IMPROVING MINING PROFITABILITY
BY EFFECTIVELY MANAGING YOUR ASSETS

How an International Coal Mining Company Revamped its Asset Reliability Program to Adapt to Market Fluctuations

Charlie Payne
Senior Operations Manager
Global Mining & Metals Practice

USC Consulting Group

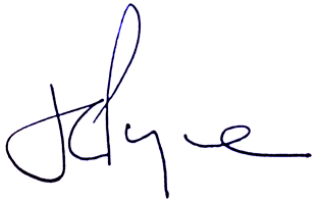
Significant capital investments are not always required to drive profitability. Inexpensive and sustainable approaches to building a profitable and world-class mining operation include:

- Updating asset reliability programs using work identification methodology
- Building critical skills and knowledge bases in core operations teams
- Developing a comprehensive and adaptable Mine Management System

USC Consulting Group (USCCG) has implemented maintenance management programs at various mines throughout the Americas, Eurasia, and Europe.

In this eBook, you will gain first-hand knowledge of strategies, processes, and methodologies necessary to develop an asset maintenance and management program, as well as how it was implemented at multiple mine sites for a major international coal company. You'll find that the lasting results are well worth the effort.

Should you have any questions, please feel free to contact me directly at charlie.payne@usccg.com.



About Charlie Payne

With over two decades of Operations Management Consulting experience, Charlie has worked all over the globe helping clients implement World Class Maintenance, TPM, Six Sigma, Lean, and Supply Chain Management principles.

He has worked in many industries including Mining, Oll & Gas, Power Generation, and Food Production and as he puts it, "I enjoy helping clients achieve the desired business results while bringing meaningful and lasting change to their operation."

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As worldwide commodity prices continue to fluctuate, many industrial sectors are struggling to right-size their operations, and match increased demand with the availability of their major assets.

Featured Client Details:

Revenue:	$8 Billion
Tons Sold:	250 Million
Number of Active Mines:	28

The increased need of major assets such as haul trucks, shovels, and bulldozers has become essential to boosting production, and so the need to leverage fixed assets has never been more critical.

Consider that the value generated from increased asset utilization has a multiplier effect. Just a 1% improvement in utilization can have an exponential effect on the bottom line.

However…what might be true in theory is often not fully realized in practice. Why? Because assets have become more expensive to maintain and operate, which has diminished the value of increased production.

Leveraging fixed assets by keeping maintenance and operating costs low should be one goal of any mining company. A fleet of mobile mining equipment can in some cases represent billions of dollars in capital investment. Keeping it well maintained and capable of meeting present and future production demands requires a robust and efficient Asset Reliability Program.

Maximizing the utilization of your mission-critical heavy assets can be a key driver to improving financial performance.

Keep the Equipment Working and Keep the Costs Down

In short, this was the major objective of our client, to leverage their fixed assets by keeping maintenance and operating costs low. We were tasked with helping them accomplish this by:

- Developing a Work Identification methodology.
- Transferring skills and knowledge to their team.
- Equipping them with the tools to accelerate their ROI over a three-year period.

Tackling these objectives required not only our expertise but technology to enable long-term success, so we utilized asset performance management software.

While improving the reliability of the mining equipment, the actual business of digging up coal could not be ignored. To manage both simultaneously required a comprehensive, adaptable Mine Management Operating System (MMOS).

Developing the MMOS is an interactive process, involving the mine engineers, operations, and maintenance personnel to determine what their assets can achieve over the next year to 20 years, and coordinating with the finance department to determine at what cost this production will be met. From these plans the detailed one-year plan is often broken down into monthly buckets and, from there, to weekly plans.

Each week, Maintenance, Operations, and Engineering meet to review their attainment to the plan. Did they miss the plan? By how much? Was the right sequence followed for development and production benches? What do they need to do together over the next week or month to recover and what equipment reliability will they need to get there?

Even with this strict focus, the mine plan can often go wrong from the very start. To mitigate this as best they can the company established four specific goals:

Goals of the Asset Reliability Program and Mine Management System

1. **Develop leading and lagging KPIs that allow the Asset Reliability Program and Mine Management Operating System to monitor performance.**
2. **Implement a program of condition-based proactive maintenance and a capacity plan based on optimizing the use of existing assets.**
3. **Optimize mine production through effective use of equipment and personnel.**
4. **Continuously track the operating conditions, maintenance requirements, and history of key assets on site, while ensuring that the information is actionable.**

Creating a Foundation of Knowledge

Prior to retooling the Asset Reliability Program, we began examining the company's critical and non-critical assets using the two Work Identification methodologies. We chose two software packages: RCM2™ and Maintenance Task Analysis (MTA). RCM2 was chosen for the critical assets because it relies on formal analysis in a facilitated group forum to establish the foundation for a comprehensive Asset Reliability Program.

MTA was used for non-critical assets because its semi-formal analysis, done in either a facilitated one-on-one series of interviews or group environments, fosters quick development and documentation of the basic requirements for an Asset Reliability Program [Moubray, 2001].[1]

As part of the knowledge transfer process we trained and equipped the mining company's Core Teams, a total of 15 employees based at three sites, in the analytical and facilitation skills they would need to make the transition from the old to the new approach.

For two months, the Core Teams received instruction in the software, and the associated technical and facilitation skills they would need over the next three years.

Building the Asset Reliability Program

Over the next four months, the Core Teams were mentored as they conducted MTA and RCM2 analyses on three large assets:

- CAT 789B haul truck
- CAT 5130B track hoe
- P&H 4100 shovel

Core Teams assigned to each asset consisted of subject matter experts (SMEs) including asset operators, mechanics, electricians, and corporate management. Through a Work Identification methodology, the Core Teams were able to determine the proper equipment maintenance requirements and intervals, so that the right work would be done at the right time. By developing Preventive Maintenance (PM) using condition-based indicators, scheduled restoration, and discard intervals, the company was able to build a proactive maintenance system.

When this system is fully implemented, there will be a higher percentage (>80%) of tasks driven by some form of condition monitoring and a much lower percentage (<20%) of time-based tasks, or tasks related to operating age. In addition, the failure analysis will identify the corrective work to be performed when early signs of failure are detected.

Condition monitoring tasks, driven by an understanding of failure modes, create a picture of equipment health from visual inspections and the appropriate use of predictive technology (thermography, vibration, and non-destructive testing) and online equipment data (pressure, temperature, flow, amps, etc.). Managed appropriately, this data prompts actions that can prevent further failure. The Core Teams' methodology was

applied to every component of the assets. These were broken down into such major classifications as engine, hydraulics, steering system, and fire suppression. As a result the following failure modes were created:

- 454 Failure Modes for the CAT 789B haul truck
- 412 Failure Modes for the CAT 5130B track hoe
- 559 Failure Modes for the P&H 4100 shovel

As Work Identification was completed on each asset, the Core Teams integrated their findings using updated PM check sheets, inspection routes, and modifications to the assets to address safety, environmental, and operational concerns.

The Maintenance Management System

As the Asset Reliability Program was developed, ongoing operations still had to be measured and controlled. By devising a core set of leading and lagging KPIs, on which successful programs rely, maintenance and operations teams were able to address work management issues outside the Work Identification portion of the project. Using the KPIs, the company was able to determine where it stood in such areas as Schedule Attainment, % Work Planned, % Proactive Work, Backlog, and Mean Time Between Failure. Work management controls were then implemented and monitored to improve downtime, tonnage per truckload, unitization, and adherence to scheduled hours [Wireman, 2004][4].

Results For the 3 Assets Included in the Project

- **Schedule Attainment increased from 68% to 91%**
- **% Work Planned increased from 45% to 83%**
- **% Proactive Work increased from 65% to 87%**

World Class Maintenance Management

Climbing the ladder to world-class status begins with determining where a company stands against world-class reliability maintenance principals and standards. This requires an in-depth analysis in all key maintenance areas, including organization, work order system, planning and scheduling, inventory and purchasing, reporting, and use of technology. Then, typically, a pictorial overview of the current flow of maintenance information is developed. This requires involving every employee in a review of their role in the maintenance process and putting every activity into a schematic diagram. Once this view of current operations is in place, the percentages of the day spent on adding value, performing non value-added tasks, or time idle is documented and graphed for all to see. This can be an extremely enlightening experience. A visual management system that displays daily targets for each trade is then installed to help keep everyone focused on individual turnaround times and that of the mining assets. Most importantly, management skills at various levels are upgraded through training and on-the-floor coaching.

Poor planning and scheduling, along with unplanned maintenance, significantly eroded production capacity. By learning the client's entire operating system from top to bottom, the team was able to quickly identify and address the key areas where the capacity erosion was occurring.

The Right Equipment at the Right Time

Determining whether use of the haul truck fleet, loaders, and operators has been optimized consistently over a number of shifts is not as simple as it might seem. If the mine moves a lot of BCM for the day, everyone goes home satisfied with a good day or even a great day. We see results like these reflected in good shifts, days, and occasionally, up to a record month, but we rarely see it reflected in the consistent, credible attainment of the mine plan and budget – whether for costs or volume.

The difficulties arise first with the equipment mix, including the variety of truck sizes, ages, and manufacturers, as well as the mix of load units. Add to this the variation in haul distances and the ever-changing conditions, e.g., weather or equipment reliability issues, and it all has a great impact on the shift. Often the mine conditions change very early in a shift, which leaves the pit foreman and dispatcher to make the best decisions they can best align the equipment.

In this instance, the mine dealt with this complexity by ignoring it. It was much easier for them to break down the monthly or weekly plan into a flat daily plan, aiming for the same volume to be moved regardless of equipment, planned maintenance, or pit conditions. On a good day the plan could be exceeded easily. On a bad day however, the pit could work very hard but because of bad weather, unplanned breakdowns, or even planned maintenance on a key shovel, the attainment to the plan could look terrible, and even worse, demand some explanation!

This can erode the mine plan's credibility and, by extension, the mine management team's credibility with the operators in the pit.
In this situation the early challenge is to understand the flow of the pit and what is actually happening, and the only way to do this is to go out in the pit to observe the process in action. Typically, we have seen that as attainment to the mine plan drops, the natural response is to push more trucks and assets (cost) out into the pit. The logic is that more trucks and equipment means more volume. However, this is a very slippery slope. Pulling more trucks into the pit to the detriment of any planned maintenance means a constant search for more trucks (in this case even starting up some old ones). Availabilities dip as planned maintenance is lost and production volume suffers. Ultimately costs increase while production decreases.

By delving into the facts of the process and flow, we are able to see, in many cases, that the larger number and mix of trucks actually causes bunching, with the newer, faster, and often bigger haul trucks delayed behind smaller, slower, older trucks. More trucks often just create more bunching with increased wait times -- and increased employee frustration -- at the loaders and dumps.

The solution requires a very bold step. Placing some of the trucks in maintenance removes them from this cycle, reduces bunching, and can even increase production volume. Relieving this congestion enables the mine managers to dig into more detail to the next level of opportunity.

Knowing Where and When Equipment Should Be Ready to Go

The complexity and diversity inherent in the operation because of constantly changing mine conditions must be considered. This is where capacity planning plays an important role.

Capacity planning in its most basic form is math. Most mines know their cycle times - spot, load, haul, and dump times. These are often very well monitored through the use of a Mine Dispatch System. But how this system provides real-time data that is meaningfully reflected against a live plan that can change as circumstances change is the real challenge.

Getting live data for the operating equipment to feed an improved OEE (Overall Equipment Effectiveness) is a step in the right direction.[5] this allows us to look at the shift and ask: Did we get the most out of the equipment? In many cases the OEE is still based on some of the calculated optimums taken from the cycle time data, so the next level of detail needs to dig into what the optimum should have been for the changing conditions for that shift. To this a Capacity Model has added the ability to tie in pit conditions that allow us to evaluate how the pit performed with the varying equipment, in existing weather conditions.

It was important to make the interface between the capacity plan and the foreman easier if we wanted the tool to stay in place. This was accomplished through the use of "drag and drop" menu items. When configured, this tool allows supervisors to move equipment as quickly as pit conditions change and, from there, establish new optimum production goals. Foremen and dispatchers can look at the changing scenario in the pit and move their equipment around in a capacity plan to determine the best scenario. At the end of the shift, this can be used as a true reflection of what the optimum was, against which the actual production can be compared. This gives the pit crew credit not only when it has worked hard in difficult conditions, but also when it has pushed on easier days to not only exceed a level plan, but also achieve an extraordinary result.

In this way, operations can work against a plan that reflects their actual situation, so they can achieve better results while at the same time working with maintenance and planning in a closer format to meet or exceed the mine plan - all at a reduced cost.

- By highlighting equipment and assigning it to the specific bench for the day, the application calculates the maximum amount of material that can be moved from each site.
- Adding or removing resources automatically causes the shift's plan to update.
- After populating the planned efficiencies and hours for the equipment, the program gives a quick synopsis of the day's schedule for each dig site.
  - ⇒ Scheduled Load Unit BCY is compared to Truck BCY to show if we are over or under trucking shovels.
  - ⇒ This helps to ensure that priority load units are maximized and shows which units can be "robbed" in order to hit the overall mine plan.
  - ⇒ Will allow Goal-Seeking and "What-if …" scenarios to be run quickly and easily.

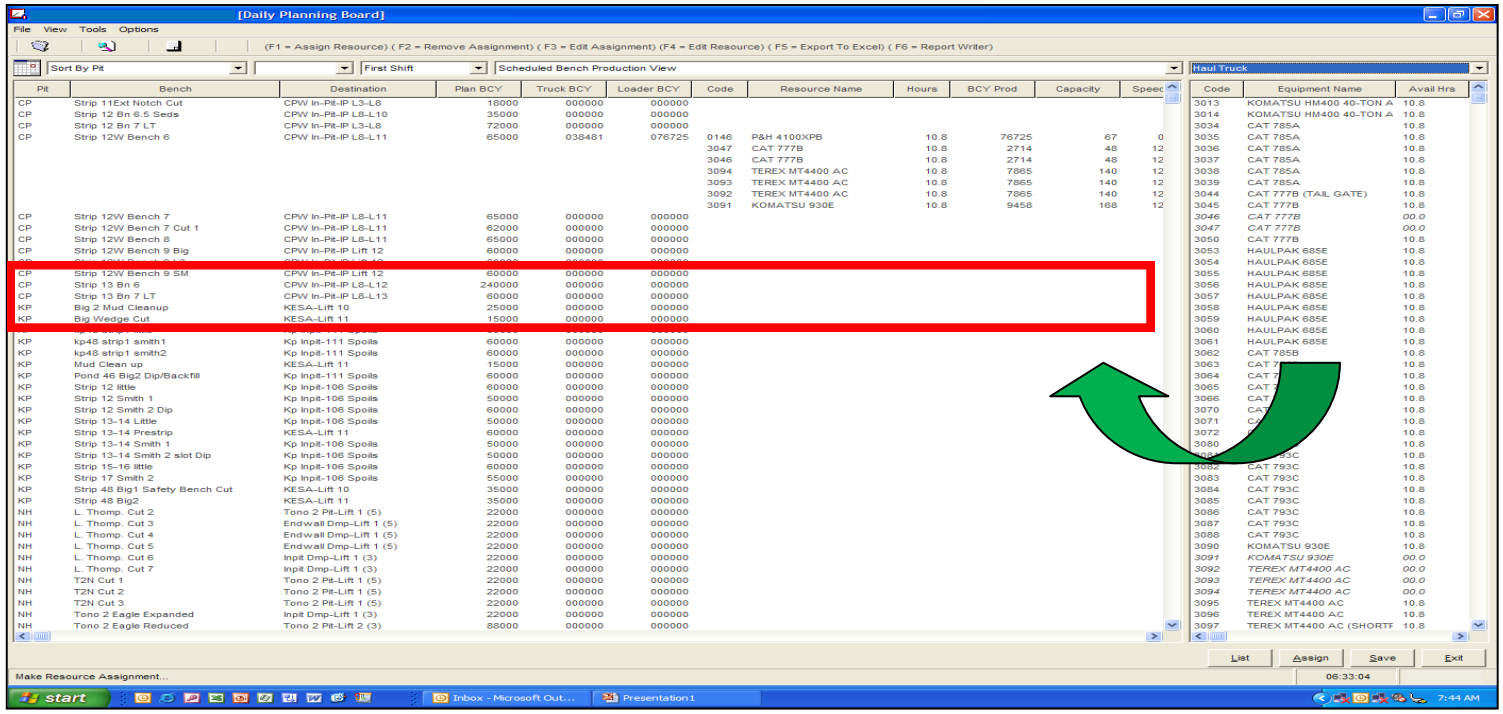
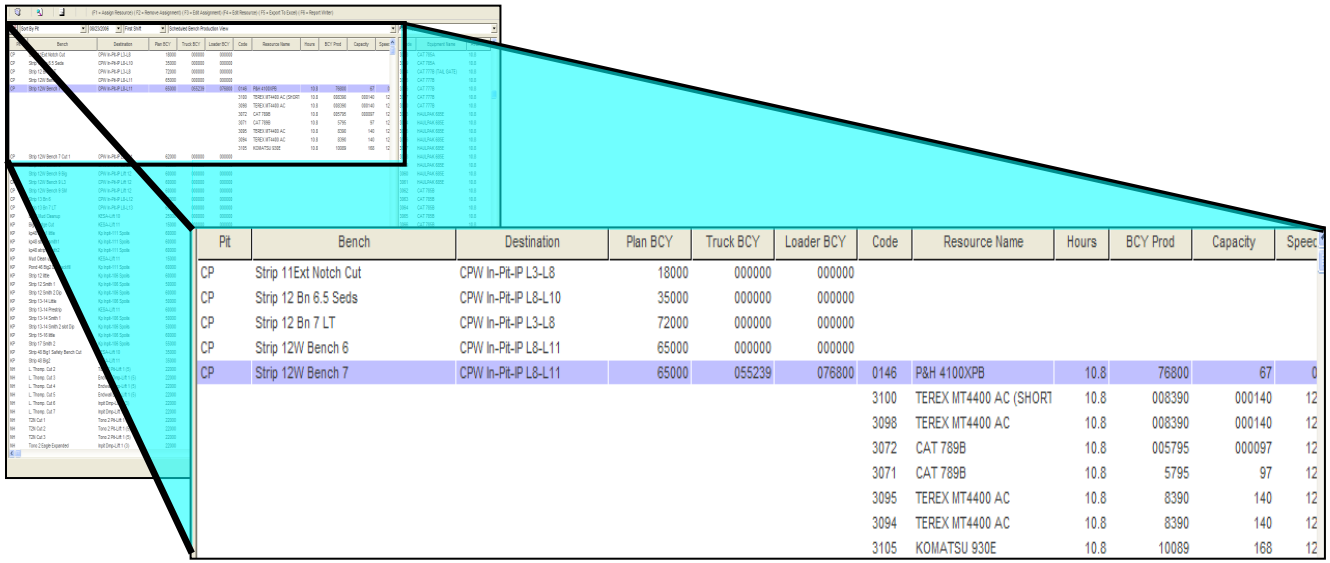


Figure 1—Capacity Plan Example



Pit	Bench	Destination	Plan BCY	Truck BCY	Loader BCY	Code	Resource Name	Hours	BCY Prod	Capacity	Speed
CP	Strip 11Ext Notch Cut	CPW In-Pit-IP L3-L8	18000	000000	000000						
CP	Strip 12 Bn 6.5 Seds	CPW In-Pit-IP L8-L10	35000	000000	000000						
CP	Strip 12 Bn 7 LT	CPW In-Pit-IP L3-L8	72000	000000	000000						
CP	Strip 12W Bench 6	CPW In-Pit-IP L8-L11	65000	000000	000000						
CP	Strip 12W Bench 7	CPW In-Pit-IP L8-L11	65000	055239	076800	0146	P&H 4100XPB	10.8	76800	67	0
						3100	TEREX MT4400 AC (SHORT	10.8	008390	000140	12
						3098	TEREX MT4400 AC	10.8	008390	000140	12
						3072	CAT 789B	10.8	005795	000097	12
						3071	CAT 789B	10.8	5795	97	12
						3095	TEREX MT4400 AC	10.8	8390	140	12
						3094	TEREX MT4400 AC	10.8	8390	140	12
						3105	KOMATSU 930E	10.8	10089	168	12

Figure 2—Capacity Plan synopsis of one-day schedule for each dig site.

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CONCLUSION

The result of completing all these activities was a World Class Reliability and Mine Management System where:

- Work was identified proactively.
- Three major assets were templated for worldwide implementation in whole or on a component-by-component basis, resulting in ~1300 Failure Modes identified.
- Three Core Teams were trained and are now capable of conducting additional analysis and training other Core Teams at other sites.
- 27 condition-based PM routes have been implemented.
- More than 500 people were educated in Work Identification methodologies.
- A management operating system was installed throughout the mining sites.
- KPIs that reflect current operations provide better control of operations.
- Attainment to production goals increased significantly as the capacity of existing equipment was maximized.
- A management system was installed that ensured the optimum balance between attaining production and maintenance goals, and is adaptable to changing real-time circumstances.

Best of all, this mining company will realize a projected ROI of 3:1 over the next three years. This is based on dramatically improved reliability of every major asset, the happy result of integrating the benefits of an overhauled reliability system with a more informative and controllable operating system. The increase in availability will improve tonnage for all existing assets and allow for new assets to come online using the same reliability program. The company now has the knowledge and tools it needs to continue down the path of success. Benefits of an overhauled reliability system with a more informative and controllable operating system. The increase in availability will improve tonnage for all existing assets and allow for new assets to come online using the same reliability program. The company now has the knowledge and tools it needs to continue down the path of success.

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