

Mine Construction: On Time, On Budget



Stop accepting project delays and cost overruns. How mining companies can use lean management practices to increase excavation and extraction rates, eliminate project delays and capture billions of dollars in revenue.



Executive Summary

In this article we describe the impact of lean practices on a massive construction project.

Key takeaways include:

- How the subterranean construction project went from running nine months behind schedule to being completed on time
- Methods for doubling—then quadrupling—productivity
- Keys for capturing gains and sustaining forward progress

11/03/20 | Eduardo Spina, Daniel Anell, Oscar Castillo, Gustavo Tena and John Ferguson

As the operational benefits add up and financial gains are realized, lean management practices have become an essential success factor for all types of businesses. Applications in mining include daily operations as well as construction.

Metrics	Before	After Lean Improvements
Financial Impact	Hefty, delay-related financial penalties	• \$460 million in cost savings • Captured \$1 Billion in revenue
Blastings per day	3	19 Plus a 20% yield increase per blasting
Excavation (meters/month)	320 m	1,700 m
Extraction (tons /month)	44,000 tons	188,000 tons
Mine opening	9 months behind schedule	Finished on time

Mining companies are increasingly using lean management methodologies to improve yields, increase responsiveness and build more resilient organizations. These revolutionary work management practices can have an especially significant financial impact on mine construction and expansion projects.

Mine construction booms when commodity prices climb. **With long lifecycles and enormous amounts of capital at stake, most of these megaprojects (4 out of 5) are completed late and run a whopping 43% over budget.** These delays can postpone billions of dollars in anticipated revenues. And, if commodity markets turn south in the meantime, miss profit opportunities altogether.

It doesn't have to be this way. With a lean approach mine construction projects can be accelerated, and handoffs can be completed on time, even early. Lean mining is designed to improve lead time and utilization. Value stream mapping helps to optimize the sequence of work steps, reduce costs, improve cash flow and avoid unnecessary capital expenditures. In this article we explore how lean management methodologies have—in addition to delivering direct cost savings—helped get a mine construction project back on track, hit scheduled milestones, finish on time and realize the forecasted return on investment.

Case Study: \$1 Billion Reasons to Get Back on Time and On Budget

Mine construction companies have extensive project management expertise and can generate up-to-the-minute status reports and detailed project plans.

Despite such capabilities, construction of a new subterranean mine at a massive mine site in South America had fallen significantly behind schedule. With contracts spread between multiple firms, the construction work was poorly coordinated, and the different organizations were not taking advantage of lean project planning tools.

With crews executing just three blastings per day, everyone involved in the project was frustrated and pessimistic. On our first site visit and assessment the major issues that we observed included:

- Contract deadlines nine months behind schedule
- Hefty fines for non-compliance with contract terms
- Inefficient drilling processes
- Disorganized movement of equipment between fronts
- Many people standing around waiting with nothing to do

We started by implementing a plan-of-day (POD) and monthly “obeya” meetings. Surrounded by up-to-the-minute metrics and status reports, for the POD meetings where managers from different areas met every shift to review performance. They discussed any pending issues and brainstormed solutions as a group, then assigned responsibility for implementing those solutions.

Obeya simply means “big room” in Japanese. Obeya works like a main control room with bi- or tri-weekly tactical meetings and monthly strategic meetings. During these weekly meetings, the team looked forward at the schedule to identify and eliminate any future restrictions that could delay work. The multidisciplinary approach optimized the use of resources and improved compliance with construction milestones.

The daily POD and Obeya meetings were some of the first steps in implementing a comprehensive lean management system at this mine site. This included enhanced tracking and reporting of key metrics so everyone would know exactly how the teams had performed on any given shift. We also helped them develop a contractor “playbook” to establish common rules, standards, and procedures, which further minimized different groups working at cross purposes.

Within 30 days of adopting this and other lean management practices, we had helped them double their daily productivity.

Increasing productivity to six blastings per day was just the beginning, however. They were a long way from the target of seven blastings per shift and 14 per day. They were still missing major project milestones and at risk of incurring additional financial penalties.

Root causes of the delays included a lack of standardized processes, minimal employee training, weak problem-solving capabilities, low equipment uptime and all kinds of daily operational headaches. We helped launch a series of targeted kaizen improvement events to address these deeper issues. Each area of the construction process was targeted from fortification, drilling, and blasting to the removal of rock from the mine.

Clearing Out the Waste

One such event targeted the removal of waste rock, which had fallen behind and was getting in the way of the drilling equipment. On a good day the 60-ton dumper trucks could not extract more than four kilotons of waste rock per day from the blasting operations. More than 140 kilotons of waste rock had accumulated inside the mine.

To get back on schedule and clear the way for increased activity on the mine fronts, the average extraction rate needed to improve from 2.8 kilotons to at least 6 kilotons per day.



Lean Mine Construction Best Practices Summary

- Detailed recovery plan
- Daily management system
- Contractor playbook
- Plan-of-day meetings
- Obeya meetings
- Enhanced metric tracking and reporting
- Asset availability
- Pull Planning
- Standard work
- Targeted kaizen events
- Enhanced problem-solving tools
- Supplier selection and certification

A kaizen event team led by representatives from the mining construction company—supported by TBM—identified the causes for the slow extraction rates and created a multi-part turnaround plan. Ultimately, without having to make any new equipment investments, they boosted output to 6.2 kilotons per day, exceeding the target.

Another kaizen event tackled the blasting process itself, which was suffering from poor efficiency. They were not advancing far enough with each blast; only 3.16 meters on average compared to the target of 3.9 meters. That shortfall might not seem like much, but it adds up over the course of a month.

The kaizen team on this initiative included explosives experts, geologists, surveyors, engineers, and drilling equipment operators. The solutions they came up with included advance validation, cleaning the legs of the hill to optimize equipment positioning, and many other ideas. Within two weeks their efforts had boosted progress to 3.85 meters per blast, increasing the advance rate by 18% per shot, or an additional 331 meters per tunnel per month.

“Pull” vs. “Push” Project Planning and Management

On major projects, following the kick-off meeting, a designated scheduler typically generates plans for from the defined start date. He or she consults with the different team leaders and stakeholders to arrive at an ideal and highly detailed sequence of activities. Pull planning, a lean construction management practice, starts with the completion date and works backward.

Backward planning is not the central strength of the pull-planning process, however. The power comes by transferring control and ownership of the schedule from the central scheduler and giving responsibility to all stakeholders. Key stakeholders work together as a group to identify predecessor activities and streamline the flow of work between departments and organizations. The collaborative effort breaks down departmental and organizational divisions, which the traditional approach tends to reinforce. This enables everyone to coordinate work more effectively and sequence tasks to avoid interference and drive toward on-time completion.

On this project we helped the client teams leverage pull-planning to identify restrictions that could cause delays and then take preventive measures. We redesigned work sequences to make sure the teams and different firms weren't working at cross purposes.

For example, the client needed to assemble a 12 km-long conveyor as quickly as possible to meet the final project deadlines. The kaizen pull-planning team consisted of engineers, belt operators, representatives from procurement and quality, and planners. Starting with the key milestones—the on-site arrival of the belt, assembly, and weaving activity, and so on—they identified potential areas of interference as well as slack time when additional work could be completed. As a result, the assembly and construction work was not only completed on schedule, the total time was reduced by 20%.

Making Up the Difference: From Nine Months Behind to On-Time

Executing the improvement plans and kaizen projects gradually built up the company's internal continuous improvement capabilities. As management and construction processes became more consistent, and they repeatedly achieved the targeted improvements, the construction site leaders, managers, and supervisors became more confident at implementing changes. Over time the management behavior and culture has become much more proactive and less reactive.

In addition to improving daily productivity, these combined efforts increased yield per blasting by 20%:

- Boosting excavations from 320 to 1,700 meters per month
- Rock extraction increased from 44,000 tons to 188,000 tons per month
- Equipment availability improved from around 66% to over 85%.

The initial CI leaders have moved into additional leadership roles, further integrating a continuous improvement mindset into the organizational culture. Current construction projects continue to utilize kaizen projects, value-stream mapping, and other lean methods.

In total, eliminating scheduling overruns reduced total costs on this project by an estimated \$460 million. When we first started working with this client, they were running nine months behind schedule. They ultimately made up the entire deficit and completed mine construction on time. Accounting for market price fluctuations, on-time start-up easily accounted for around \$1 billion in production revenues.

Lean Mining: Real Results

Over the years, we have spoken to mining executives and operational leaders who have expressed doubts about the relevance of lean management practices. With lean's origins at Toyota and the automotive sector, they find it hard to make the connection. In the past mining companies have made good money doing things the ways they have always done them. Managers may even acknowledge the waste in their operations but tend to see any process change proposals as causing more disruption than they are worth.

Along with the influx of automation, digital management and databased decision making into mining operations, this skepticism is fading away. As in healthcare, construction, chemicals, services, logistics and many other industrial sectors, mining industry leaders are seeing the business benefits of faster, more streamlined processes.

For example, in the Codelco annual report the company noted a 20% productivity gain from 2014 to 2018 (two years ahead of their target). Company leaders attributed this achievement and \$1.7 billion in cost savings to the rollout of their C+ continuous improvement, lean management system.

Mining operations, markets and technology are unique without question. They have many challenges in common with other businesses as well, mostly revolving around processes and people. Over time lean techniques and mindset enable people at all levels of a business—especially those closest to issues—to identify and solve the highest priority problems faster and more permanently. Problems like excessive costs, delays, poor quality and ineffective management that erode mining companies' market and financial performance.

Areas where lean management practices can have a measurable impact on mining operations include:

- Reduced construction costs overruns
- Reduced project delays
- Achieve safety improvements
- Worksite organization
- Efficient use of vehicles and equipment
- Better control through standardization
- Planning and project management
- Supply chain management
- Inventory control

Lean Mine Construction Turnaround Approach

By attacking the causes of cost overruns and overcoming common barriers to effective project management, we help mining companies achieve immediate operational improvements and financial benefits.

1. **Diagnostic – Assessment and mapping of current processes to identify obstacles and opportunities for improvement.**
 - Review current financial and operational metrics
 - On-site diagnostic: Observe and gather input from all departments and organizations
 - Identify primary cost drivers and scheduling barriers
2. **Planning – Prioritize activities based on strategic objectives, aligning daily, weekly, and monthly metrics and objectives.**
 - Evaluate current recovery plan and develop new recovery plan
 - Determine resource requirements
 - Establish performance measurement processes
 - Introduce plan-of-day and obeya meetings for managing current vs. expected performance
 - Introduce pull planning to meet key milestones
 - Communicate the plan and expectations to managers and employees
3. **Stabilization – Begin work on areas with high immediate impact.**
 - Support critical improvement initiatives
 - Introduce daily management system through training and demonstrations: Starting with safety, set goals, measure progress, identify misses, and root causes, and course correct on a daily basis
 - Introduce and establish standard work
4. **Recovery & Improvement – Follow plan-of-the-day process for responding quickly to issues and focus teamwork.**
 - Continue to execute recovery plan
 - Deepen daily management system
 - Improve asset availability and performance
 - Develop higher level problem-solving capabilities
 - Raw material waste reduction
 - Supplier selection and certification
5. **Follow Up – Leaders become adept at monitoring key construction project indicators and problem solving.**
 - Mentor leaders and reinforce most effective management behavior
 - Strengthen organization-wide problem-solving capabilities
 - Sustain forward progress

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