Digitization for Optimization: Easier and Cheaper

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Abstract

In many occasions during the Mining operation life, blasting engineers find different and controversial results of fragmentation, dilution or wall control for the same geotechnical domain and blast design (pattern and explosive charge).

Most of the times, the difference between same blast designs is not measured, not controlled. Once a blast designed is defined, the most important part of the process after that is the implementation of every step of the blast on site. Almost nobody is measuring it, controlling it, but just controlling implementation is possible to relate blast design with results in a consistent way, to optimize the full process of D&B.
Controlling implementation not only per event but also to check and change trends and decision-making is paramount for optimization and saving millions of extra costs every year.

The lack of resources and the hardness to manage all the info created every day in a blast make this process very tough and difficult to maintain in long term. The use of new technologies on site and software that allows a best, more consistent and continuous control of blast implementation have been proved to be the key for optimizations and cost saving.

This document shows the evolution of drilling and blast digitization process, savings and trends in a mine, using new technologies that creates business opportunities and general improvement of D&B process.

Introduction: Profits of Blasting Quality Control

A proper control is paramount for a real improvement, optimization and savings in the D&B process and its direct and indirect impact on the global mining operation.

The general basic steps for such control are as shows in Figure 1: Measure to report for improving.

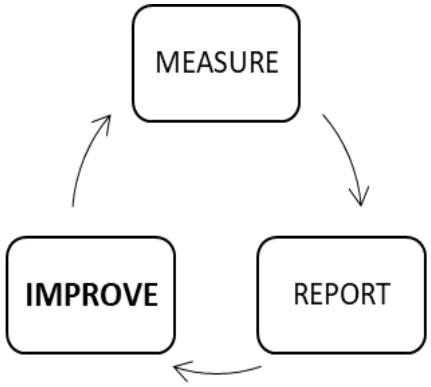


Figure 1. General process of Quality Control

The quality control of the blasting is essential for the evaluation and improvement of blasting. Without a quantitative assessment of the quality and accuracy of the blasting implementation it is impossible to execute efficient changes and real optimizations of the process.

Key Performance Index (KPI`s) control is the basis for optimisation and cost savings. The main KPI`s that any operation should control are:

-Drilling length
-Drilling position (x, y coordinates)
-Lenght of Stemming
-Linear Density of the load

In addition to other controls, both quantitative and qualitative, such as: Bench preparation, explosive quality control (density measurement) or implementation according to "best practices".

The average savings per operation is USD 400,000 for over-drilling. Not counting the side effects and downstream repercussion of an uncontrolled process.

Continuous control of the quality of blasting provides benefits to:

-SHORT TERM: Control of the implementation at the same time of the drilling and/or charging for identification of solved incidents that can avoid problems like flying rock or bad results by inaccuracy in the drilling, among others.

-MEDIUM TERM: Identification and diagnosis of behaviors according to the quality tendencies of the different KPI`s. Control and decision making by identifying a de-calibration of autonomous drilling systems, for example.

-LONG TERM: Above all economic benefits by taking control of the quality and efficiency of blasting. This ensures the possibility to optimize the work and achieve significant direct savings (drilling and explosive savings) and indirect (better overall performance in hauling and transport, maintenance, fragmentation, slope stability, etc.)

The continuous control of the KPI has always been a tedious and difficult task to maintain in a constant and consistent way in time due to a general lack of resources and time. The typical data-taking and management protocol prior to digitization was as shows in Figure 2:

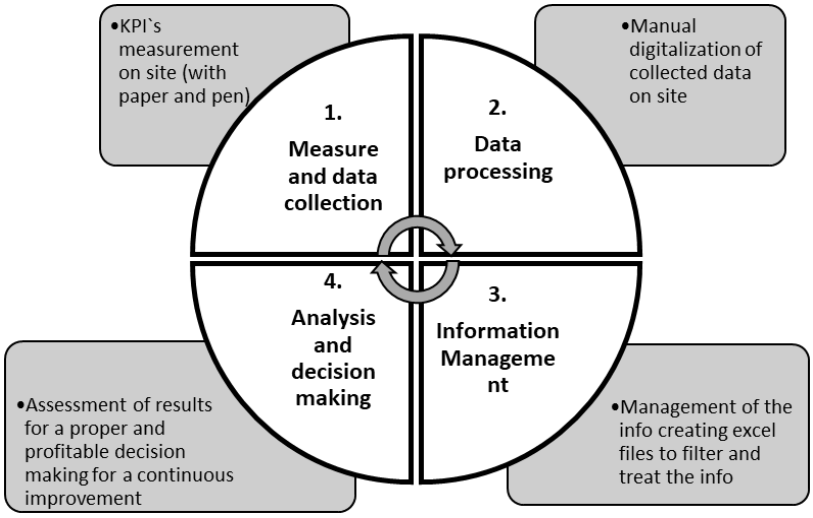


Figure 2. Typical Blasting Quality Control process: on site and at office

Fortunately, in recent years, technologies have been developed for the process digitization, really practical and easy to maintain control in the long term, mainly helping to take data in the field.
Once the digitalization of data taking has been implemented in the field, the process is limited to two steps, the data taking and the analysis of the same, leaving all the management and processing already automated done from the moment of data taking in field by a digital way.

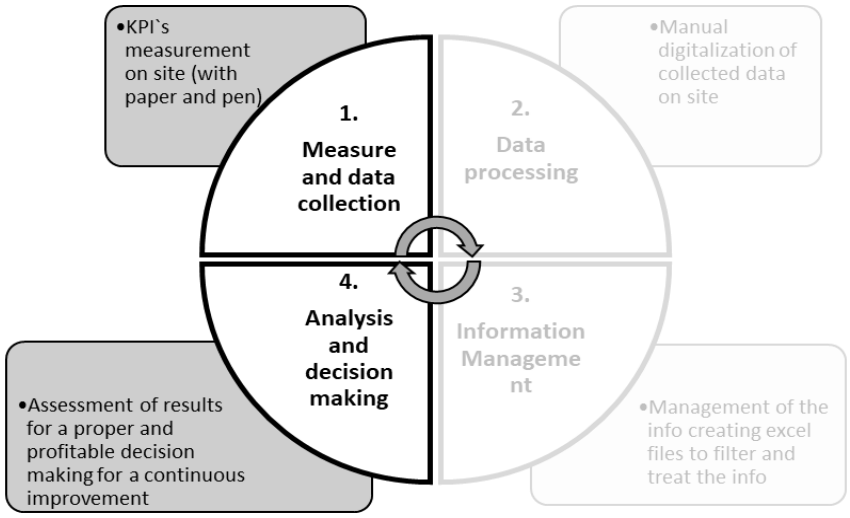


Figure 3. Digitized Blasting Quality Control Process: on site and at office

Digitized process provides the following benefits:

- Savings of approximately 70% of the time of the global QA/QC control process by eliminating the most laborious and unproductive parts of processing and managing the data collected on site. Therefore, time takes advantage of measuring and analyzing to improve.
- More representativeness of the data as it is possible to sample more information at the same time overall of the process.
- The time or staff that was concerned with information processing, can now be measuring more

blastholes or analyzing the results to provide improvement proposals and decision-making.
- Continuity of the process and, therefore, medium- and long-term benefits with large associated savings.
- Direct and instant link between field and office for faster and more efficient decision-making.
- Saving on paper and ink.
- Continuous quality control provides fundamental information for the optimization of the process at all levels: economic, productive, gas emissions, etc.

This document includes a case study showing the evolution of an operation from the absence of field control, first steps in a discontinuous control, semi digitization and total digitization on site and at the office to get the best results of the work.

Case study: Progress of Drilling and Blasting Quality Control

The present case study was started in 2016 in a gold mine, tracking and improving up to nowadays.

The following are the situations analyzed in the operation on quality control issues, proposals made, follow-up and improvements generated with the final implementation of a strict control process supported by technology of digitization.

a. 2016 Initial stage: nothing at all.

In November 2016, the first quality audit was carried out in the mining operation.
The state of on-site controls was initially assessed. At that time, the quality controls of the blasting were totally nonexistent by the Mine.
The contractor carried out certain on-site controls, such as measuring pre-load drilling (which is a good standardized practice in the industry) but sending this information and charge details late and error prone.

The following problems were diagnosed following the necessary measurements and controls in the field:

-Null Control in design and implementation of blasting.
-Identification of bad practices in priming and loading of the explosive.
-Primitive blasting designs but with great optimization potential
-Annual surcharge in more than USD 1.2M for excess uncontrolled drilling (excess of drilling meters and the relevant explosive)

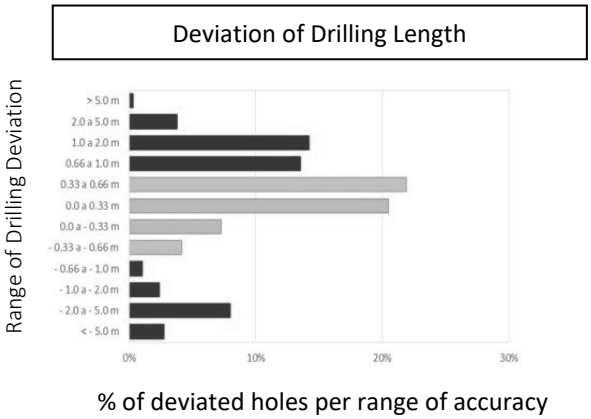


Figure 4. Example of priming bad practices (left) and hole length deviation (right)

Clearly, QA/QC quality control was necessary, to achieve quality levels of implementation of blasting and, from there, begin the optimization of the designs.

The solutions proposed for the elimination of bad practices and the gradual improvement of the drilling and blasting process were as follows:

- Implementation of QA/QC protocols with the measurement and follow-up of the main KPI`s and the theoretical and real comparison of each one of them to study the deviation.
- Other additional implementation and monitoring of results such as:
  - o Quality Control of the explosive or use of best practices
  - o Bench preparation supervision (floor and free face)
  - o Control of results: fragmentation, slopes, dilution, vibration, etc.

These solutions were established as tasks for Mine and Contractor during the absence of the external Auditor.

At this time the operation did not have any digital system to support the field control work, so the protocol was followed as Figure 2 and 5 details. A slow and inefficient process.

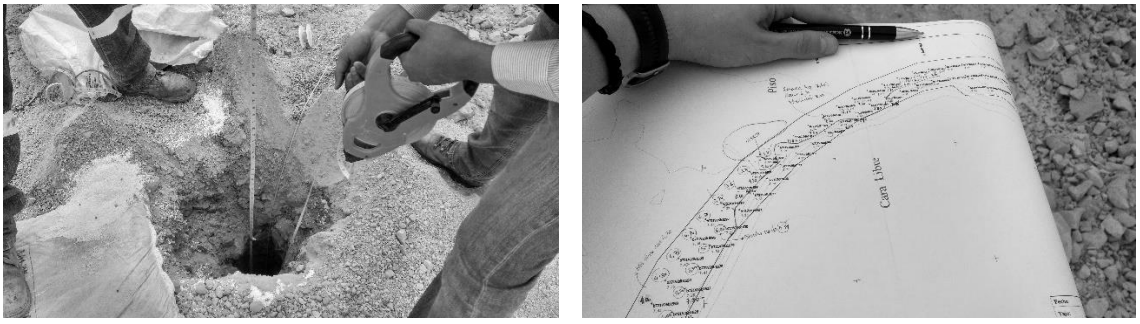


Figure 5. Protocol of hole measurement and data collection on site

b. 2017-2018 definition of controls: Start-up and follow-up

Throughout 2017, the quality Control protocol established in the operation was in the following situation:

-The control by the Mine is only carried out during the visits of the external Auditor.

-The field Control by the Contractor was made more accurately, but only when the staff of the Mine or external Auditor were around.

-The reports of the monitoring of the blasts were still late and with mistakes, which made the blast assessment very difficult if reports are delayed more than 2 days.

-The quality percentages of the principal KPI`s still did not reach the world standards of quality of 80% of precision in the implementation.

With continuous field control and appropriate and consistent processing of information, it was possible to diagnose certain problems, trends and solutions, such as:

-Identification of de-calibration of the gauge in drills with autonomous system.

This problem was solved by warning those responsible, who did a calibration campaign on all the drills in the operation.

-Maintenance and exhaustive increase of the controls in field to reach the world quality ranges (80% KPI precision).

Throughout the year, the evolution of quality and its economic impact on the operation showed the efficiency of the Protocol.

Figure 6 shows the drilling length precision control from February to October 2017 and its annual and yearly economic impact (according to estimated number of annual holes).

The percentage of long blastholes decreases considerably, from 54 to 31%. In the rainy months it reached 10% but these values were conditioned by the humid period and the difficulty of avoiding collapses or clogging of holes according to the material and quantity and type of water.

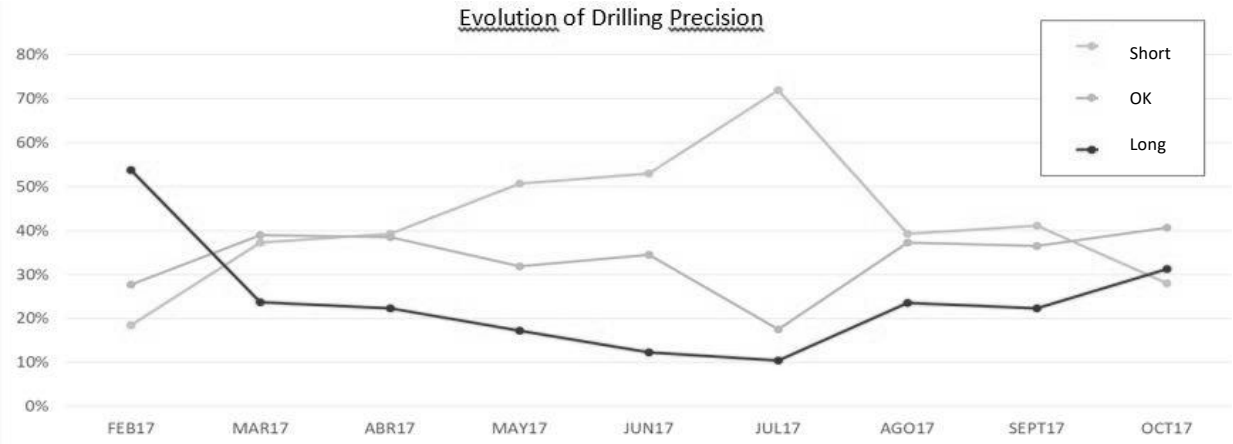
Avoiding extra over drilling implied, in this operation:

-Great savings in extra drilling.

-Securing crests of berms.

-Better control of floors and all that this entails for the cycle of D&B, digging and hauling.

-Better fragmentation.



	FEB17	MAR17	ABR17	MAY17	JUN17	JUL17	AGO17	SEPT17	OCT17
Short	18%	37%	39%	51%	53%	72%	39%	41%	28%
OK	28%	39%	39%	32%	35%	18%	37%	37%	41%
Long	**54%**	**24%**	**22%**	**17%**	**12%**	**10%**	**23%**	**22%**	**31%**

Figure 6. Evolution of Drilling Quality from February to October of 2017.

According to the accuracy values of drilling length implementation, it could be concluded that:

-Based on the accuracy of February 2017, the extra annual cost was estimated at USD 610,312.

-Based on the accuracy of October 2017, the extra annual cost was estimated at USD 354,552.

The global savings (Feb-Oct17) of extra costs was estimated at USD 255,760 in D&B for the control of drilling lengths, considering extra-drilled meters and extra kilos of explosive load.

Table 1. Progress of estimation of extra costs by drilling inaccuracy from February to October 2017

				Rain Session					
% extra	54%	24%	22%	17%	12%	10%	23%	22%	31%
USD extra drilling	$ 14,531.25	$ 6,412.50	$ 6,015.40	$ 4,672.02	$ 3,332.64	$ 2,820.59	$ 6,344.49	$ 6,036.18	$ 8,441.72
USD extra Explosive	$ 36,328.13	$ 16,031.25	$ 15,038.50	$ 11,680.04	$ 8,331.59	$ 7,051.48	$ 15,861.23	$ 15,090.45	$ 21,104.29
Extra costs per month	**$ 50,859.38**	**$ 22,443.75**	**$ 21,053.90**	**$ 16,352.06**	**$ 11,664.23**	**$ 9,872.07**	**$ 22,205.73**	**$ 21,126.62**	**$ 29,546.00**
Extra Cost per year	**$ 610,312.50**	**$ 269,325.00**	**$ 252,646.82**	**$ 196,224.69**	**$ 139,970.71**	**$ 118,464.80**	**$ 266,468.71**	**$ 253,519.48**	**$ 354,552.04**

Despite operational and economic improvements, the control carried out during 2017 remains insufficient.
During 2018, the lack of control was significant.
The problem was: lack of resources (personal/time) to ensure consistency and continuity of QA/QC control in field and at office.

The proposed solution was to implement a Project of "Digitization of the design and control of implementation of blasting".

This project included the incorporation of the following software or technologies to support the work of quality control:

-Blasting design Software – JKSimBlast.
-Tablet on site for quality control – simply digitization with Excel (compatible with JKSimBlast).
-Fragmentation Analysis Software – Split-Desktop.

Besides control systems and monitoring such as radar and seismographs.

In the last months of 2018, the use of a Tablet was implemented in the field for direct digitization of the blast data, but the processing and analysis steps were still present and continued to hinder the desired workflow.

This method saved only about 20% of the total QA/QC time.

In 2019 the definitive step was made towards the digitization and quality control of blasting QA/QC in the operation.

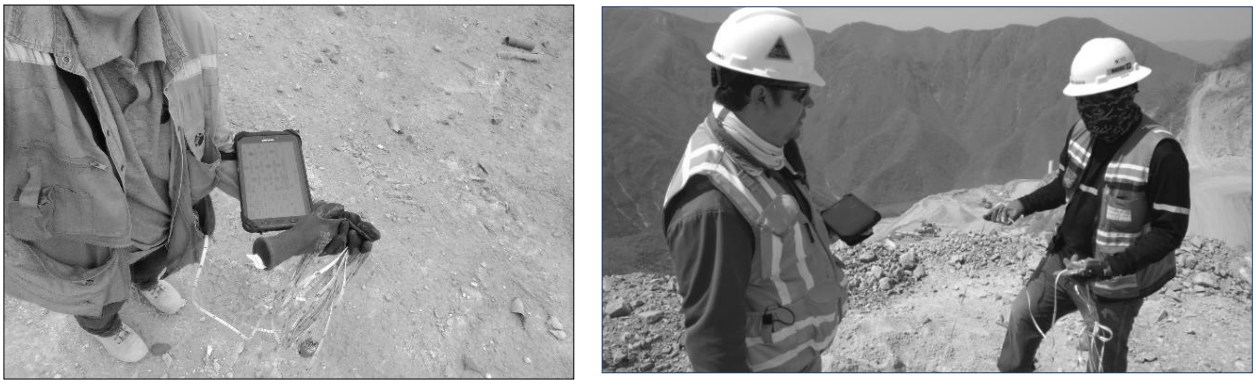


Figure 7. Staff collecting data digitally on site

c. 2019 Total Digitization: Savings and optimization

In 2019, within the same project "digitization of design and control of implementation of blasting", a substantial improvement was made in the quality control phase.
They joined the operation the online blasting quality control system QA/QC, Blastatistics®.

The direct benefits of this system are:

-Use of simple and friendly Tablet on site where monitoring and control the quality of the implementation of blasting, not only with measurements, but also by capturing other details through alarms, images or statistics for immediate decision making.

-Online system that links ground (Tablet) and Office (web) continuously so that all involved in the work of D&B are at the moment informed of the state of control, drilling and loading of the blasting.

-Complete information, classified and analyzed statistically from it taking in the field to make the most of the land and, therefore, to the work of engineering and analysis in the office.

-Cost calculations and instantaneous estimates of extra expenses for inaccuracy in implementation.

Table 2 shows the evolution of QA/QC quality control process in the operation.

Table 2. Evolution of quality control process from 2016 to 2019

YEAR	Data Collection	Processing	Management	Analysis	Reports
2016	-	-	-	-	-
2017	Manual	Manual	Manual	Manual	Manual
2018	Digital	Digital/Manual	Manual	Manual	Manual
2019	Digital	Automated	Automated	Automated	Automated

The indirect benefits are clear: if the real digitization facilitates the complete control process, this increases the monitoring and therefore the representativeness of the sampling and thus the decision making is more direct and efficient in favor of the improvement and the optimization of the work.

Analyzing the implementation of this system, since April 2019, and according to the inaccuracies found and the cost estimates provided by the program, the advance is as follows:
-Precision Drilling Length (Figure 8. Chart 1): 86%
-Drilling precision X, Y (Figure 8. Chart 2): 98%
-Precision in Stemming length (Figure 8. Chart 3): 87%
-Estimated annual extra costs: USD 42,661.

Thus, it is concluded that, thanks to the continuous and consistent control of the quality of the blasting, supported by easy technologies that simplify the extensive work of QA/QC, the following advances have been achieved in the operation:

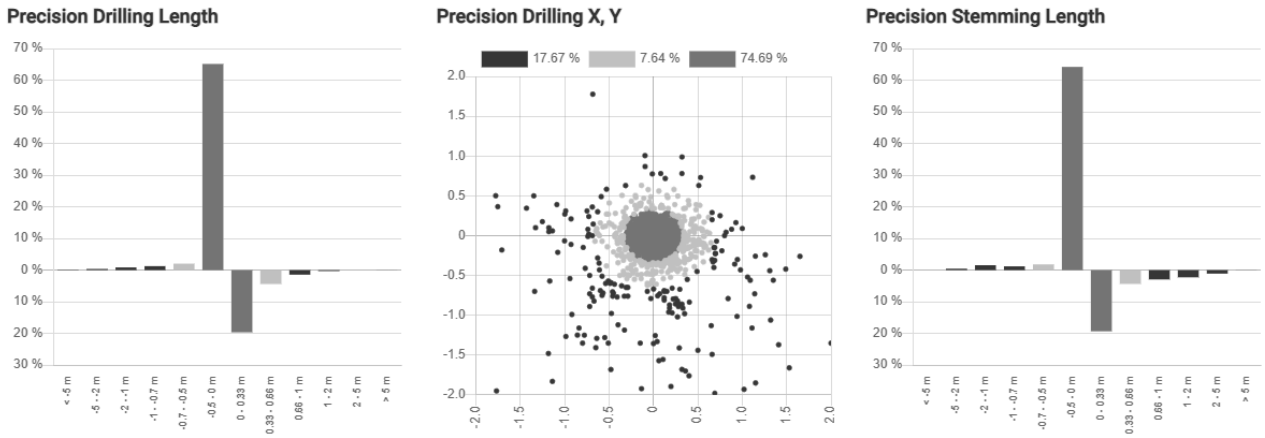


Figure 8. Quality control charts and precision of main blasting KPI`s

-Notable improvements in the quality of the implementation that give opportunity to the optimization of the blasts and their impact downstream.
-Discipline and consistency in quality controls and best practices.
-Better communication among those involved in having the information at the moment, thus avoiding inefficient waits for decision-making.
-The annual extra cost from October 2017 to May 2018 has been reduced by approximately USD 320,000.
-Nowadays, since a full digital system has been implemented and a continuous control, the extra costs have been reduced up to USD 270,000 more. Therefore, the estimated annual extra cost by blasting quality is less than USD 50,000.

Summary

Quality control optimization is possible through a correct digital process, including all the necessary information and all those involved in a single platform, thus reducing data processing time and converting that time into productive time of greater monitoring, analysis and engineering for continuous improvement.

We can now anticipate events in the field and decision-making, innovate blasting designs, control real-time D&B KPI`s, instant drilling control, optimize the loading, and reduce the time and costs of processes, fulfilling the Company's objectives.
With innovation and digitization, we have been able to contribute to the profitability of the work of D&B and the operation in general.

With this summary, we can talk about a digitization for optimization, because the quality and its control are the key to start optimizing processes. Easier digitization process because there are friendly, practical and simple tools that facilitate the work of field control and eliminate the processing of unproductive data. And a cheaper digitization because by making the long-term follow-up of the qualities, the improvement is inevitable and therefore the investment in technology and control personnel is a residual cost based on the great economic benefits obtained and savings achieved.