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# 2016 MINING AUTOMATION

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*White paper*

## Digging deeper into cash cost reduction and productivity

Lower commodity prices, weaker demand, environmental regulations, lower ore grades, higher running costs are some of the main challenges that the mining industry has to deal with every day.

But it is a good time, while activities are off peak, to adopt sustainable cost control measures beyond the traditional and generate data that will improve productivity and process stability. Reducing C1 cash costs and increasing revenues can be done, with extensive use of automation and robots in the laboratory, to gain in productivity and remain competitive (1).

*"Rio saves $200m a year using robots, big data"*

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In 2015, RioTinto announced they could save $200m a year using robots and Big Data (2). RioTinto is not alone following this path. Almost all mining majors, in a quest to sit at the right end of the cash cost curve, are currently exploring the new opportunities that automation can offer.

## Data generation

No need to say that processes must be improved, in order to increase profitability and reduce costs in a sustainable fashion. Basically, data can be used to identify and manage operation problems, improvements (desired or needed), productivity and costs. This being said, expanding the scope of the data includes a series of challenges that must be properly managed: collection, recording, access and analysis. The data management must be done fast enough to lead to almost real-time decision-making or adjustments. However, if processes and data generated are not analyzed, there is no way to improve anything.

***Automated machines can easily collect and send samples to the lab***

To illustrate this, not so long ago in the US cases of influenza were reported to CDC (Center for Disease Control) by doctors and pharmacists. Information usually suffered from a one- or two-week lag, was sparse, and gave CDC a broken image from the past with few control over the disease. Nowadays, CDC gets the information in real-time, automatically. This happened because some robots count the numbers of 'influenza' searches on Google made by users, per location. Algorithms tell CDC where the epidemic comes from, where it goes and how fast it spreads, almost every second.

In the mining industry, there obviously are not millions of 'users' able to help with sample collection. Like reporting from MD and pharmacist, incoming materials and products are already analyzed. However, the traditional 'bucket sampling' method is not quick enough and would require an army of operators to obtain sufficient data.

A good existing solution, on-line CNA crossbelt analyzers are very fast and solve many problems for many applications, particularly where elemental analyses can provide important process information. The crossbelt analyzers are not universal solutions however. In some cases, additional analysis techniques are required to measure low concentrations or mineral structure.

In these cases, an automated machine can collect samples, then send ore or concentrate to the laboratory much faster than manually. This means that incoming material or final product can be monitored a lot more frequently.

The great variability of ore composition justifies by itself a large amount of control samples, simply to maintain the stability of the process along with proper monitoring. For instance, if ore is well defined upstream, it will be easier to use the appropriate process downstream, adjustment or reaction.

***Automation allows to make use of each minute***

Robots can also proceed to sample preparation and chemical analysis. Although the benefit of higher speed is not as significant as in the case of sample collection, there are other important upsides to automated analysis.

Once data has been collected, all information is transferred to an intelligent system for systematic analysis and generation of relevant statistics.

## Monitoring or controlling

Monitoring, while providing valuable information, tells us what happened in the past, once the truck has long gone. There is no way to adjust the process or take decisions, to avoid poor quality of the final product. But to control a process, a fast turnaround is needed. Every minute gained on sample taking, transport and analysis becomes available for process adjustment and leads to better quality, higher selling prices and less waste.

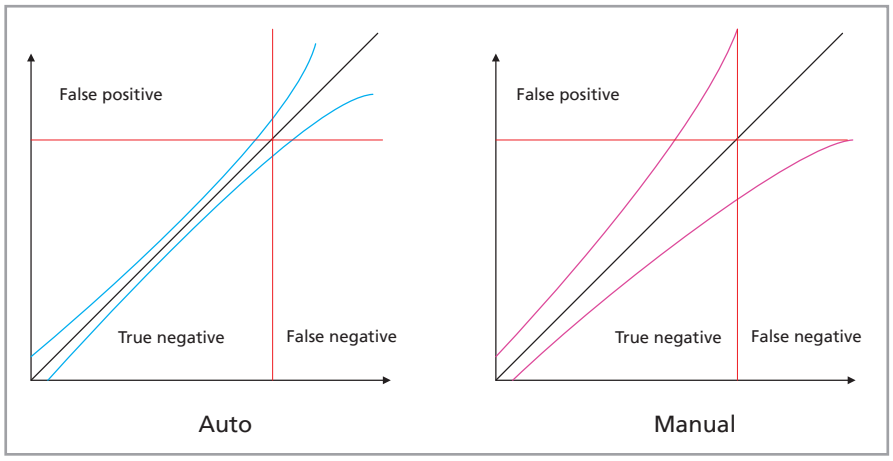
Automated samplers need few seconds, while tube systems can carry the necessary amount of sludge or solids at speeds up to 72 km/h.

Automation is multitasking. This means it can manage dead times and allows to make the best use of each minute, allowing true process control beyond simple monitoring.

## Human error

From one moment to another, there is operator induced bias and at the same moment, there is bias from one operator to another (3) (4).

The graphs below illustrate the comparison between operator and robot. Manual is on the right, while automated analysis is on the left. These graphs represent the classification of an ore. A false negative is when an ore is qualified as waste. And a false positive is when waste is qualified as an ore. The horizontal axis shows the first value obtained and the vertical shows the replicate value. Red lines crossing is what the result should be (certified).




*The blue and purple curves are the confidence bands.*

As can be seen, improper qualification occurs much less frequently when automated techniques are in place. This is mainly due to the systematic approach, better sample preparation and the strict observance of standard operating procedure, in automation.

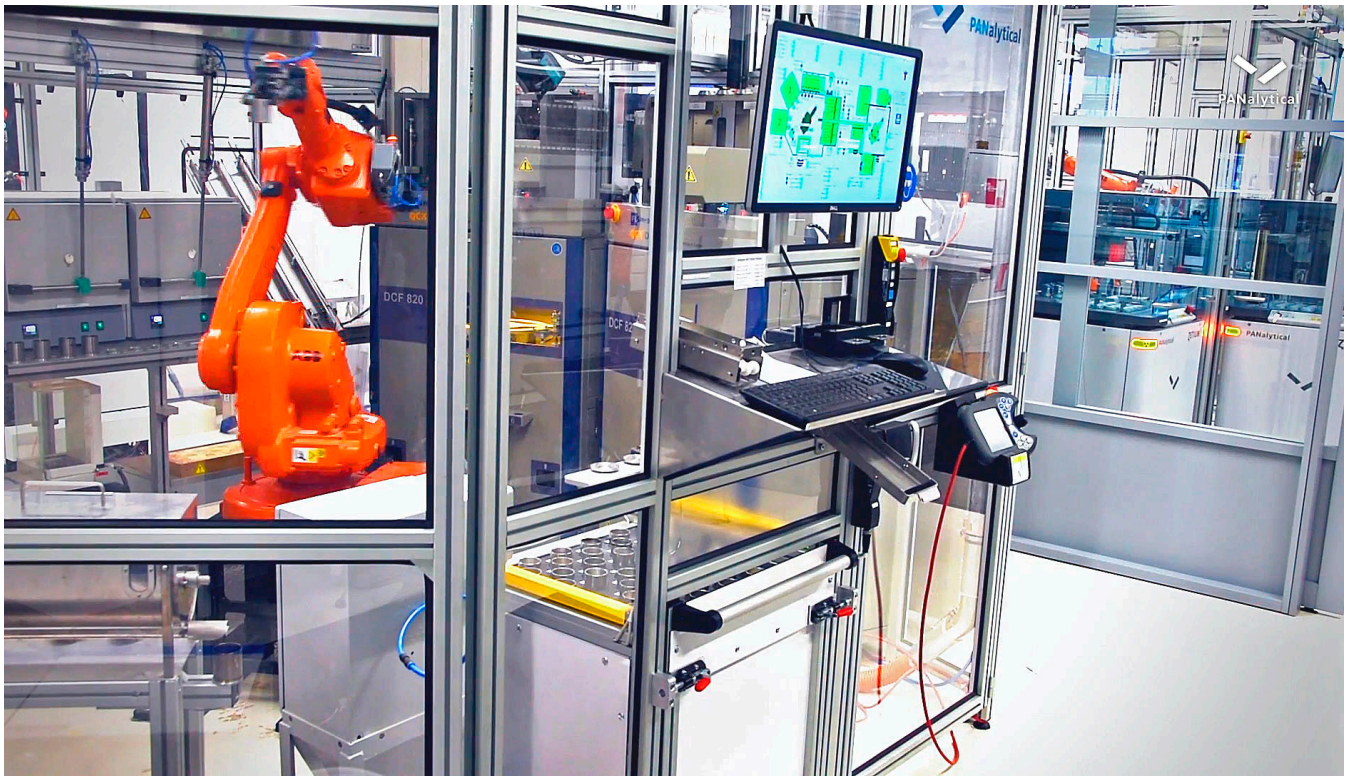
## The tools

There are many different tools to implement robotized analysis of materials and products.

Slurries can be collected by funnel-based devices. Powders are taken by endless screw or piston samplers. Small rocks are held by automated shovel systems. All of these devices are computer-controlled.

Samples preparation is taken care of by crushers, millers, pulverizers, presses or fusion machines. A central robotic arm handles the material and transfers to the analytical instruments.

Instrumentation can be X-ray fluorescence, loss on ignition, combustion analyzers or any type that could help in a mining laboratory.




*An automated mining central lab*

## Financial considerations

***Payback is not a sufficient evaluation tool***

While robotization of quality control has many advantages, the necessary investment needs to be considered, and thoroughly compared to existing solutions. The main tools for this purpose are payback time and internal rate of return (IRR). The payback shows the time needed to recover the full amount of an investment, when compared to an alternate solution. But, although very intuitive, this value does not take into account the value of money over time.

The IRR does, as it is a direct comparison to other investments. It indicates the rate of return of an investment over a period of time, compared to another investment. In other words: is the money saved by investing worth the investment? Would the money be better at the bank at a 9% rate?

The example below shows payback and IRR for the case of a manual analytical technique vs automated, in a silver mine. The ICP (Inductively Coupled Plasma) is manual, while XRF (X-ray Fluorescence) is automated.

| Per year | XRF use | ICP | AU-XRF | Payback in years |
|---|---|---|---|---|
| $/sample | | $4 | $0.1 | $1 200 000 |
| 500 s/day | 0% | $730 000 | $0 | never |
| | 50% | $365 000 | $9 125 | 3.4 |
| | 70% | $219 000 | $12 775 | 2.4 |
| | 90% | $73 000 | $16 425 | 1.9 |
| | 100% | $0 | $18 250 | 1.7 |

The ICP analysis had been evaluated at a cost of 4$ per sample, with a throughput of 500 samples per day, for an initial 1.2-million-dollar investment. The table above demonstrates that automated analysis could be paid back in less than two years.

Next table shows IRR calculation over a 10 year period, with progressive replacement of an existing manual ICP.

| Period (years) | AU-XR use | Cash flow | Cumulative |
|---|---|---|---|
| 0 | 0% | –$1 200 000 | –$1 200 000 |
| 2 | 70% | $498 225 | –$345 900 |
| 4 | 80% | $521 400 | $744 900 |
| 5 | 90% | $580 575 | $1 325 475 |
| 10 | 90% | $544 575 | $4 192 350 |
| | | IRR | 39.3% |

These tables also take maintenance of the equipment into account.

Despite higher initial costs, robots are less expensive over time compared to traditional methods, and above all, all expenses are predictable and savings are sustainable.

This particular example of a silver mine is applicable to all types of mines where sample collection, preparation and analysis are required.

## Conclusion

Improving productivity, reducing costs and managing capital effectively in a sustainable way are now obviously essential to ensure a bright future for the mining industry.

Robots and automation have the ability to achieve these goals, by taking many challenges out of the equation. Being fast, without bias, systematic and financially predictable, they clearly represent the future of mining.

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