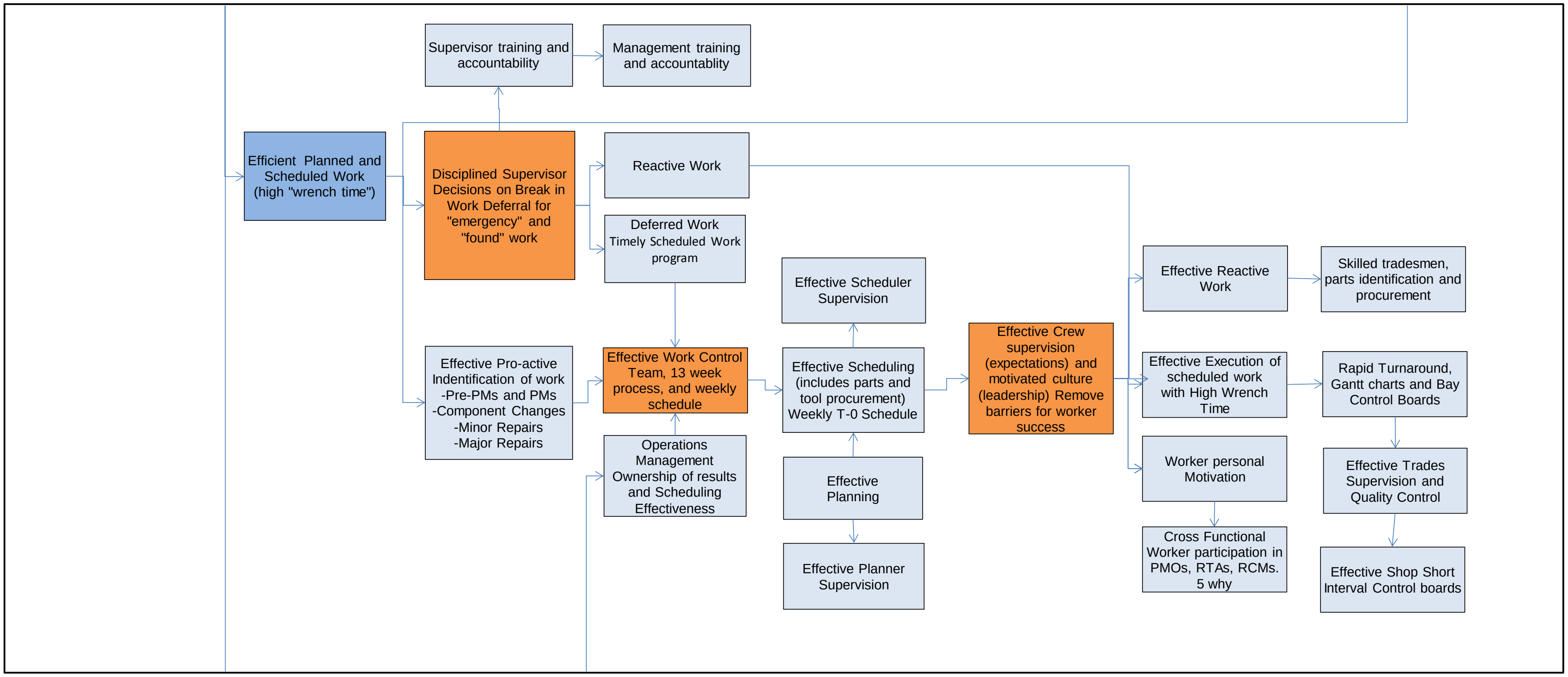
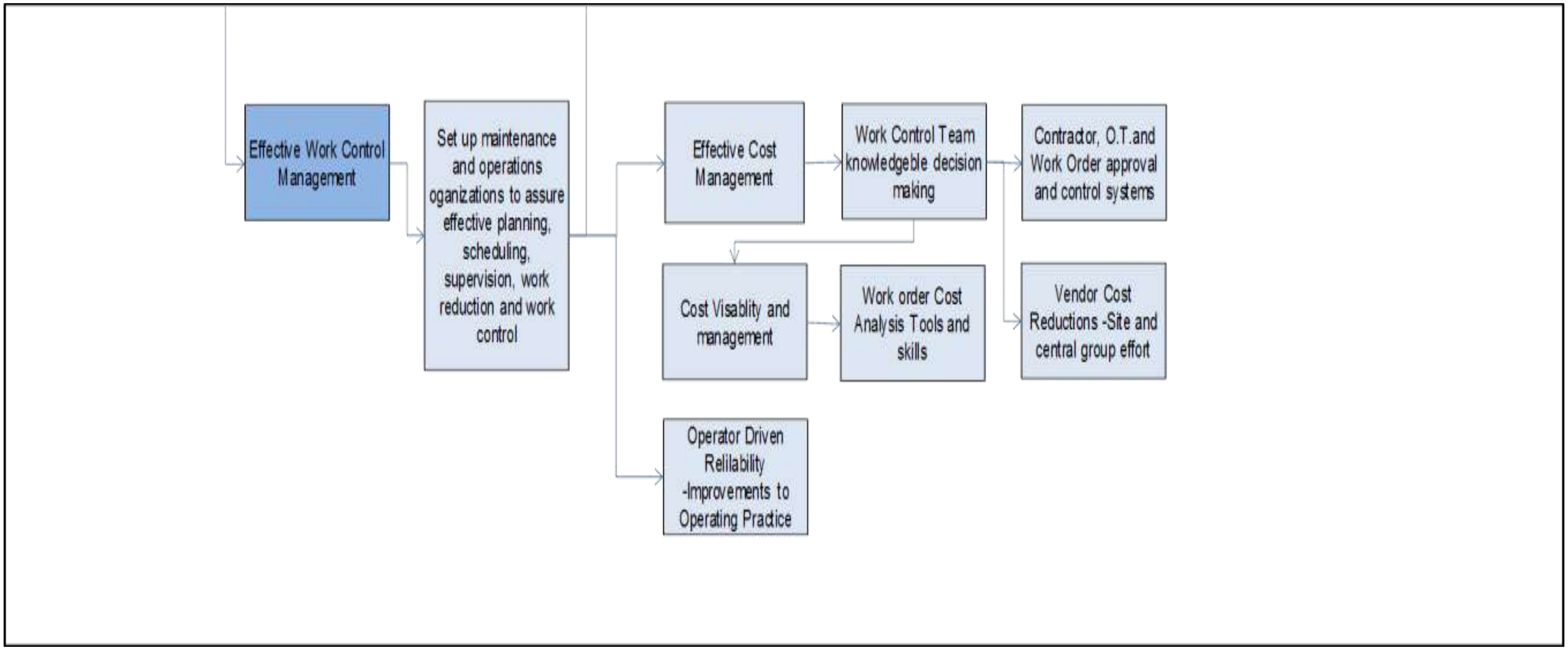


Figure 3.1(c) Cause and Effect Tree for Maintenance Expense, Part 3 of 3



Source: Summary of white board exercise for this paper

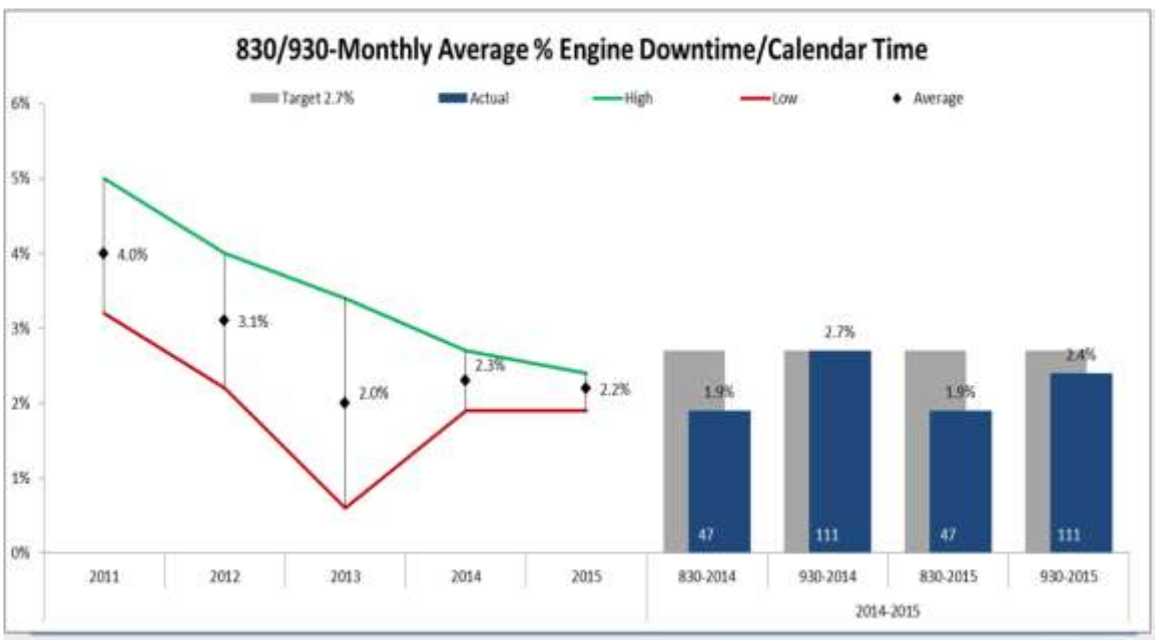
The cause and effect exercise for maintenance expense in figures 3.1(a), (b) and (c) identifies three key activities with a direct influence on reducing costs.

<u>Effective Work Reduction</u>

This could be described as the reliability effort and is the cumulative result of data based decisions, root cause analysis, component management strategies, and improved operating and maintenance practices. The result is a reduction in maintenance work due to failures that no longer occur, early intervention on pending failures, and extensions to component life.

It identifies two distinct and important roles. One is for the central group to maximize data and specialized knowledge across all sites to better optimize common component strategies and lever vendors and OEMs for product and service improvements. An example is development of more effective engine strategies that are based on failure and condition data from dozens of engines.

Figure 3.2 Results of an improved engine strategy



Source: Sparwood monthly reporting of engine downtime for vendor engagement June 2015

Table 3.1 Progression in engine life and cost reduction value of improvements in engine reliability

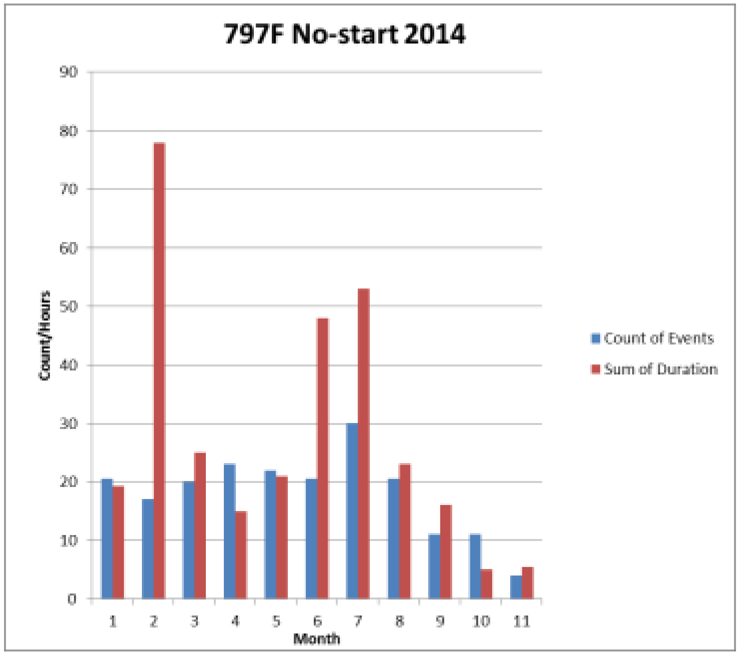
Year	2011	2012	2013	2014	2015
Engine Characteristic Life					
QSK60 -Hours	16,430	19,140	20,730	22,000	26,000
Value			$4.6 M annual average	Plus TBD	Plus $2.4-$3.6 M

Source: Internal presentation June 2015

Figure 3.2 and table 3.1 demonstrate the value in analysis and tracking of data across sites to drive vendor and site behavior in reducing causes of unscheduled engine downtime and increasing condition based engine change outs to increase average engine life and reduce costs. The central team adds value in developing and maintaining data across sites. Engine strategies developed from the evaluation of 35 engine changes across sites is significantly different from a strategy developed by a single site considering possibly three change outs.

The second role in work reduction is for site reliability specialists who are positioned to be more effective in evaluating site specific operating and maintenance practices. Key activities are emergency work reviews, bad actor identification, 5 why, and root cause analyses.

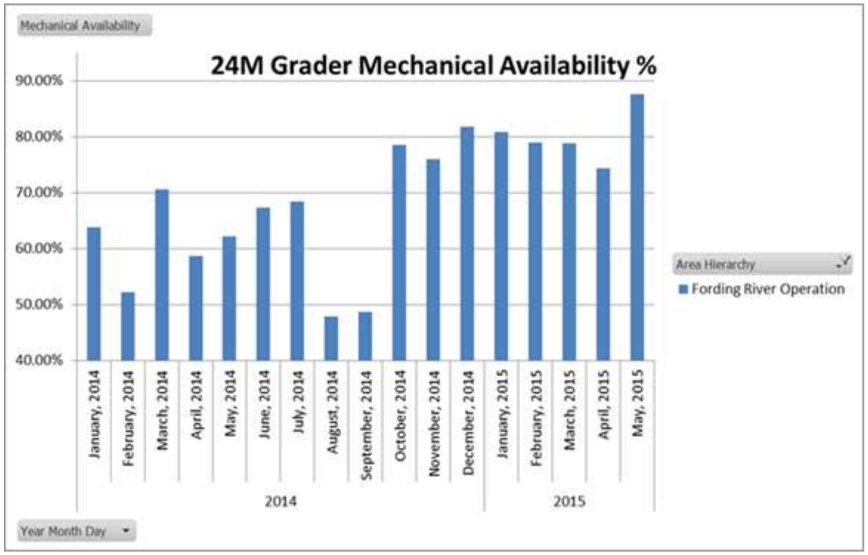
Figure 3.3 Examples of Site Driven Work Reduction 797F haul truck no start issue



Source: Site presentation June 2015

Figure 3.3 demonstrates the value of a joint initiative of a site with a vendor to aggressively identify and correct the causes of no-start issues on a haul truck fleet. The improvement was a result of a vendor upgrade to improve the fuel system, training and supervision of operators to follow required shut down procedures, and improvements to maintenance practices to reduce air leaks. The cumulative result was a +0.5 percentage point improvement in availability.

Figure 3.4 Examples of Site Driven Work Reduction – Poor availability on 24M graders



Source: Site presentation June 2015

Figure 3.4 again demonstrates the value of a joint initiative between a site and the vendor. The improvement was a result of new training of operating personnel and improvements in maintenance practices.

Additional examples of improvements include:

- Increased front suspension life on 930 trucks- A site identified that the common failure mode was the 2 ball valves and seats for oil control in the suspension and recommended a change to 4 valves to reduce the speed of the oil flow through the valve. The local vendor and Sparwood office pressured the O.E.M. to make the modification. The result was to more than double the expected component life for annual savings of $3.6 M across coal when the suspensions are upgraded through normal change outs.

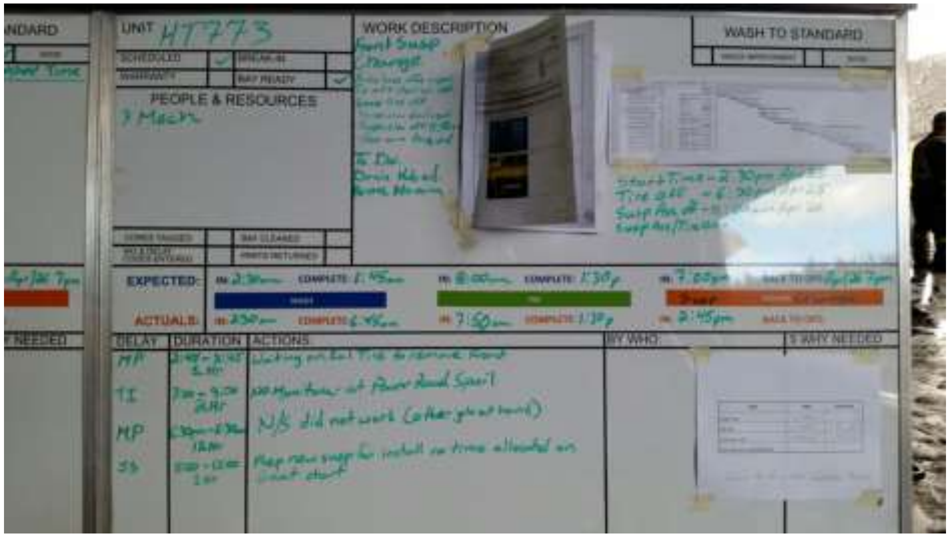
- Mobile Equipment Monitoring on trucks and shovels- In 2013 a system to remotely monitor equipment systems in near real time was installed as a pilot at one site. The value of reduced maintenance costs through early detection and avoidance of expensive equipment failures was $0.9 M in 2014. There was also an immediate reduction in operator over speed events, improvements in accident investigations, and improvements in road maintenance that increased haul truck speeds which have not been quantified. There was an additional $0.7 M in potential component failure avoidance that was identified but not acted on in a timely manner demonstrating the requirement of effective work control to get the full value of a proactive maintenance program. The analyses of root causes of engine failures on the 797F haul trucks have driven development of the monitoring system for early detection of fuel pump and other failures.
- Improved life of the main hydraulic pumps on shovels at CMO- Site root cause analysis of the hydraulic system resulted in changes in maintenance practices increasing average pump life from 4,500 to 9,155 hours for cost savings of $100,000 and downtime reductions of 24-36 hours. One key success was recognizing that inadequate pre-lube of pumps after installation was contributing to reduced life. This demonstrates the value of effective supervision and job quality standards.

The improvement examples given demonstrate that changes in practices were required by operators, maintainers, and the vendor. The discipline of data based processes by reliability specialists is critical to cut through subjective judgements by responsible parties to achieve results.

Efficient Planned and Scheduled Work

When work is identified pro-actively and is effectively planned, scheduled, and executed there is a notable improvement in wrench time or trades productivity and a corresponding reduction in downtime. A previous study of haul truck engine change out times demonstrated when optimized that a planned and scheduled change-out took 1/3 the time and ½ the man-hours as an unscheduled failure. Following is an example of the improvements in front suspension change out times at one site as the execution of a job plan improved through the use of bay control boards and tracking of results.

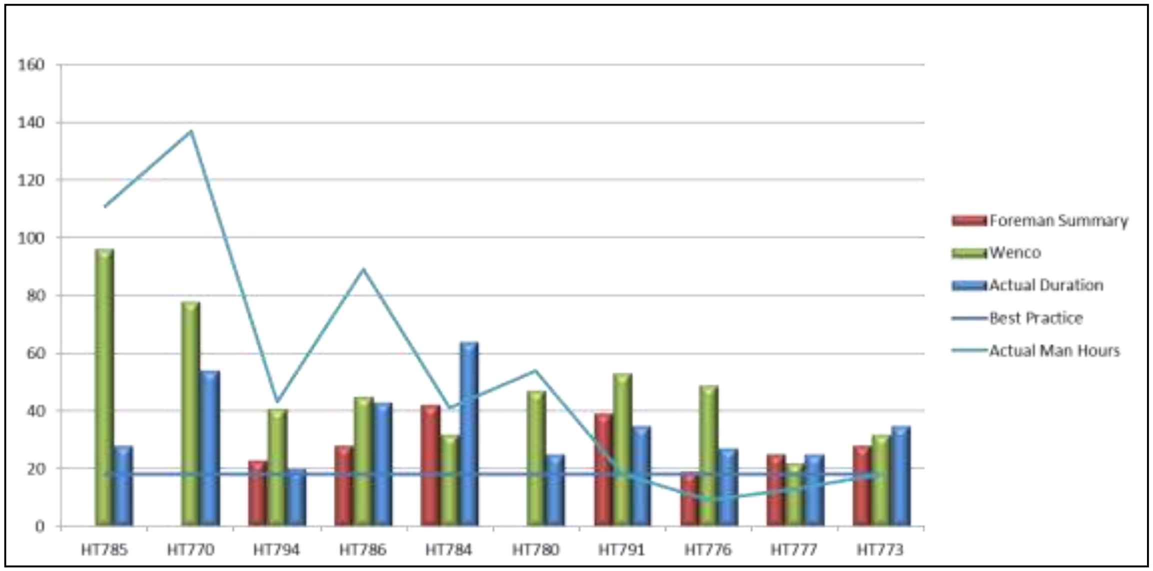
Figure 3.5 Picture of a bay control board



Source: Site presentation June 2015

Figure 3.5, the bay control board is a key control point to optimize trades wrench time or productivity for planned jobs and are best used on high frequency repetitive P.M.s and component changes. Maintenance workers and supervisors update the board to report achievements of expected times and identify potential issues that could result in delays. Actions to resolve delays are assigned to individuals. The Gantt chart is critical to direct the best sequencing in achieving optimal labour and duration times. A secondary value of the board is to identify systemic organizational or process delays requiring further investigation and management for improvement of work processes.

Figure 3.6 Progressive improvements in suspension changes on 930 haul trucks



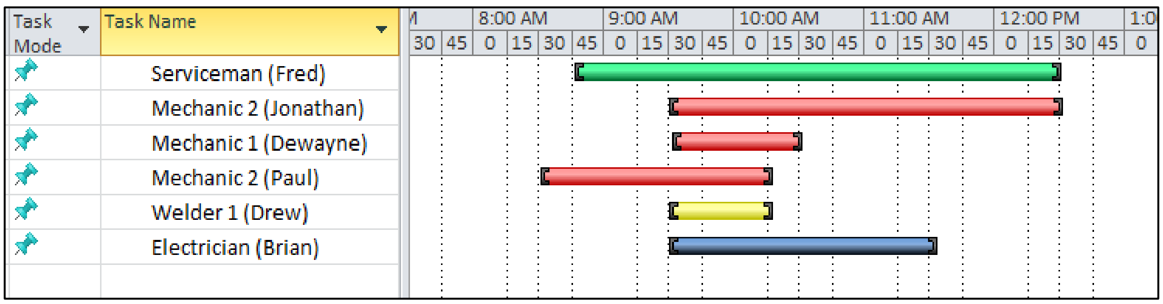
Source: Site presentation June 2015

Note in figure 3.6 that as the duration and labour for suspension change out was tracked that there was a progressive improvement in both the accuracy of reporting shown by a reduction in variability between reporting systems, and a reduction in the WENCO (site dispatching and time tracking system) duration and maintenance man-hours. The WENCO duration is from the mine dispatch system and indicates the time the unit was returned to operations which is the record of concern. A key element for success is to post results in the work area.

Early focus on training and improving planning and scheduling had limited results due to supervisors and tradesmen not effectively following job plans. In late 2014 it was determined that the use of bay control boards, Gantt charts, and supervisory leadership on select jobs can overcome the barrier.

The cause and effect exercise also identified that the pre-P.M. and the structured work program are critical to effective work identification for mobile equipment. Also that effective supervisor break-in work decisions and an effective Work Control Team were critical to success.

Figure 3.7 Internal presentation of rapid turnaround exercise for Coal management in June 2015 demonstrating potential gains from effective planning, scheduling, supervision and work control.



Source: Site presentation of results of rapid turnaround exercise on 930 haul trucks

Figure 3.7 is a Gantt chart showing the results of a RTA on 930 trucks. The figure demonstrates:

- Total PM duration was reduced from 7.5 hours to 4 hours
- Total man-hours were reduced from 21 to 12 hours
- Total distance travelled by workers reduced from 2.9 kilometers to 1.2 kilometers

This rapid turnaround exercise took place over a 3 day period and demonstrates the value achievable. The first day the crew performed a P.M. on a haul truck under observation of a multisite team that tracked the sequence of activities and distances travelled. The second day the workers and observers jointly analyzed the results and identified improved ways to organize the work space, sequence the activities, and assign skills. The result was a dramatic improvement in turnaround and labour efficiency. As this exercise is repeated at different sites, the total value has not been sustained with the following learning:

- The reductions in P.M. duration can be achieved solely by the supervisor setting expectations and the employees' personal motivation. This has been the result at most sites.
- The reduction in man-hours is only achieved if supervisory leadership, Gantt chart sequencing, and bay control boards are effectively used.
- Capturing the value of the newly created man-hours and equipment hours is only achieved if there is effective work control assuring that the planning, scheduling, and supervision is effective in scheduling value added work around the P.M. Palmer speaks to the value of fully scheduling man-hours to improve productivity in "Maintenance Scheduling Boosts Productivity" (Palmer 2013) He references the widely quoted term "Parkinson's Law" first coined in 1955 by Cyril Northcote Parkinson which states that "work expands to fill the time available for its completion". My personal observations on the floor are that if workers are assigned to a job without an expected and accurate duration being assigned, the workers will pace themselves, work inefficiently to keep busy, or add new low value work. Most workers are motivated and will fill the time void if not supervised effectively.

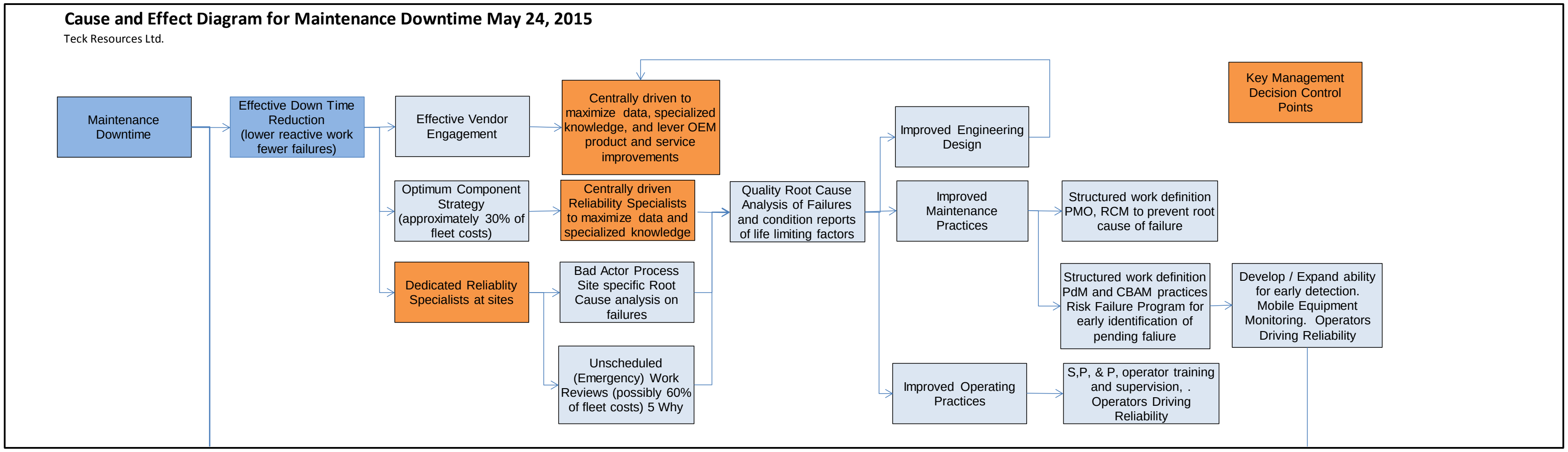
These observations lead into the next critical activity.

Effective Work Control Management

The third key element identified was effective work control management. This requires both maintenance and operations site management to take responsibility for the program objectives to be met. This requires an adequate knowledge of the program objectives for senior management to be successful in the multitude of pro-active decisions required. This requires setting up the organization with the right staffing and crew structure, the right people to fulfill roles, the right training, knowledge and motivation to lead and oversee the work processes to achieve results. Critical staffing is assuring adequate ratios and training of planners, schedulers, and supervisors to tradesmen and the assignment and training of effective middle managers.

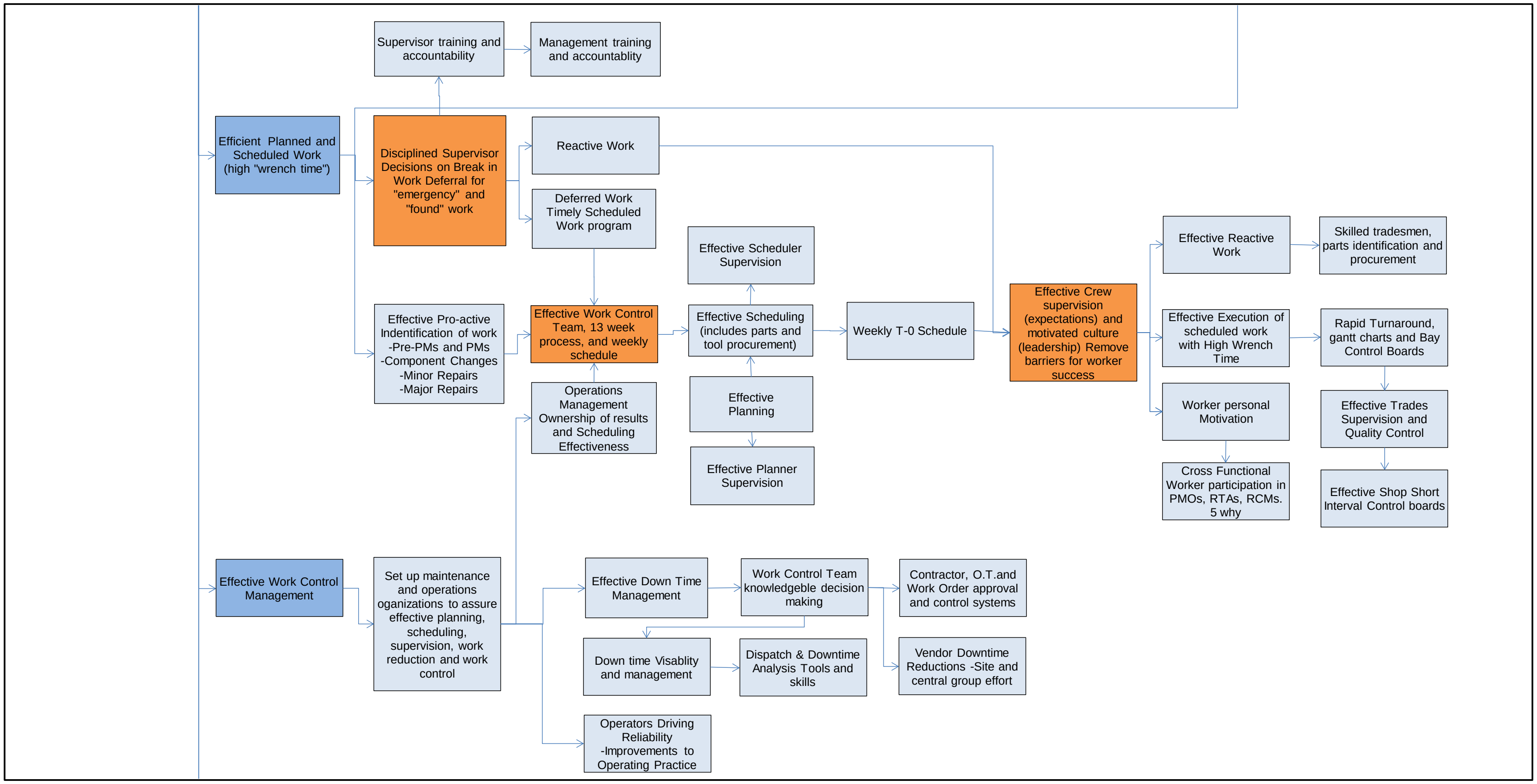
3.1.2 Equipment Performance

Figure 3.8(a) Cause and Effect Tree for Equipment Performance (Downtime Reduction)



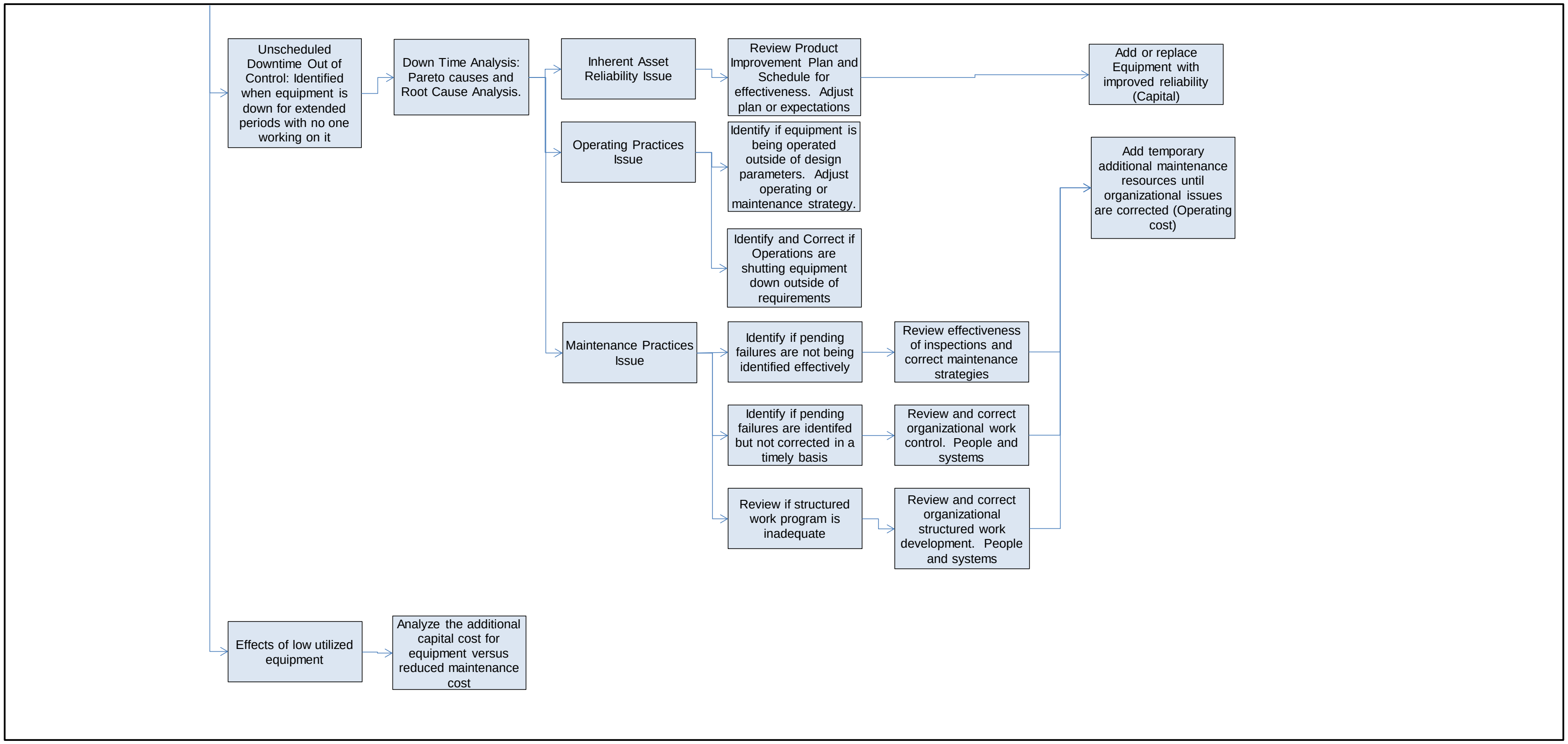
Source: Summary of white board exercise for this paper

Figure 3.8(b) Cause and Effect Tree for Equipment Performance (Downtime Reduction)



Source: Summary of white board exercise for this paper

Figure 3.8(c) Cause and Effect Tree for Equipment Performance (Downtime Reduction)

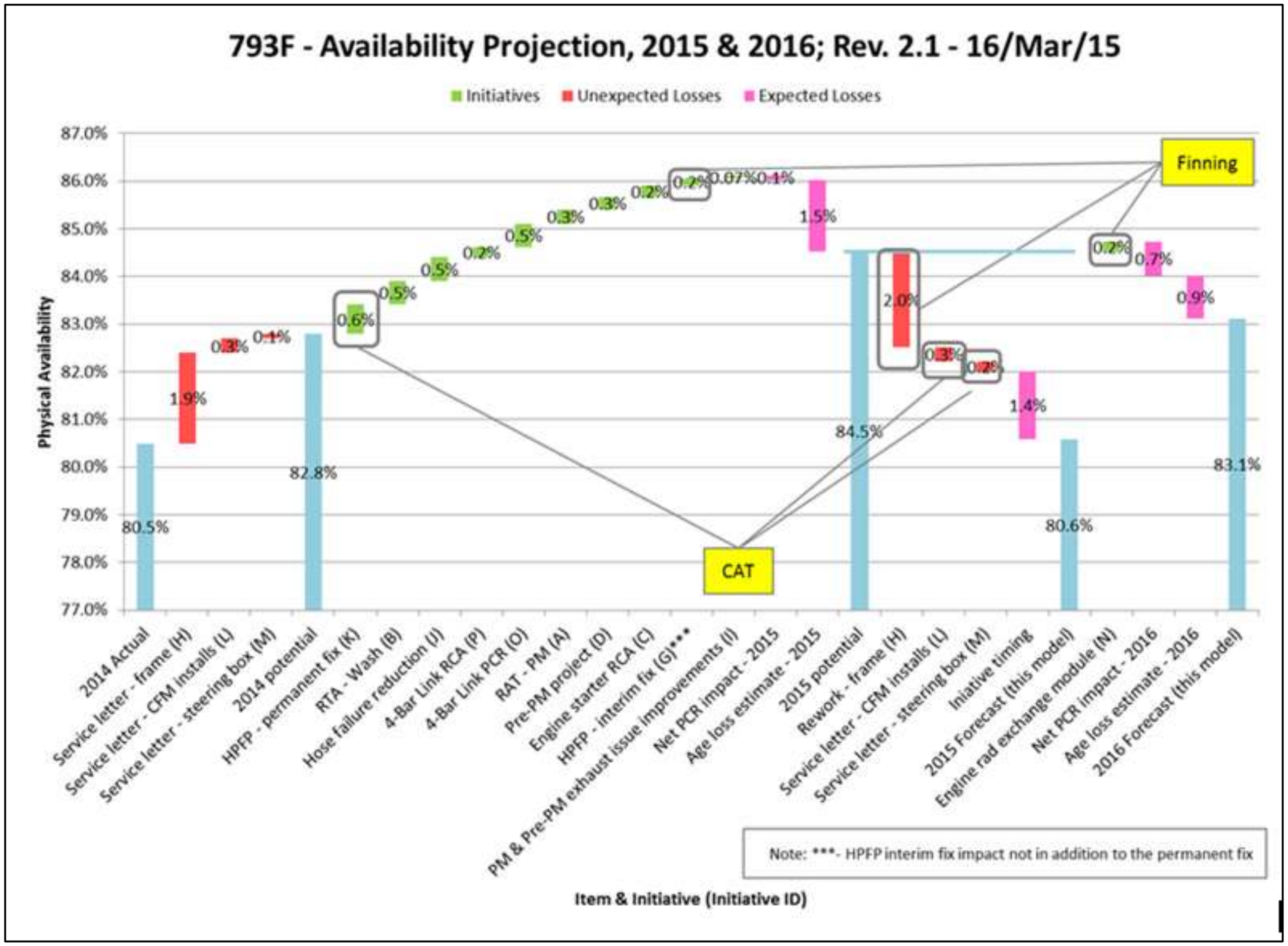


Source: Summary of white board exercise for this paper

Note that the first three elements in figure 3.8 for reducing downtime are near identical to those of reducing costs. The activities of effective work reduction, efficient execution of planned and scheduled work, and effective work control management all contribute to reduced maintenance downtime. Therefore that commentary will not be repeated in this section. Two additional elements are added; excessive unscheduled downtime and the effects of low utilized equipment:

<u>Excessive Unscheduled Downtime</u>- The previous stated activities assume a steady state in the organization. Occasionally unscheduled downtime becomes excessive exceeding the capacity of maintenance crews and shop space to return equipment to operation. This is evident when equipment sits down for extended periods and requires a management intervention. A recent example was the new CAT 793F series of 240 ton haul trucks. A joint vendor-site-Sparwood office conducted a root cause analysis and planning session to create the following waterfall diagram in figure 3.7:

Figure 3.9 Cumulative effects of forecasted availability on 793F fleet

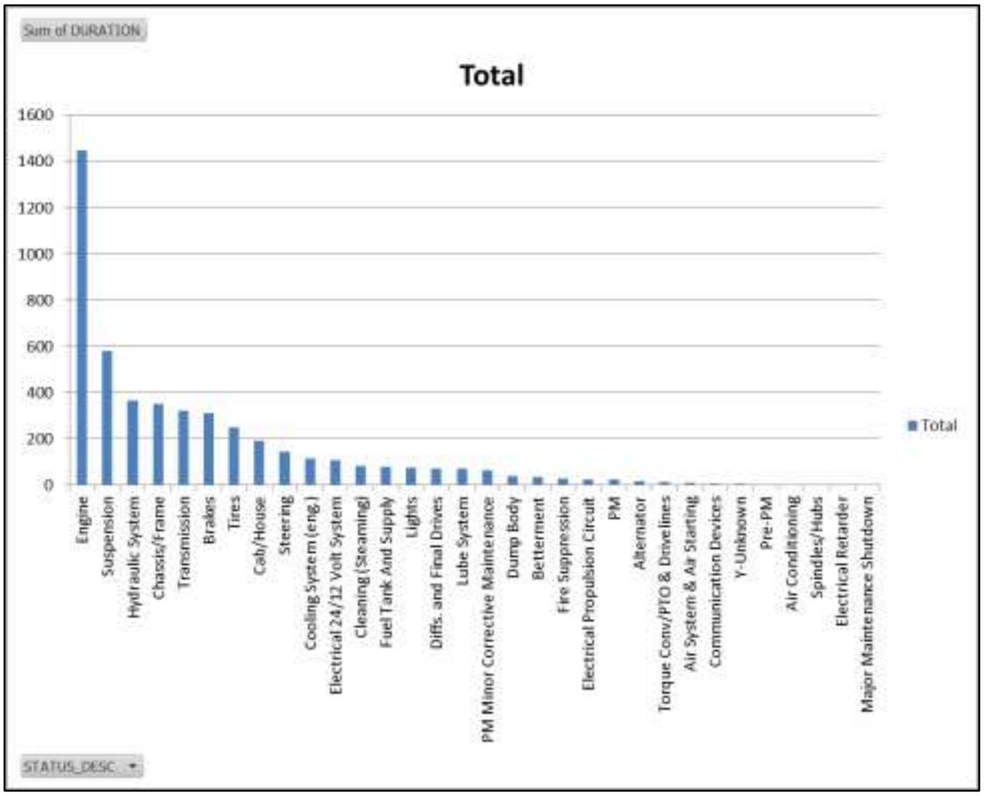


Source: Site presentation June 2015

The diagram effectively identified the specific activities the vendor and site could undertake to improve availability and set new expectations as to what production hours the fleet could achieve. The exercise was critical in separating product issues from site operations and work process losses to motivate the three responsible parties. Issues and responsibilities that were identified included:

- Inherent asset reliability issue- The frame cracking issue was identified as the primary product issue contributing to significant downtime causing a stress on shop space and man-power that had a ripple effect on other work. There were also contributors from engine and four bar linkage issues. The original equipment manufacturer and local vendor to act.
- Operating practices issue- The downtime analysis identified potential operator issues on brake application practices that contributed to an engine overheat failure. The site operations group to act.
- Maintenance practices issue- Further downtime analysis identified actions that the maintenance group could undertake.

Figure 3.10 CAT 793F unscheduled downtime in a 3-month period



Source: Site presentation June 2015

Figure 3.10 shows a graph of truck systems causing downtime and further work order analysis identified the downtime was related to engine fuel pump failures, engine starter failures, suspension failures, and hydraulic system leaks related to inadequate work processes to identify the work in the pre-P.M. for correctly prioritizing and scheduling of a pro-active repair. It was also identified that resourcing was inadequate to affect a pro-active repair. There were also maintenance activities identified to mitigate the downtime losses related to failures of the four bar linkage on the suspensions.

<u>Effects of low utilized equipment:</u> Current internal thought is that operating and maintaining more equipment than is required has a negative effect on Availability and Costs. The results of the competitors' equipment performance in chapter 2 suggests there may be cost advantages to low utilization of equipment and there are examples of this on secondary fleets within Teck. This is to be monitored and evaluated in the future as data and analyst resources become available.

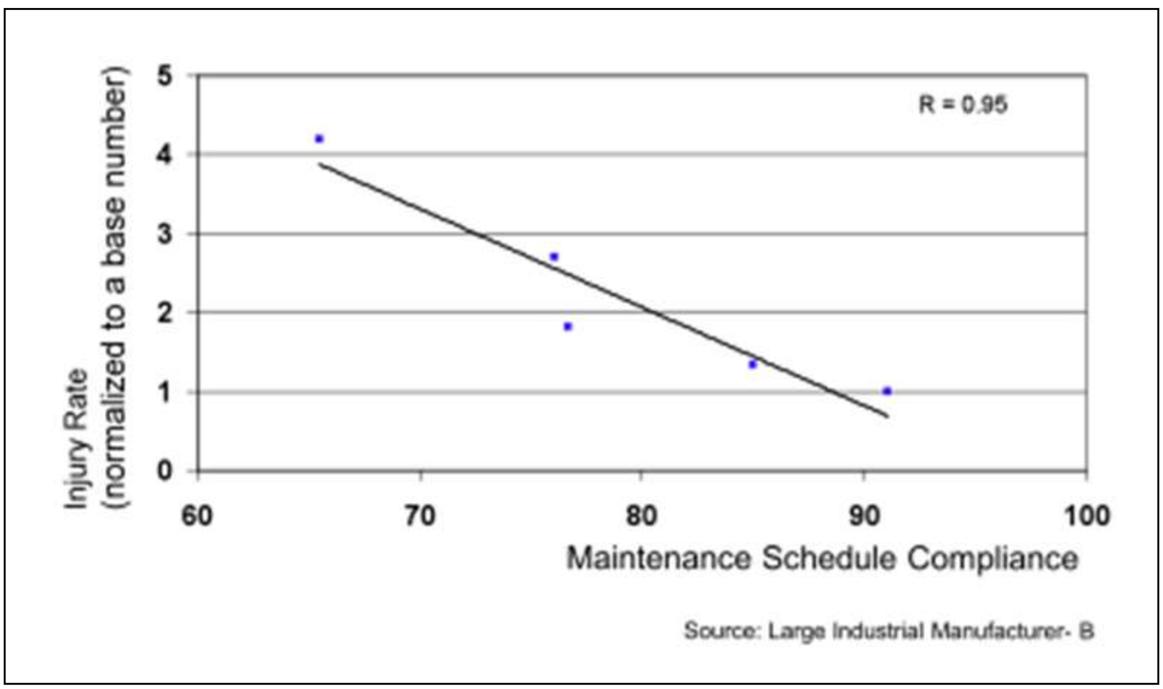
3.1.3 Reduced Capital Expense

Improved availability and reduced maintenance costs have a positive effect of reducing sustaining capital. There are no additional cause and effect diagrams for this. The value will be identified in chapter 4.

3.1.4 Acceptable Business Risk

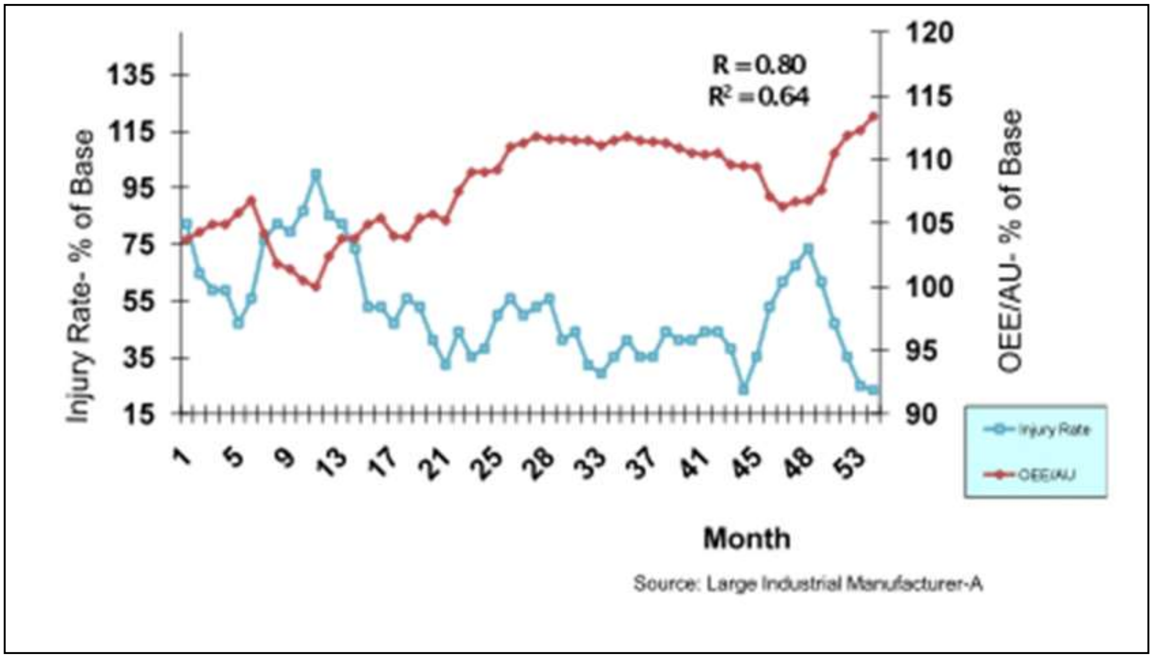
The fourth value proposition is in reducing business risk. This is a major driver for oil, gas, and chemical businesses that have experienced major disasters related to equipment and work process failures. Figure 3.11 (a) & (b) show the relationships between the results of an improved maintenance program and safety at sites in other industries. There are common underlying employee and management behaviors that drive both improved equipment reliability and safety. These underlying behaviors are believed by the author to be a sense of unease, and a timely response to indicators of potential failures. The following diagrams (Moore 2013) demonstrate a high correlation between discipline to a maintenance program, production, and safety results.

Figure 3.11(a) Relationships between safety and reliability presented to senior management April 13, 2013



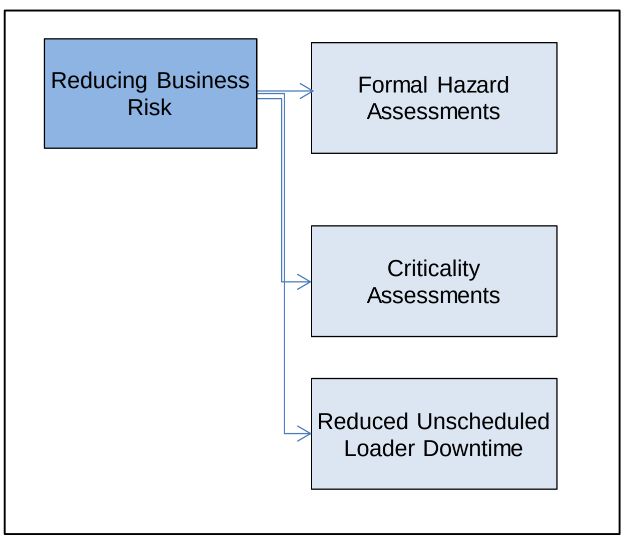
Source: Ron Moore, the RM Group Inc Knoxville, TN October 2013 presentation "Reliability Essential for a Safe, Cost Effective, Environmentally Friendly Operation"

Figure 3.11 (b) Relationships between safety and reliability presented to senior management April 13, 2013



Source: Ron Moore, the RM Group Inc. Knoxville, TN October 2013 presentation "Reliability Essential for a Safe, Cost Effective, Environmentally Friendly Operation"

Figure 3.12 Cause and Effect Tree for Reducing Business Risk



Source: Summary of white board exercise for this paper

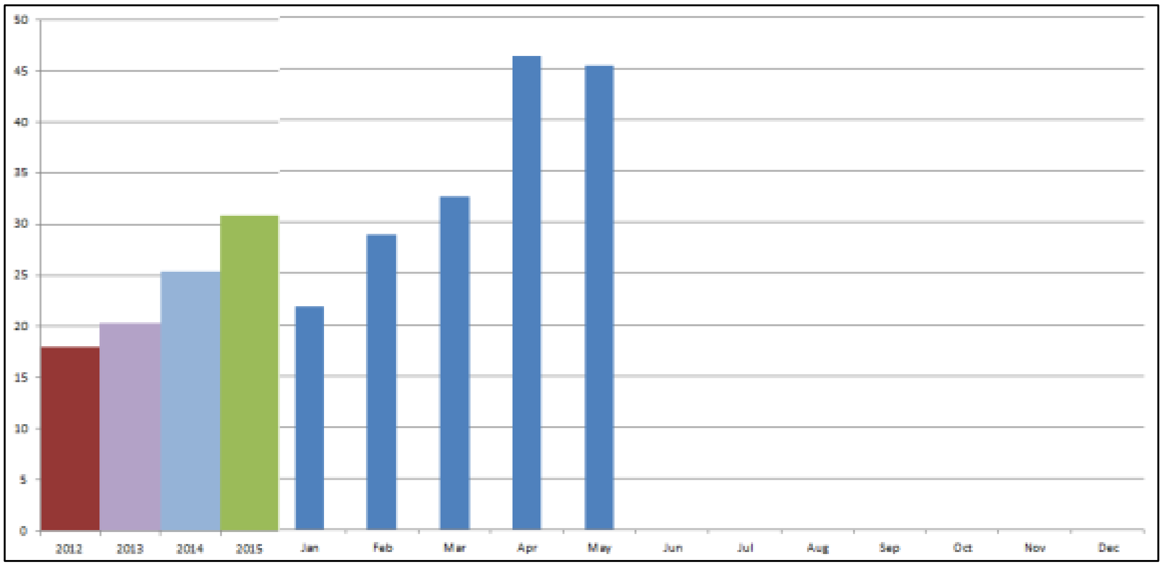
Figure 3.12 represents the cause and effect diagram for reducing business risk with three significant elements.

Formal Hazard Assessments: Teck has a format for hazard assessments which are undertaken when required. This adds value that is not presently covered in the maintenance program.

Annual Criticality Assessments: Within the maintenance program there are annual assessments consisting of a facilitated cross functional group meeting(s) to identify assets that are critical to the business. The production pieces of equipment are readily known, but other equipment is often over looked. Two examples of risks identified in criticality assessments was that the road sanding equipment at one site and the flocculent stations at another had no maintenance program at all. One was critical to maintain mine operations in adverse weather conditions and the other critical to maintain environmental permit compliance. Another example is that recently senior management has recognized the value in reviewing and improving the maintenance program for site main transformers. It is challenging to show the value of reducing risk prior to an incident of events that “might” happen. The biggest challenge of an effective maintenance program is celebrating negative events because they never happened.

Reduced Unscheduled Shovel Downtime: Truck haulage is the largest single cost at a mine site and has a direct effect on production. Even a short outage on a loading unit can back up several trucks. The activities identified in this paper contribute to an increase in MTBD on loading equipment. Figure 3.12 demonstrates the results to date on the primary loading unit, the 4100 shovel.

Figure 3.12 MTBD improvements for 4100 shovels in hours



Source: June 10, 2015 Teck Vendor Engagement Meeting

The above slide was part of the Quarterly Engagement with the vendor and sites demonstrating reduced short term electrical downs. Sites submitting fault logs to the vender, the vendor subject matter expert analyzed for the root causes of the fault, and then the sites addressed the root cause. A very good example of the value of data based actions and joint efforts of sites and vendors. The long term target is to achieve 100 hours between downs.

3.2 Summary of Cause and Effect Mapping

The cause and effect exercise identified effective work reduction, efficient execution of planned and scheduled work, effective work control, and criticality assessments as the primary activities of the maintenance program contributing to shareholder value. The activity also identified key management decision- control points as the work control team, supervision, organizational structure, the central reliability group, and site reliability personnel as being critical to success. Several examples of learning from several sites supported the conclusions. Understanding of figure 3.5 and the relationship between planning, scheduling, supervision, and work control is the most significant learning in this chapter as it applies to getting the most value. These activities will form the basis of chapter 4 to assign dollar values and will contribute to developing the activity map in chapter 6.

4: Cost Analysis

In this chapter, I complete a detailed cost analysis across the six sites to identify cost reductions achieved to date and potential future cost reductions. The objective is to understand where we are in the cost reduction portion of the journey and define a more detailed activity based business case with measureable results going forward.

The size of future cost reductions are estimated by comparing the maturity of new processes on specific fleets and sites to the results achieved to date on comparable fleets at other sites. The exercise will also identify the leading metrics to drive results in each of the activities.

4.1.1 Cost Reduction

The cause and effect map identified activities that could generate measurable cost reductions. The 2014 maintenance spend for Coal is used as a “typical” year to size the potential reductions relative to the typical spends. The nature of mine equipment maintenance is that some of the cost reductions are not realized for several years. For example, the extension of expected engine life from 16,000 hours to 22,000 hours will not realize full value for more than 3 years depending on age distributions of the engines. This model is an indication of relative savings considering fleet costs are made up of a mix of equipment in life cycle stages that vary from zero to 100,000 hours (0 to 20 years). In the future, we will develop reporting that segments fleet costs by equipment age for more granular analysis.

<u>Component Strategy and Labour Reductions on Scheduled Change-outs:</u> Haul Truck component costs of $69 M make up 45% of total truck maintenance costs of $152M and have the greatest opportunity for improvement. Estimated cost reductions are the value of extended component lives through the work reduction effort and the value of reduced labour through the rapid turnaround on component changes. The following table estimates the potential:

Table 4.1 Haul truck component cost summary Teck Coal, 2014

2014 Costs											
Fleet	Engines		W Motors, Final Drives		Alt, Trans, Diffs		Boxes		Suspensions		Totals
	Labour	Total	Labour	Total	Labour	Total	Labour	Total	Labour	Total	
930E	611,162	10,726,817	40,575	7,717,430	117,642	1,243,691	520,001	10,577,870	424,541	7,262,216	39,241,945
830E	229,774	3,900,596	78,870	2,844,394	46,542	204,007	41,872	577,376	59,332	851,065	8,833,827
797F	535,233	4,176,952	63,404	1,352,076	129,059	1,238,427	118,519	436,692	73,276	927,519	9,051,159
793	555,933	4,060,658	99,521	2,894,177	196,715	2,009,509	172,851	1,005,201	125,389	1,191,545	12,311,499
Totals	1,932,102	22,865,023	282,370	14,808,076	489,959	4,695,634	853,244	12,597,138	682,538	10,232,346	69,438,430

Projected Cost Reductions depending on maturity of program development or identified potential as %											
Fleet	Engines		W Motors, Final Drives		Alt, Trans, Diffs		Boxes		Suspensions		Totals
	Labour	Total	Labour	Total	Labour	Total	Labour	Total	Labour	Total	
930E	25%	15%	25%	20%	25%	0%	41%	0%	25%	50%	
830E	25%	10%	25%	20%	25%	0%	41%	0%	25%	0%	
797F	25%	20%	25%	40%	25%	40%	41%	0%	25%	20%	
793	25%	20%	25%	30%	25%	30%	41%	0%	25%	20%	
Totals	25%	16%	25%	28%	25%	18%	41%	0%	25%	23%	#DIV/0!

Projected Cost Reductions depending on maturity of program development or identified potential in $											
Fleet	Engines		W Motors, Final Drives		Alt, Trans, Diffs		Boxes		Suspensions		Totals
	Labour	Total	Labour	Total	Labour	Total	Labour	Total	Labour	Total	
930E	152,791	1,609,023	10,144	1,543,486	29,411	0	213,200	0	106,135	3,631,108	7,295,297
830E	57,444	390,060	19,717	568,879	11,635	0	17,168	0	14,833	0	1,079,735
797F	133,808	835,390	15,851	540,830	32,265	495,371	48,593	0	18,319	185,504	2,305,932
793	138,983	812,132	24,880	868,253	49,179	602,853	70,869	0	31,347	238,309	2,836,805
Totals	483,025	3,646,604	70,593	3,521,448	122,490	1,098,224	349,830	0	170,635	4,054,921	13,517,769

Source: Data derived from 2014 work order costs. April 2015

Table 4.1 identifies the opportunity in each area as:

- Engines are the single largest component cost. Reliability efforts to date have increased the expected engine life on the 930E and 830E trucks from 16,000 production hours to 22,000. This effectively reduces the engine replacements in a 100,000-hour truck life cycle from 5 engines to 4 saving $500K for each of 160 active trucks over a 20 year life span. A further strategy recently completed is expected to increase this by 25% from 2014 performance. The CAT 797F and 793 engines have an expected life of 12,000 hours. Teck efforts to work with the original equipment manufacturer and vendor started in 2014 and projections are less optimistic due to vendor performance with an overall projection of 25% improvement. Although the number of engines replaced in a year with trucks typically operating 6,000 hours can vary, the 2014 total engine spend is taken as typical.

- Wheel Motors on 830 and 930 trucks- Life has increased from an average of 15,000 hours to 25,000 hours by changing from hour based change outs to condition based change outs and introducing an oil filtration and condition management program. Currently several motors are exceeding 35,000 hours and future saving is estimated as an additional 25% of 2014 performance.

- Final Drives on CAT 797F and 793 trucks- Data from the vendor is not fully analysed to build a component management strategy. The CAT 797F truck components have a significant potential for extension by developing a condition-based program. The CAT 793F component change outs are proactively extended by the site in anticipation of developing a program. Cost reductions are estimated accordingly at 40% and 25%. CAT mechanical drive components are more complex than electric drive trucks with limitations on condition monitoring.

- Drive components- Electric drive alternators have already had the major cause of failure addressed through a seal modification and are on a condition-based program so no new savings are identified. The maintenance strategy for drive components on the 797F and 793F mechanical drive trucks have yet to be developed. Estimated savings are conservative due to unknowns.

- Boxes- In 2014 boxes were on a condition-based program. Although there are continuous improvements to box design and rebuild practices, they are judged to be incremental and no new savings have been identified in box life extension. Significant delays occur in box change practices across sites due to poor execution of job plans. The reduction in labour costs is estimated by the difference in the average box labour cost and the average of the five lowest cost box changes.

- Suspensions- Upgrades to the front suspensions on the 930E trucks in 2014 appear to effectively double suspension life and this is reflected in the cost saving estimate. No changes in practice are planned for the 830E trucks. Savings on the CAT trucks are estimated at 25% as more component change outs are based on condition rather than hours.
- Labour Costs- Best practice job plans are developed for most of the described component changes but are not consistently executed across sites. The effective execution of the plans as described in the cause and effect maps will generate the savings and must be a significant part of a new implementation strategy.

Rapid Turnaround on Preventive Maintenance Practices: P.M.s are typically performed at 500 or 750 production hour intervals. They are scheduled and repeatable making excellent candidates for rapid turnaround. RTA exercises were undertaken on haul trucks at three sites. The greatest improvement at one site was a reduction in labour hours by 50%. The least improved site was a reduction of 20%. These studies were in 2014 and the practices are not fully implemented or sustained at all sites. It is assumed that the materials cost will remain the same and the labour costs will be reduced by an average of 30% on haul trucks and 20% on shovels, drills, and auxiliary equipment. The target reduction on shovels and drills is less, as this has received more supervision than trucks in the past reducing the gap. It is less on auxiliary equipment because of the large variety of types of equipment takes more effort to optimize. The estimated cost reduction is $3.4 M on $13 M spend as identified in table 4.2.

Table 4.2 PM labour cost summary for Teck Coal 2014

	2014 PM Labour Costs					Work Order Count		Potential Labour Cost Reduction	
Mtce Organization Totals	**Contractor**	**Employee**	**W/O Items**	**Total**	**Total W/O Cost**	**Contractor**	**Employee**	**20% Reduction**	**30% Reduction**
Truck and Loaders	1,721,442	5,759,805	4,879,159	7,481,247	12,360,406	3,908	2,656	$1,496,249	$2,244,374
Shovels and Drills	660,757	1,911,394	1,366,424	2,572,152	3,938,575	987	917	$514,430	$771,645
Auxilory	809,801	2,520,769	1,419,191	3,330,570	4,749,760	2,013	1,682	$666,114	$999,171
Totals	3,192,000	10,191,968	7,664,773	13,383,968	21,048,741	6,908	5,255	$2,676,794	$4,015,190
							Target	**3,424,918**	

Source: Data derived from 2014 work order costs. April 2015

Future Work Control: The management purpose of the work control team is to direct the value achievable by the work reduction teams and the planning, scheduling, and execution teams. This potential cost reduction assumes that the gap of 29.1% reactive maintenance can be reduced to 20.0% for savings of $30 M on a $330 M spend. Note the percent reactive is less here than the % reactive in chapter 1 as this is based on work order data only for production and auxiliary equipment.

Table 4.3 Percent Reactive maintenance costs by equipment type for Teck Coal 2014

Type of Equipment Type	Labour	Material	Sub Total	% Total	%Reactive	% Scheduled
Trucks and Loaders	45,862,295	132,549,490	178,411,785	54.0%	32.4%	67.6%
Shovels and Drills	20,600,830	63,087,019	83,687,849	25.3%	21.6%	78.4%
Auxilory	27,186,266	40,880,404	68,066,670	20.6%	29.9%	70.1%
Total	93,649,391	236,516,913	330,166,304	100.0%	29.1%	70.9%
Target Cost Reduction	$8,553,133	$21,601,428	$30,154,561	KPI	20.0%	80.0%

Source: Data derived from 2014 work order cost data. April 2015

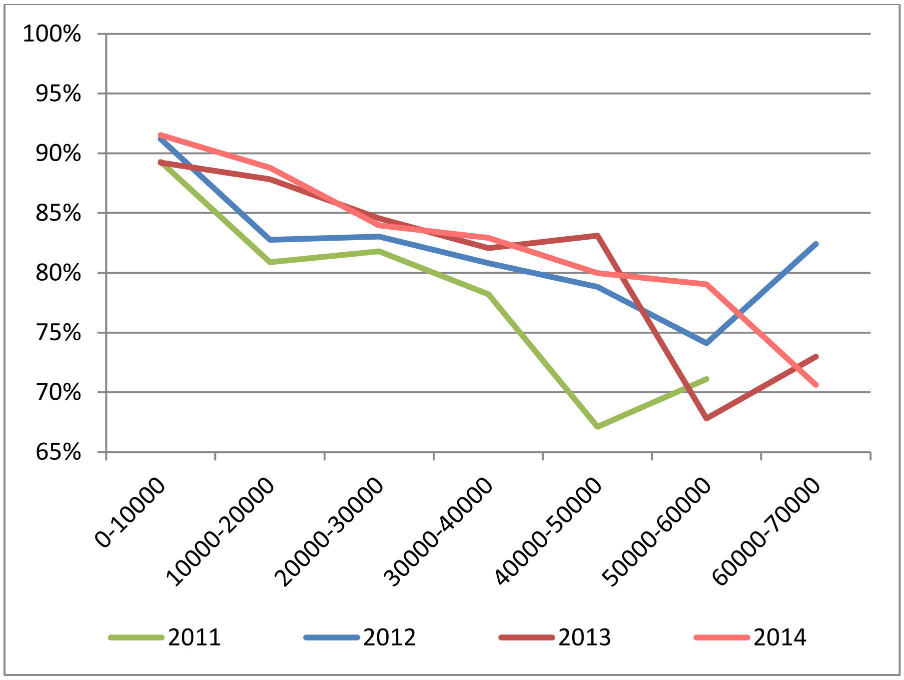
4.1.2 Equipment Performance: Availability and the Value of Reduced Capital

The coal business unit produces a mix of coal qualities from six sites with a level of substitution between products and it operates with high blasted muck, raw coal, and clean coal inventories at site and port. The primary production constraints over several decades are rail or sales limitations. Therefore, any argument, that a loss or gain in mine equipment availability will directly affect revenue is not considered in this paper as it could lead to overstated values and poor business decisions. Therefore, the primary value of improved availability is in reduced sustaining capital for replacement equipment as availability digresses with equipment age.

- Shovels- The existing maintenance program has resulted in reasonable shovel availabilities over 20 year life spans. The Teck Effective Asset Utilization for the primary 4100 72yd shovel is comparable to the PwC benchmark for shovels in the top 10% of annual production. Typically additional or replacement shovels are justified by mine plan requirements therefore an estimated value will not be placed on increased availability for this paper.

- Haul Trucks- Figure 4.1 demonstrates the digression of availability by age for 930E haul trucks across three sites. The 930E is the most cost effective truck for Coal and is the baseline for fleet comparisons. It also has the most extensive data bank for analysis due to the large number of trucks. The graph also demonstrates the improvements in availability across the life cycle of the truck achieved over the last three years from the reliability effort to date. Note there is both a gain in availability but also a deferral in drops as equipment ages. The drop that occurred at 40 to 50 K hours in 2011 is delayed 4 years to 60-70K hours in 2014. It is expected that continued reliability efforts will flatten the digression of availability at a point over 80% in the near future.

Figure 4.1 Improvements in 930E haul truck maintenance availability segmented by age

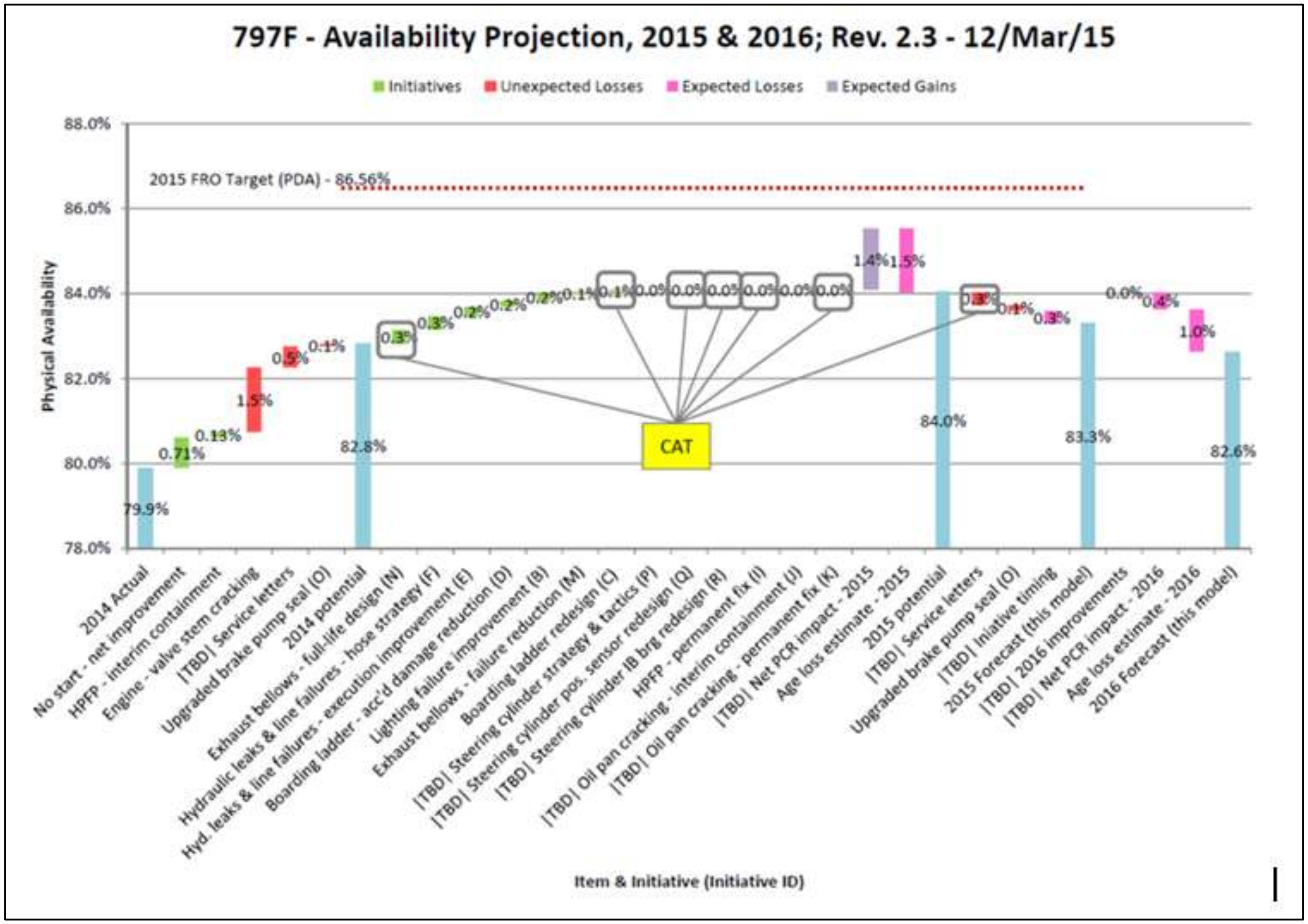


Source: Teck slide, January 2015

The value of this improvement is equivalent to capital savings of $32 M to achieve the same production hours.

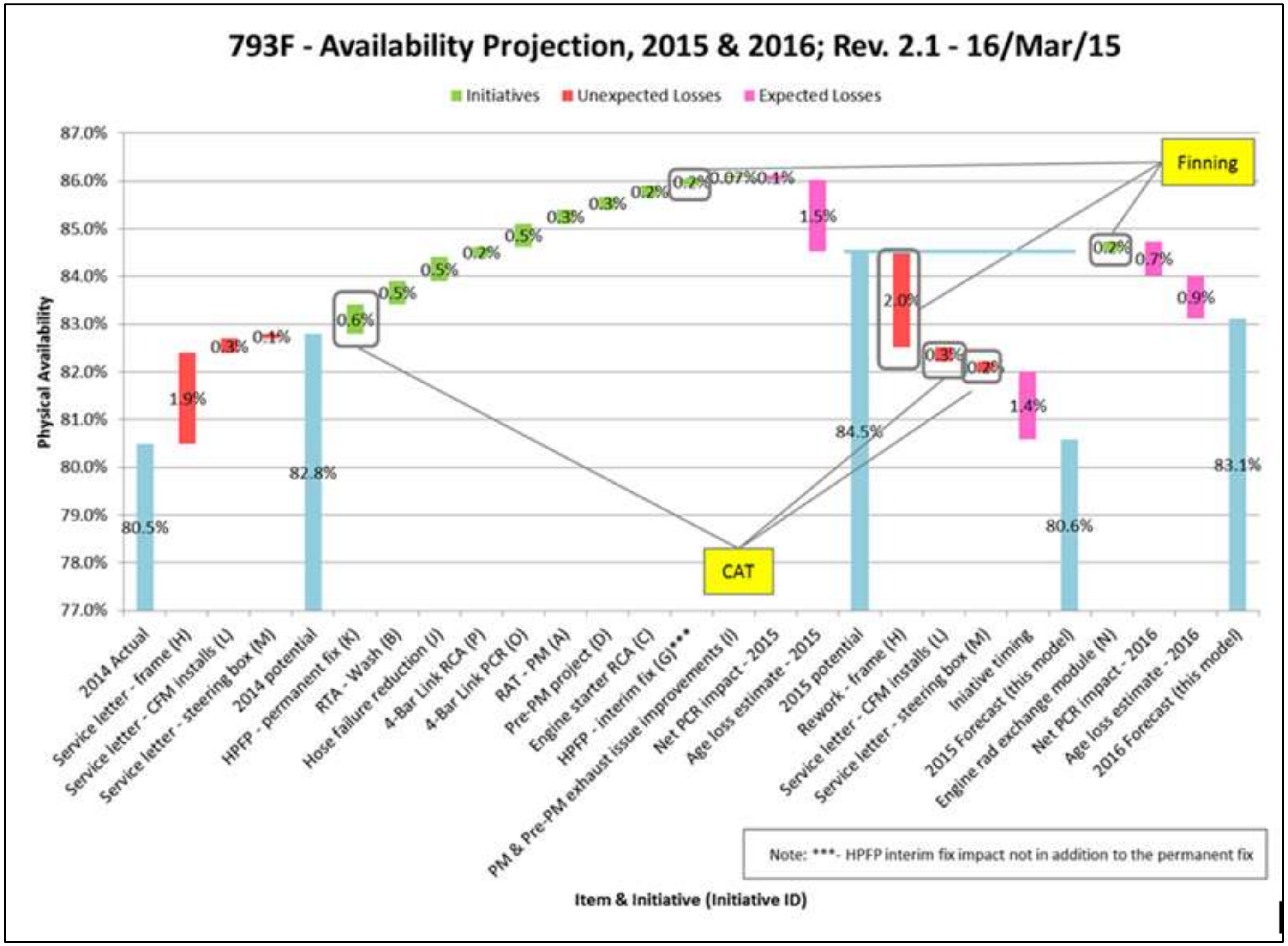
The following figures 4.2 (a), (b), (c), are availability projections of planned availability improvements estimated for respective sites in the different truck fleets.

Figure 4.2 (a) Availability projection from joint vendor – site engagement for 797F trucks



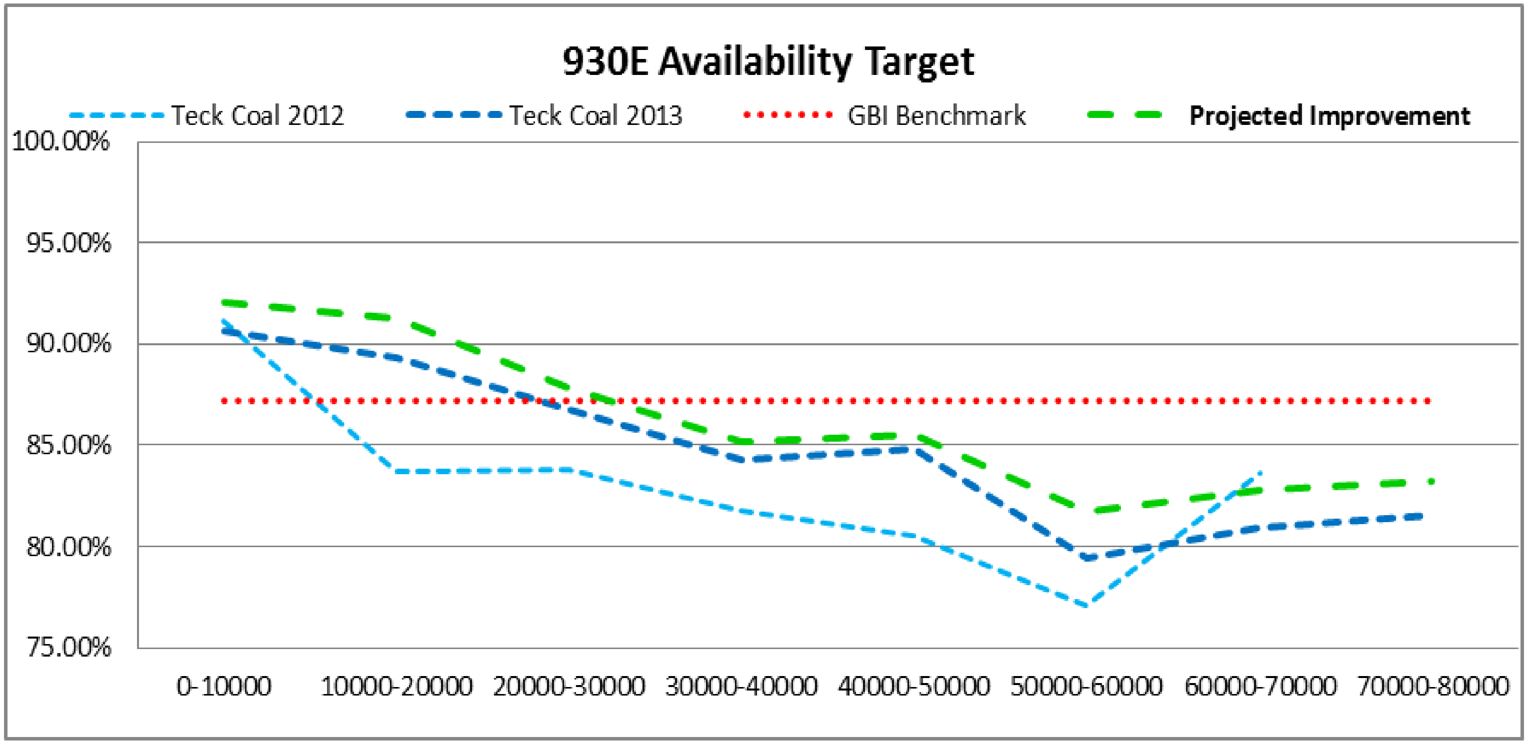
Source: Site presentation June 2015

Figure 4.2 (b) Availability projections from joint vendor – site engagement for 793F trucks



Source: Site presentation June 2015

Figure 4.3 Availability projections from joint vendor – site engagement for 930E trucks in 2013



Source: Teck Slide- Aging truck availability improvement initiative 2014

Each of the previous availability forecasts have an action plan for implementation and becomes the basis for the forecasted truck fleet availabilities adjusted for the current digression as the trucks age. Assuming the required annual truck production hours are constant for each mine site the following tables 4.4 to 4.7 estimate the net present value of reduced and deferred truck purchases over a five-year period.

Table 4.4 Forecast of future fleet availabilities due to aging if no change in practices.

Forecast of Fleet Availability For Age (Five Year Plan)								
Site	**Fleet**	**2014 - Actuals**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
FRO	**KOM 930E**	82.4%	81.6%	80.2%	79.1%	78.0%	77.2%	76.4%
FRO	**CAT 797F**	79.9%	77.5%	76.5%	74.6%	73.4%	72.4%	69.5%
EVO	**KOM 930E**	87.5%	83.9%	83.2%	80.5%	80.3%	77.9%	77.4%
GHO	**KOM 930E**	88.3%	85.6%	83.5%	82.8%	80.0%	79.1%	78.4%
LCO	**Cat 793F**	80.5%	77.1%	76.2%	74.7%	73.7%	72.3%	69.9%
CMO	**KOM 830E AC**	86.7%	81.3%	80.5%	79.3%	80.0%	79.5%	77.3%
CRO	**KOM 830E AC**	82.7%	81.3%	80.0%	79.9%	79.5%	79.0%	77.3%

Source: Sparwood five-year plan forecast. June 2015

Table 4.5 Forecast of future additions of trucks to fleets to offset digressions in availabilities due to aging if no change in practices.

Timing of Truck Purchases to maintain production hours with no change in practices (2014 base line)									
Site	**Fleet**	**2014 Baseline No. of Trucks**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
FRO	**KOM 930E**	46	0.4	0.6	0.5	0.5	0.4	0.4	2.8
FRO	**CAT 797F**	9	0.2	0.1	0.2	0.1	0.1	0.3	0.9
EVO	**KOM 930E**	41	1.5	0.3	1.1	0.1	1.0	0.2	4.2
GHO	**KOM 930E**	29	0.8	0.6	0.2	0.8	0.3	0.2	2.9
LCO	**Cat 793F**	17	0.6	0.1	0.2	0.2	0.2	0.4	1.8
CMO	**KOM 830E AC**	7	0.4	0.0	0.1	-0.1	0.0	0.2	0.7
CRO	**KOM 830E AC**	10	0.1	0.1	0.0	0.0	0.0	0.2	0.5
Coal	**Total**	159	4.0	1.9	2.3	1.7	2.0	1.8	13.7

Source: Analysis of five-year plan forecast. June 2015

If practices do not change, a total of 13.7 additional truck purchases would need to be made in the first 2 years to maintain the same annual production hours.

Table 4.6 Reduced number of sustaining trucks required if planned improvements to availability are achieved

Timing of Truck Purchases to maintain production hours with new practices									
Site	Fleet	Availability Improvement	2015	2016	2017	2018	2019	2020	Total
FRO	KOM 930E	2.1%	-0.6	0.6	0.5	0.5	0.4	0.4	1.8
FRO	CAT 797F	2.4%	0.0	0.1	0.2	0.1	0.1	0.3	0.7
EVO	KOM 930E	2.1%	0.6	0.3	1.1	0.1	1.0	0.2	3.3
GHO	KOM 930E	2.1%	0.8	0.0	0.2	0.8	0.3	0.2	2.3
LCO	Cat 793F	4.1%	-0.1	0.1	0.2	0.2	0.2	0.4	1.1
CMO	KOM 830E AC	0.0%	0.4	0.0	0.1	-0.1	0.0	0.2	0.7
CRO	KOM 830E AC	0.0%	0.1	0.1	0.0	0.0	0.0	0.2	0.5
			1.3	1.3	2.3	1.7	2.0	1.8	10.4

Source: Analysis of five-year plan forecast. June 2015

Table 4.7 Forecast of savings in capital spend with improved availability

NPV of Reductions in Truck Purchases to Maintain Annual Production Hours with Availability Improvements									
Site	Fleet	NPV	2015	2016	2017	2018	2019	2020	Avg Annual Capital
FRO	KOM 930E	$1	1.0	0	0	0	0	0	$0
FRO	CAT 797F	$1,741,320	1,880,626	0	0	0	0	0	$313,438
EVO	KOM 930E	$4,791,465	5,174,782	0	0	0	0	0	$862,464
GHO	KOM 930E	$3,138,042	0	3,660,212	0	0	0	0	$610,035
LCO	Cat 793F	$3,667,382	3,960,772	0	0	0	0	0	$660,129
CMO	KOM 830E AC	$0	0	0	0	0	0	0	$0
CRO	KOM 830E AC	$0	0	0	0	0	0	0	$0
Coal	Annual Totals	$ 13,338,209	11,016,181	3,660,212	0	0	0	0	$ 2,446,065

Source: Analysis of five-year plan forecast. June 2015

If improvement objectives are achieved the number of new tucks to purchase would be reduced to 10.4 for a capital reduction Net Present Value of $13.3M.

4.1.3 Reduced Business Risk

An estimate of the dollar value of reducing business risk is not attempted as part of this paper due to the challenges of assigning value to events because they did not happen. Figure 1.2 described how a maintenance program reduced insurance premiums by 10% for Scottish Power and figures 3.9 a and b demonstrated how discipline to a sound maintenance program improved safety and operating results in a study across major manufacturing plants. Also in chapter 3, we saw how the underlying employee and management behaviours of chronic unease and early response to potential failures contribute to both a reliable and safe operation. Significant bottom line dollar savings were identified in reduced maintenance costs and improved availability to justify the program and so for the purposes of this paper, additional dollar value will not be estimated for reduced business risk. Value is expected to be achieved indirectly as Teck management normally invests significant effort in improving safety and reducing business risk as a principle.

4.2 Summary of Cost Savings Analysis

A summary of the value achieved to date by the program is compared to the potential future value in the following figure 4.5 to demonstrate where we are in our journey. It demonstrates an achieved value to date of $46.6 M in reduced annual costs and total capital with a potential further savings of $43.2 M through the identified activities.

Figure 4.4 Teck Savings Summary June 2015

Partial list of Savings to Date	Estimated Dollars
Wheel Motors	$5.4 M
Engines	$4.6 M
Partial Work Reduction from Sites	$4.6 M
Sub total on Costs	$14.6 M
Capital Savings on Haul Trucks	$32 M
Total	$46.6 M

Source: Internal slide prepared for Teck management presentation, June 2015

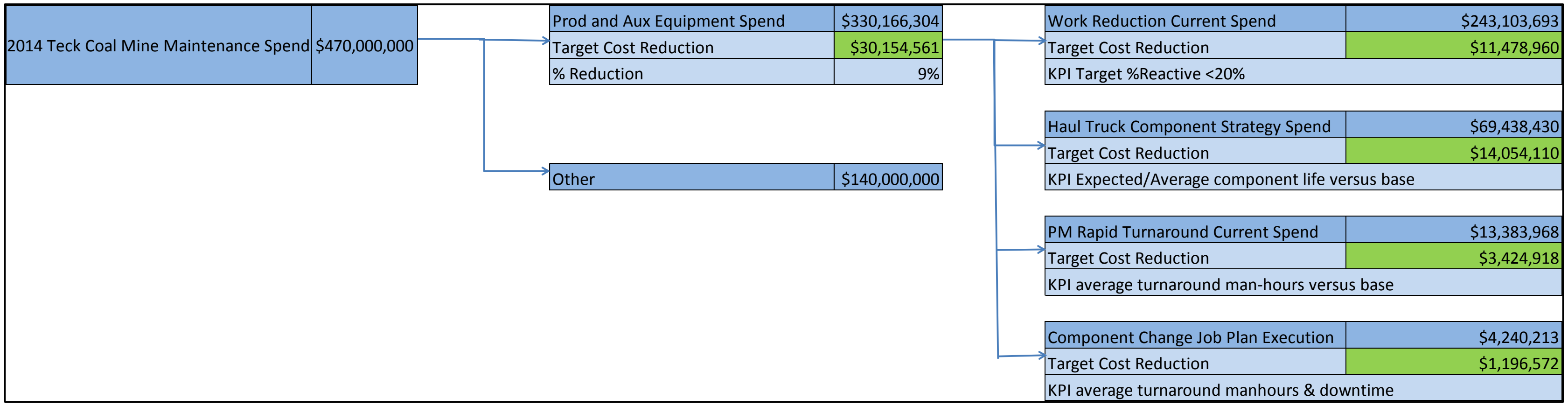
Figure 4.5 Planned Savings Summary June 2015

Planned Savings 2015, 2016	Estimated Dollars
Component Life Extension	$14.1 M
Work Reduction at Sites	$4 M
RTA on PMs	$3.4 M
RTA on Components	$1.2 M
Work Control and Further Reduction in Reactive Work including Pre-PM	$7.5 M
Sub total on Costs	$30.2 M
Capital Savings on Haul Trucks	$13 M
Total	$43.2 M

Source: Internal slide prepared for Teck management presentation, June 2015

The driver tree below in figure 4.6 summarizes the 2014 actual spend across sites and the expected and potential cost savings and includes the leading site metrics to drive behaviour. It does not include capital savings.

Figure 4.6 Value driver tree of total mine maintenance spend for Teck Coal 2014



Source: Data derived from 2014 work order cost data. April 2015

The cost estimate is conservative in that it does not include estimates of savings when improved availability on lower cost primary fleets reduces operating hours on higher cost secondary fleets or savings in reduced maintenance cost per hour as demonstrated in Fig. 2.2. These numbers will help identify the key metrics in the activity map to be developed in chapter 6.

The Activity map in chapter 6 will connect the savings identified in this chapter to the key performance metrics around P.M. and component change out turnarounds, component life, haul truck availability metrics by truck age, shovel MTBD, and the percentage spend of reactive maintenance.

5: Key Teck Differentiators

An objective of this paper is to understand causes for the program implementation being slower than planned and make recommendations for a faster return. In this chapter, I identify the Teck characteristics or differentiators from competitors to be considered in developing a successful major change initiative. Differentiators can include assets, resources, policies, culture and processes that would significantly influence the outcome of any major change management initiative. These characteristics can either enhance or inhibit change and so inclusion in implementation planning is critical to success. The differentiators are also important from a shareholder investors' perspective as they may influence choices as to which mining company to invest in.

The following items are Teck differentiators from other major mining competitors that were collected through site observations and discussions with Teck management employees with recent experience with other mining companies.

5.1 Geography

The biggest part of our business is in Canada and Chile. Five coal sites accounting for more than half of our mobile equipment are within one hour's drive of one another. Mining methods across sites are very similar as truck- shovel, open pit mining. Operational vice presidents are in close proximity of mine sites with regular contact. This creates advantages of synergy and change management.

5.2 People

Overall Teck has been successful in developing employees who are personally motivated to succeed. The offset is that it is challenging to implement change that requires discipline to new roles, plans, schedules, and outcomes.

- Courageous Safety Leadership has been a successful corporate initiative in developing a common value that motivates employees to take personal action to reduce risks and prevent personal injury.

- Trades Culture- There is a long term trade's culture that was once described as "If you give the tradesmen the tools, they will do a good job". Although effective in reactive work when the mines were smaller, it has developed a culture where people are empowered with limited accountabilities. Trades are able to scope their own jobs, identify their own parts, and complete work to their own defined quality standards with minimal supervision. The cultural result is that supervision to trades ratios are very high (up to 35:1), trades are resistant to follow job plans, trades are reluctant to sign and complete work orders, and planning, scheduling, and supervisory skills are weak. Process change requires a high level of individual engagement. Supervisors tend to be "coordinators" rather than actively directing resources towards a defined outcome.
- Retention- Although the retention of skilled people is a constant concern, retention rates tend to be better than our major international competitors. People tend to stay for long periods and sometimes return from other corporations. Teck has been successful in recruiting skilled people from other major mining companies.

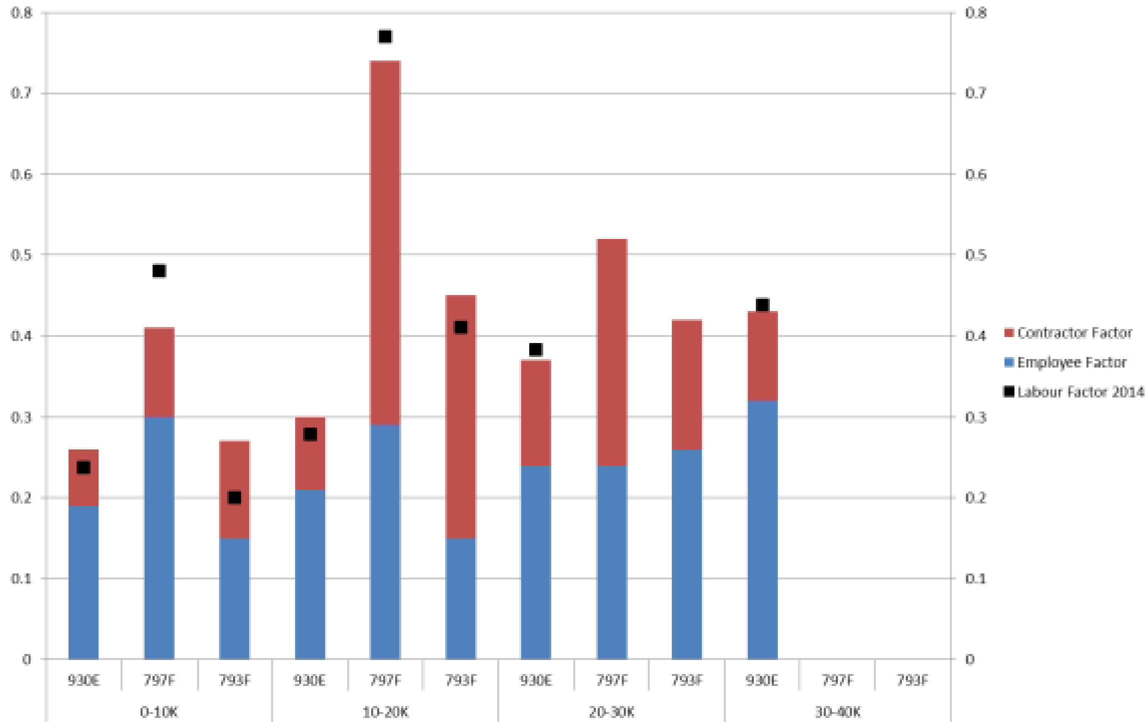
5.3 Corporate Culture

Teck is in the process of adjusting from a collection of independent mines into a medium sized mining company. From being very people successful to developing defined work processes. Teck has a position of being an early adopter of maintenance improvement but not on the leading edge and can learn from mistakes of others. We have been successful in recruiting maintenance staff from more advanced mining companies. Teck is one of the largest users of open pit mining equipment in North America creating synergy and leverage with vendors, but is small enough that there is a high level of personal contact and minimal bureaucracy.

5.4 Standardization of Equipment

Some standardization of equipment is giving benefit but it is a long ways short of South West Air's standard of Boeing 737 planes only. Haul trucks are primarily Komatsu 930Es, with fleets of Komatsu 830Es, CAT 797s, CAT 793s, and another ten types. Shovels are primarily P & H 4100 and 2800 but there are small numbers of another six types of shovels. Loaders and dozers are CAT, Komatsu, and Letourneau. Auxiliary equipment varies significantly to meet a broad number of requirements. From a maintenance perspective, the Komatsu electric drive truck requires significantly less maintenance man-hours per production hour, has better availability, higher average component life, and has lower component rebuild costs. Studies separate from this paper compare the truck fleets by unit cost considering productivity differences in banked cubic meters and kilometres, pay loads, and cycle times. Figure 5.1 demonstrates the large variation in maintenance labour requirements for different types of trucks and age. The best maintenance performance is with the 930E Komatsu electric drive truck.

Figure 5.1 Comparison of Teck maintenance man-hour per production hour for haul trucks by age



Source: April 15, 2015 Teck Vendor Meeting

5.5 Data Systems

Teck Coal has detailed work order data with better analysis tools (MS power pivot) than many other mining companies. History can be selected and sliced in a variety of ways which has contributed to the analysis in this paper. There is a reasonable ERP system with planning, scheduling, cost collection, and metric capability.

5.6 Summary of Teck Differentiators

The differentiators identified are considered in the Activities map in the next chapter to utilize advantages and identify areas for improvement. The standardization of lowest cost assets specifically mining trucks is not part of the current maintenance strategy and requires further study.

6: Activity Map and Value Proposition

In this chapter we organize the key outcomes of the previous 5 chapters to create an activity map similar to that for South West Air in "What is Strategy?" (Porter 2007). The map links the previously defined value proposition to Teck's assets, capabilities, and values. It considers asset types, work force practices, culture, business practices, objectives, and work processes. The map's objective is to present the critical activities at a management level of detail to provide an introductory overview of the critical elements

6.1 Activities Map

6.1.1 Value in Orange

The orange circles in the activity map represent the value proposition or shareholder value identified in Chapter 2. These are the outcomes or benefits of the program. The dollar value and availability improvements are the definitions of future benefits identified in chapter 4 directly related to the application of this plan.

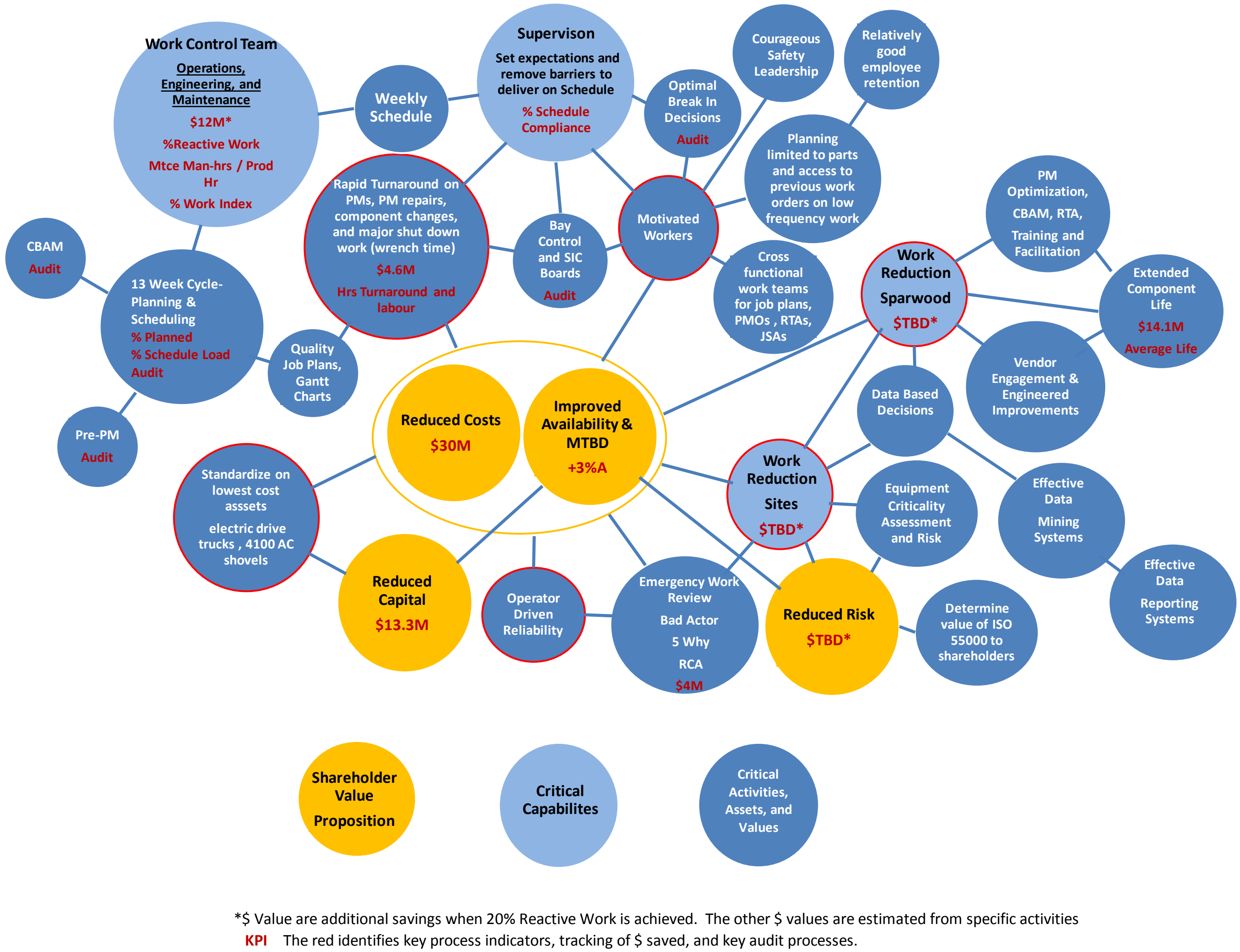
6.1.2 Critical Capabilities in Light Blue

The light blue circles represent critical capacity or resources for success as identified in the cause and effect mapping of chapter 3. Adequate resourcing, training, and coaching of the key roles of a work control team, supervision, site work reduction team, and Sparwood work reduction team are critical to success. The minimum key process indicators to drive success are identified in the circles. The work reduction teams metrics will be measured in cost reductions related to failure avoidance, increased pro-active maintenance, and extended component lives. They are noted as To Be Determined (TBD) in the map but will be a major contributor to the additional savings of $12 noted under the work team savings for reducing reactive maintenance. The effectiveness of the work reduction is only as good as the application of recommendations in the field, which is the responsibility of the work control team.

6.1.3 Critical Activities, Assets, and Values in Dark Blue

The dark blue circles highlight the key elements identified in the cause and effect diagrams of chapter 3 and the key Teck differentiators of chapter 5. They are grouped around the management areas of critical capability with connecting lines showing direct responsibility. Future savings reductions and key process indicators directly related to the activities are identified.

Figure 6.1 Teck Coal Maintenance Activities Map



Source: Author's representation

Shareholder Value Proposition- The four areas of value are identified in orange. Note the circle connecting reduced costs and improved availability & MTBD as the activities contribute to both simultaneously. The dollar values are those identified specifically in chapter 4.

Critical Capability- The four areas of work control team, supervision, Sparwood work reduction and site work reduction (reliability teams) are identified in light blue. These are critical areas that require adequate staff structure, skills, and training for success.

- Work control team- This team representing operations, engineering, and maintenance management is responsible to assure the effective reduction in reactive work through the effective application of work reduction, execution of planned and scheduled work in the 13 week cycle and execution week, and operator driven reliability. They require a high level of understanding of the related processes. Joint ownership by operations, engineering, and maintenance is critical to success. The additional value of $12 M savings related to a reduction in reactive work is assigned to the work control team as the overseers for the effectiveness of the work reduction teams and the planning, scheduling, and execution teams. A change in culture to focus on reducing reactive work is required.
- Supervision- The effectiveness of this position to set expectations with the crew and lead to deliver on the schedule is critical to success. It requires support in overcoming cultural barriers of resistance to follow a plan. It requires supervisors to take on a strong leadership role.
- Work Reduction Sparwood office- The close proximity of sites, common mining methods and equipment, and a common data system (ERP) equips this role to add significant value in data analysis and vendor engagement for developing component management strategies and vendor product improvements. A higher level of expertise can be attracted to and developed in a central role. There is significant value in developing and utilizing a common data system in transitioning to data based decisions.
- Work Reduction Site- The site reliability teams at sites are positioned for savings through emergency work reviews, 5 why, root cause analysis of site specific work and operating processes. They are situated well for real time observations and analysis and improvement of work processes and facilitating cross functional problem solving teams. A key part of success is to keep them from being assigned to reactive work and to develop an employee culture of looking below the events to identify and resolve the underlying and root causes of reactive maintenance.

Critical Activities, Assets and Values - The mapping exercise also identified five areas of focus worthy of additional mention for contributing to success. They are identified in figure 6.1 with a red outlines and are specifically; rapid turnaround, worker motivation, work reduction in central and site roles, operator driven reliability, and standardization of equipment.

- Rapid Turnaround (execution of planned and scheduled work) is limited to P.M.s, component changes, P.M. repair work, and major maintenance shut downs. Execution becomes the measure of success for the planning and scheduling effort to capture the highest value on significant repetitive work. This is a departure from the previous objective of planning and scheduling being applied to all work to the same level.
- Worker Motivation recognizes that the sites have a core of workers with a high level of personal motivation. These higher skilled workers can be used most effectively on the smaller low frequency jobs that would require significant effort to plan due to the multitude of different types of support and auxiliary equipment. Worker motivation on rapid turnaround jobs would be developed through cross functional team engagements to develop the best practices. Workers have responded positively following participation in rapid turnaround exercises.
- Work reduction in central and site roles has the greatest value in reducing reactive work by identifying and addressing root causes. Key part of success is developing and utilizing a cross site data system to make data based decisions. The reliability teams play a role in auditing the effectiveness of activities on the floor.
- Operator Driven Reliability- It can be said that the operator can have a greater influence on reliability than the maintenance department. The importance of this surfaced in this exercise and has been lagging in development. Operations need to be an active part of operating equipment within limitations and in identifying pending failures. This activity needs formal development of definition and metrics.
- Standardization of Primary Trucks and Shovels- The data shows the Komatsu electric drive truck as having the lowest maintenance effort and highest reliability compared to mechanical drive trucks. It is recognized that standardization is subject to an analysis of unit costs per volume - kilometer and so the size of truck has to be part of the analysis. The P & H 4100 AC shovel has already been recognized as the shovel of choice. Efforts to standardize auxiliary equipment would be a benefit although the specific requirements of application will limit this.

6.2 Summary of Activity Map

The activity map can focus management effort for targeted improvement. The map identifies the connections between shareholder value, key management capabilities, and critical processes, assets and values. The map will become a common reference point for the change management and the implementation plan to follow in Chapter 7.

7: Implementation Plan for New Strategy

In this chapter, I use the framework presented by Porter in “Leading Change, why transformational efforts fail” (Kotter 2007) to evaluate the implementation effort to date and make recommendations for a renewed strategy. I examine each of the eight steps defined by Porter as they apply to this initiative. Kotter emphasizes that the “right order” is critical to success and that short cutting or failure in any one step will lead to overall failure, therefore it is important that each step be assessed.

7.1 Establish a Sense of Urgency

The original justification for a new maintenance program in 2010 was the corporate recognition that maintenance was a critical part of our business and a major expense. The success of an earlier effort by the Trail operation showed significant reductions in maintenance workers and expense. The business value was estimated as $100 million to $200 million in reduced costs and increased revenue across Teck. At the time, the knowledge to implement the required cultural change and new processes across a corporation was limited and the effort was underestimated. In addition, the ability to adequately report and measure cost data in a credible manner is only recently available within the coal business unit.

The current sense of urgency is described as follows:

- The current price of coal is the lowest in a decade and requires significant changes to individual mine operations to stay profitable and meet critical capital investments. The conditions of world coal oversupply and a significant slowing of imported coal by China indicates that the low pricing will be in place for an extended period. The potential for this project to achieve a short-term reduction in costs of $30 million while improving equipment performance, reducing risk, and reducing sustaining capital is significant. The targeted maintenance activities in this paper are applicable in a tight market because they result in lower costs that can be implemented through effective management leadership with minimal or no external expense.

- The new processes resulting in improved wrench time, reduced maintenance work, and quality job plans all contribute to the ability to expand mining capacity in the future through a pending maintenance trades shortage related to an aging trades population and slow uptake of trades with a new generation. The pending loss of skilled heavy-duty mechanics and potential shortage has been a business risk for several years. These new processes including job plans and job standards are the best alternative to capture their knowledge and effectively transfer that knowledge to the future generation.
- Mining is an industry of low and high economic cycles. The benefits of these processes apply to all parts of Teck's business, not just coal.
- The targeted processes improve availability while reducing costs. There is an estimated improvement in haul truck availability of 3%, annual cost savings of $30 M and capital savings of $13 M.

Successful companies that have achieved the full benefit of changing to a pro-active culture have developed it either over several years or decades, or with significant external consulting cost, or they were driven by extreme cost or risk conditions. This paper right sizes the program to maximise short-term gains with internal effort only in a cost constrained market condition. The overall benefit is less than originally envisioned but is achievable and has the potential to establish islands of cultural change that can expand by example to whole scale change in the future. Kotter advises that 75% of managers must be convinced that business as usual is totally unacceptable to create the required urgency. This right sizing of the initiative will be more convincing.

7.2 Create a Powerful Guiding Coalition

The original maintenance program was initiated in 2010 by the newly formed Teck operating excellence group and was endorsed in a daylong workshop involving operating vice presidents and general managers from across Teck. The President and CEO of Teck has supported the initiative issuing a "Physical Asset Management Policy" with the key closing line of "Finally, we believe that reliability is everyone's responsibility and that we all have a part to play in identifying and eliminating failures and improving overall efficiency." Support organizations were set up in the Vancouver, Sparwood, and recently Santiago to facilitate the implementation. As described earlier in this paper, due to complexity, the initiative has failed to engage senior management, middle management, and supervision in a way to accomplish whole scale cultural change although there have been significant benefits achieved in the areas of reliability engineering, planning, and scheduling. The guiding coalition needs to be revisited to target changes in effectiveness of management decisions, leadership, and execution on the floor.

There is an outstanding directive from the Chief Operating Officer to the operational excellence group of Teck to create a steering team for the maintenance initiative. The operational excellence group will be proposing a structure including a steering team of vice presidents and managers supported by a working group of knowledgeable managers and reliability leads. This new format will formalize a link with senior management to be more effective in growing the program. The discipline of regular reporting of progress and results across sites by a knowledgeable working group will be significant in identifying and removing barriers. The coalition should draw together the efforts and wins in the current islands of success. The reduced scope is achievable without major external consultant expense with trackable cost benefits. Kotter cautions that in big companies the coalition needs to grow to the 20 to 50 range before notable progress is made in the next step. The coalition for success expands from the steering team to include the operations vice president, site general managers, work control teams representing site superintendents or general supervisors, and supervisors of the planning, scheduling and work reduction teams. All of the guiding coalition will need to be familiar with the level of detail portrayed in the following vision and activity maps. The leaders of the individual activities in the maps will need to be knowledgeable in their respective areas in the cause and effect maps in Chapter 3 and the related portions of the Teck requirements document and manual.

7.3 Create a Vision

Kotter speaks to the need that a vision must be a “clear and compelling statement of where all this is leading” and the rule of thumb that a vision must be effectively communicated in less than five minutes. The initial vision of “The right work, at the right time, for the right reasons” was effective for those people actively involved in the program but too general for wide spread engagement. The use of the maintenance pyramid and the requirements document was too complex and required several hours of explanation to engage even knowledgeable maintenance managers. On July 31, 2014, there was a step improvement in managerial engagement in Coal by defining the maintenance initiative as “Five Best Practices”. This identified critical elements of applying the program to specific fleets to obtain early returns and is summarized in the following slide:

Figure 7.1 Five Maintenance Best Practices

1. **Pre-PM's**
2. **Improved wrench time on common jobs**
3. **Effective Work-Control-Teams**
4. **Supervision**
5. **Work-reduction processes**

Source: Teck Presentation at June 23 Operators Meeting

The above representation is a brief presentation of the five best practices and serves as introductory headings requiring further explanation. This paper has undertaken a much more extensive analysis developing an activity map confirming the value of these practices with greater emphasis on the <u>execution</u> of planning and scheduling and an important differentiation in separating work reduction efforts of the site and Sparwood offices to achieve the best value. In addition to the best practices, this paper adds the activities of “Operator Driven Reliability”, “Standardization of Haul Truck Fleets”, and “Equipment Criticality Assessments”.

There has been value created in brand recognition of the term “Five Best Practices” that we can build on. The following is a first attempt to explain the objectives in less than 5 minutes:

The Maintenance Initiative adds shareholder value through reduced operating costs, reduced capital, increased equipment capacity, and reduced business risk. In the current market downturn, the short-term benefits of a renewed implementation strategy are reductions in costs of $30 million, reductions in capital of $13 M, improved equipment availability of 3% and reduced business risk. The renewed strategy is achievable through managerial leadership without external consulting costs or major additional costs. There is longer-term potential of reducing maintenance costs, the second highest cost of mining, by a total of 30%.

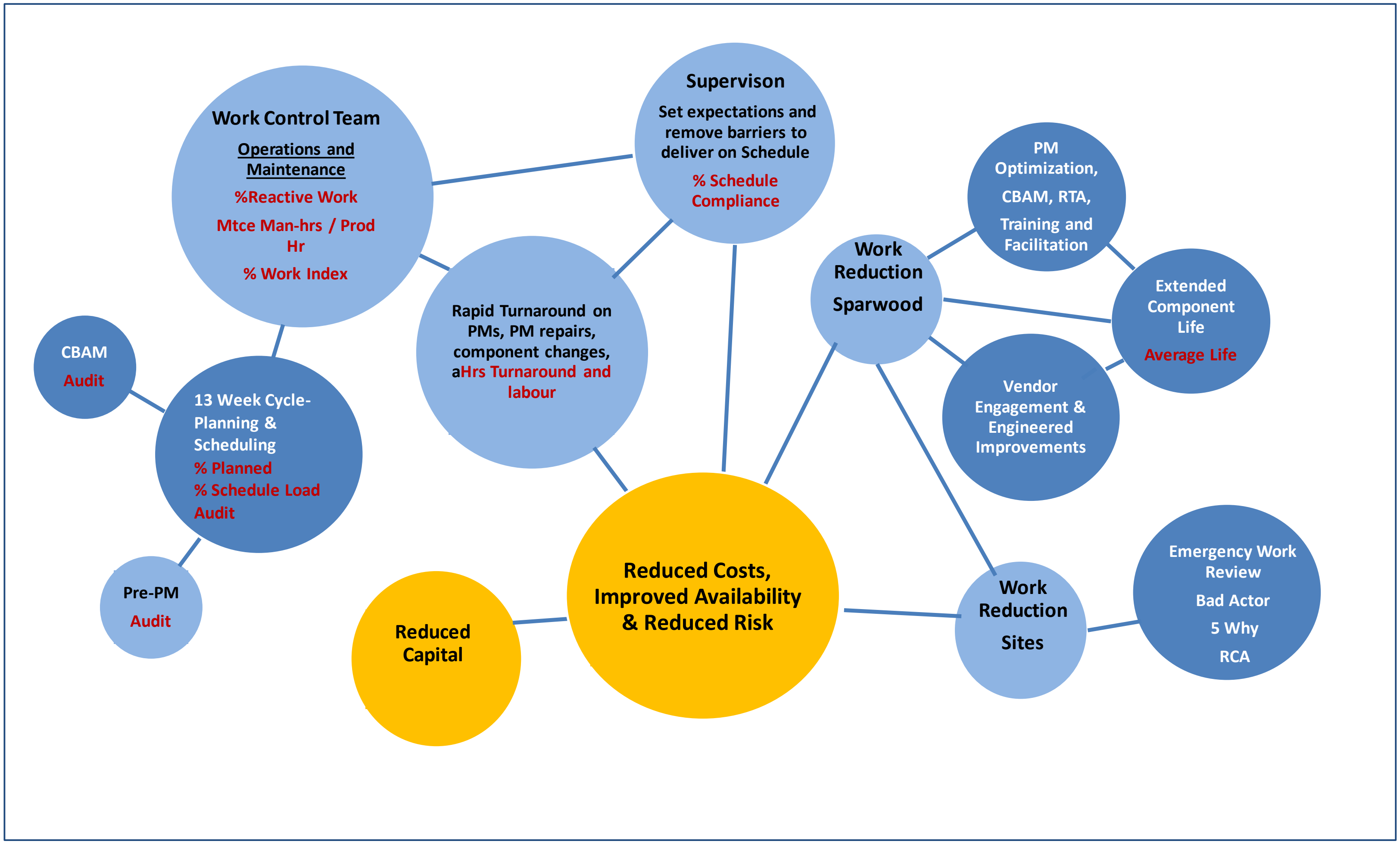
The five best practices are:

- High value field inspections prior to performing major preventative maintenance (Pre-P.M.s) that effectively identify work requirements for planning, scheduling, and efficient execution of pro-active maintenance.
- Rapid Turnaround on P.M.s and component changes for major production fleets.
- Effective Work Control Teams – Operations, engineering, and maintenance effectively manage the overall effort to reduce reactive maintenance work, and assure effective development and execution of pro-active work.
    - Maintenance and operations management take joint responsibility for reductions in reactive work.
    - The team applies the 13-week planning cycle and assures the effectiveness of planning and scheduling. The team understands the value of a full schedule load and the effects of "Parkinson's Law".
    - The team oversees the effectiveness of work reduction efforts.

- Effective Supervision achieves timely and quality completion of the work schedule by providing active leadership in setting expectations and removing barriers for a skilled and motivated team. It requires manageable supervisor to trades ratios.
- Effective central (Sparwood) and site work reduction teams- The effective application of data based decisions to minimize reactive work by extending component life, optimizing P.M.s, improving maintenance and operating practices, and engaging vendors to drive engineered equipment improvements.

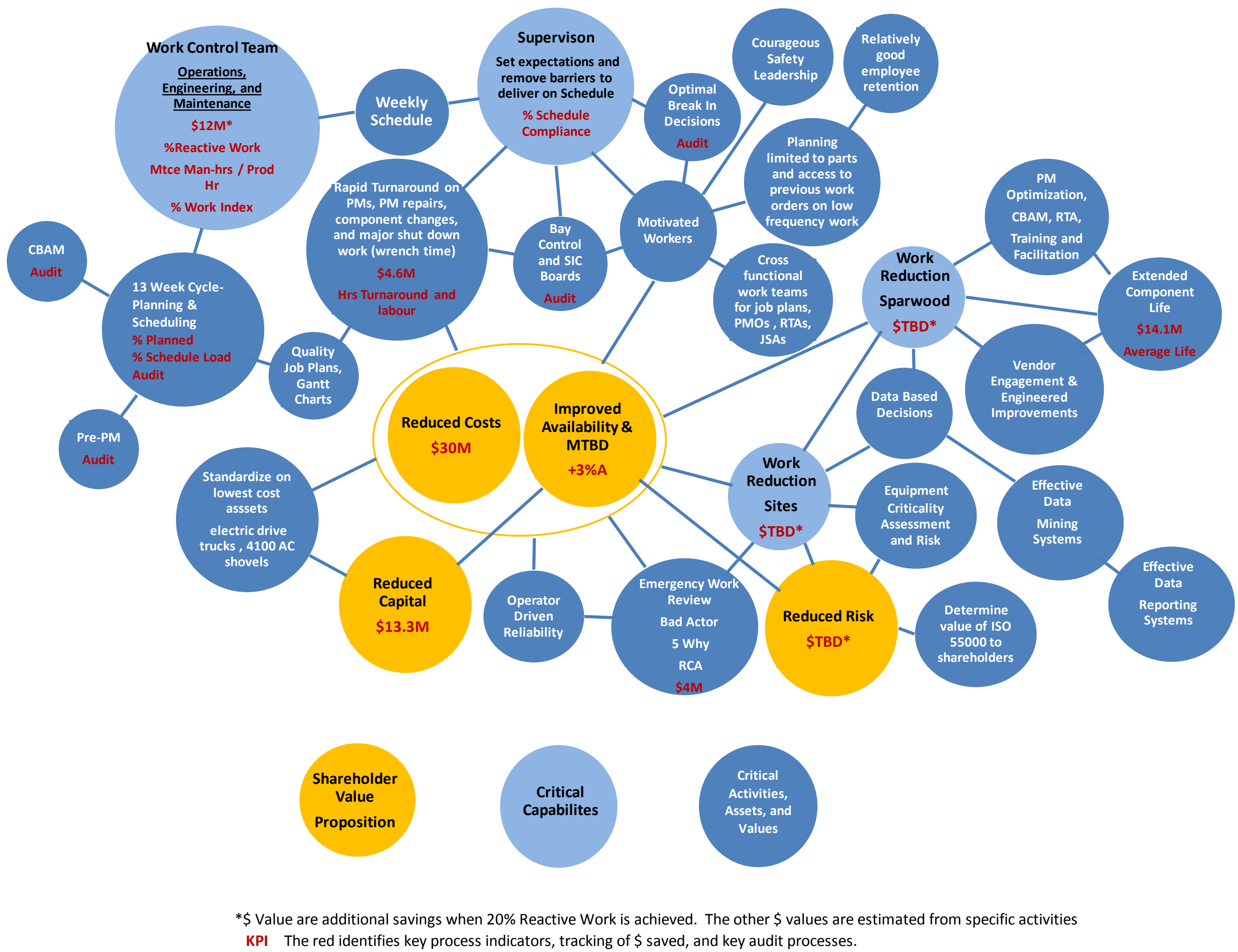
In addition to the five best practices there are the additional core activities of Operator Driven Reliability, Standardization of Haul Truck Fleets, and Equipment Criticality Assessments that are required to achieve the greater longer-term benefits.

Figure 7.2 Simplified Activity Map for presentation of current state of engagement



Source: Author's representation

Figure 7.3 Larger Activity Map for guidance in implementation



Source: Author's representation

The objective of this new representation of the vision is to reduce the complex application of the maintenance pyramid into manageable pieces that obtain the highest short-term value to be delivered through site leadership. It is intended to find an optimum representation between previous attempts that were to general or too detailed. The effective application of this vision in the short term will develop momentum growing the initiative into the broader application to achieve the full benefits of a pro-active maintenance program.

7.4 Multiply the Communication Plan by a Factor of 10

Kotter emphasizes the considerable effort it takes to communicate change effectively and the need to use every available resource. Attempts to engage management and workers to date have been inadequate to achieve wide spread organizational change. Teck has recently recognized the need and resourced change management coaches that aid managers to target the people side using the ADKAR model of change (Jeffrey M. Hiatt 2006). The model describes that organizational change requires each individual employee to go through a sequence of awareness, desire, knowledge, ability, and reinforcement (ADKAR) and that every individual involved in a change needs to be engaged five to seven times before behaviour changes. My own experience adds that the five to seven times must be in many different forms to connect with each individual. The model provides a means of planning for change including identifying the key sponsors and supervisors, and developing an intensive communication plan that engages. Recent training on the concepts within Coal has raised management awareness of what effective change management means and a renewed effort at this time could be effective. A key element for success is that managers can articulate the simplified vision easily. A renewed change management plan will identify and coach the key management sponsors and supervisors. It will focus on these areas:

Senior management demonstrates leadership in day-to-day decisions and engagements with all level of employees that portrays the culture described in chapter 2 for Scottish Power of a chronic sense of unease and lacking of any sense of complacency. Leaders act strongly to weak signals and set their threshold for intervening very low, given the understanding of the condition of their assets. They create the expectation and empower workers to demonstrate the same characteristics through floor engagements and formal management meetings.

- A typical messaging would include “Why was there a pre-mature failure on that major component? How are we changing our practices to prevent future failures? How are we reducing the level of reactive maintenance? Are we responding to early indicators on the mobile equipment monitoring systems? Are we effective in the execution of pre-P.M.s, and rapid turnarounds? Are we effective in our work reduction effort in extending component life?” Success will be dependent on management’s understanding and commitment of the objectives and processes.
- Communications at the floor level will include graphs showing progress on items they directly influence such as trends on turnaround times on planned and scheduled work and worker success stories in resolving component failures. The bay control boards described in chapter 3 are a key instrument for communicating improvement actions.
- Communications to middle management will focus on reporting results and both leading and lagging metrics. Sites will implement a superintendent or leader’s board to report and manage key results. The tracking of expected savings identified in chapter 4 will be part of this.

7.5 Remove Obstacles to the New Vision

Kotter speaks to the challenges of involving large numbers of people that are emboldened to try new approaches and to provide leadership within the broad constraints of the overall vision. In the previous five years, we have learned that communication in itself is not enough. Some recent changes in approach with a measure of success are:

- Some sites have demonstrated value in assigning new people in middle management positions with the correct skills to achieve results.
- The format of the Sparwood quarterly reviews with sites has become more direct and site specific in identifying potential issues.
- Formal peer to peer reviews auditing the application of the five best practices has been effective in developing achievable improvement plans.
- The future application of ADKAR change management processes will identify specific barriers.

- The knowledgeable application of key objectives in personal employee annual improvement plans specific to the level of management.

Possibly the greatest obstacle is the general acceptance that reactive maintenance is normal and the maintenance role is to get the equipment "up". There are few people in the organization with experience with the types of decisions required to "keep equipment running" of a pro-active maintenance culture. It is expected that the systematic resolution of issues and resultant improvements in availability and mean time between downs will develop the belief required.

7.6 Create Short Term Wins

Kotter cautions that transformation is a long journey and most people do not go in the long march unless they see compelling evidence. With the exception of a progressive improvement in availability in the 930E haul trucks over a four-year period, the wins to date are generally unknown. In the preparation of this paper I have identified many examples of successes that are not widely known in spite of all be reported in some manner somewhere. As a first step, I have prepared a slide deck of successes for personal presentation to engage senior management. Kotter also recommends producing short-term wins which is a new effort to be planned for.

7.7 Don't Declare Victory Too Soon

Kotter cautions against declaring victory too soon, as new approaches are fragile and subject to regression. Our greatest example is frequent digressions in the scoring of the maintenance pyramid at several sites. Kotter advises that the time for change to sink deeply into a company's culture can take five to ten years. Tradition is a powerful enemy and old practices creep back in quickly. A new effort needs to more effectively document the progress year over year.

7.8 Anchor Changes in the Corporation's Culture

You sometimes hear within Teck, Kotter's term that the goal for change is that it becomes "the way we do things around here". The work processes are well defined and documented in the manual and related documents but the application in the field varies widely. We have several examples where new processes were lost without a whimper when the sponsoring general supervisor or superintendent moved to another site and were replaced with a leader with a different focus. It is not enough for the new people not to be a resistor, but they must be a change champion. Our long time culture is to reward individual initiative and therefore employees do not readily embrace defined work processes. We are undergoing a cultural change from a group of successful but smaller individual mines to a mid-sized mining company with larger sites creating the need for defined best work processes. The challenge is to make the transformation successfully while maintaining the positive attributes of motivated individuals. Having the answer to the best way to do something is often not effective until the affected individual asks the question. It is encouraging to see positive "discoveries" by individuals of value that was already been identified in the maintenance manual. Kotter speaks of the need for ingraining the changes in a widespread way so that it can weather changes of individuals with different backgrounds and management styles. He also speaks of preparing the next generation of managers. A large South African company attributed their winning of an international maintenance best practice award to the fact that their reliability engineers were now progressing to senior management positions. No plan is suggested at this time, but managers' awareness of this important point is encouraged as they can be asking these questions along the journey, "Is this now the way we do things around here? Will it sustain through future employee changes?"

7.9 Summary of Implementation Plan

We have fallen short on each of Kotter's steps for successful transformation. This chapter introduced a new definition of urgency, a new guiding coalition, a new definition of the vision, and a frank observation of the other five steps Kotter advises are critical to success. The new strategy is a fundamental shift from a generic whole scale implementation of change to a targeted implementation of specific activities to specific applications within our business. The expectation is that this will achieve early returns without having to achieve the major cultural "tipping point" of change required to shift the entire organization from primarily reactive maintenance to pro-active maintenance. The expected return is smaller but more achievable. It is expected that the effective application of the targeted applications will provide the visible learning for management and workers to change behaviour and culture that can be grown to accomplish the original overall objective.

Key to success is the guiding coalition's ability to engage the personal motivation of the workers on the floor while leading to a targeted outcome. Note the importance of cross-functional improvement teams and supervisory and management worker engagement referred to in chapters 3, 5, 6, and 7.

The journey to pro-active maintenance culture is exactly that, a journey. At this point we learn from our shortfalls and reset for success. In the course of this journey, many pioneers of pro-active maintenance have surfaced within Teck and as their influences grow, major cultural change will occur. A journey of a thousand miles is one step at a time.

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