

# Business & Innovation



**We laid the foundations to position innovation as our core business process, creating Codelco Tech and applying an open innovation management system to confront challenges and play a leading role in new mining.**

## **Value-added business initiatives**

In 2016 we not only focused on innovation, but also on strategic management to develop third-party relationships, creating value for the company.

Specifically, our Business and Innovation Corporate Management is in charge of identifying, designing, assessing, planning and implementing new opportunities with third parties, through

procurement, sales and/or technology partnerships, mining assets and exploration, both in Chile and overseas.

It also develops and formulates strategies, work plans and activities to implement new technologies in our Company.

In order to fulfil its objectives, we have a multidisciplinary professional team, transversal and flexible, who have solid technical competences and skills to analyse the complete negotiation and innovation cycles, from identifying an opportunity to implementing a business, measuring its impact and internalising lessons learnt.



In 2016 we restructured our technology companies, i.e., IM2, BioSigma and Codelco Lab, into Codelco Tech. This technology subsidiary, 100% owned by Codelco, has a strategic mandate to lead and promote research to minimise the environmental impact of mining and risk for people.

Codelco Tech combines and promotes the experience, knowledge and skills of IM2, BioSigma and CodelcoLab, to create to a model that develops open solutions, incorporates and promotes initiatives provided by suppliers, research centres, start-ups and other entities.

The primary goal of our subsidiary Codelco Tech is to achieve technological breakthroughs for mining challenges, such as grade decline, deeper deposits, mineral impurity, lack of enabling resources, such as water and energy, and higher environmental standards.

Codelco Tech's field of work focuses on solutions, such as processing mineral resources, pyrometallurgy, hydrometallurgy, water & energy, underground mining, open-pit mining, biotechnology; automation, robotics, remotisation: data science; new uses of copper, lithium, molybdenum, sulphuric acid and by-products.

We also established our innovation management system that will systematise the innovation process and measure its impact on results through time. During 2016, an extensive diagnosis was carried out of the innovation projects implemented and under development, a baseline was defined and priority was given to the initiatives that would be promoted.

In 2017, our goal is to expand the system, that in general focuses on identifying, valuing and prioritising requirements and then find solutions among suppliers in the innovation and technology ecosystem, such as Codelco Tech and together successfully implement these solutions at Codelco operations, increasing its benefits.

## Key Projects

During 2016, our innovation projects focused on our priority topics, such as automation, construction and we started operations at the Integrated Information Centre, its goal is to analyse the historical data from mining processes (Big Data) and prepare predictive models and also search for technological breakthroughs in metallurgy, pyrometallurgy, hydrometallurgy and technologies in response to safety, environmental sustainability and community requirements in the mining business.



**Loader automation:** Codelco Tech was in charge of designing with functionality suppliers improvements to enhance the performance of LHDs in underground mines. The loader has autonomous haulage and remote loading, operated from a control room, which could be several kilometres away, outside the mine, thus extracting of minerals without exposing employees. Currently, an industrial validation test is underway at El Teniente Division. We have also considered running tests for 100% automated underground trucks at the end of 2017.

**Extraction point overhang removal device:** underground mining system used to remotely characterise, visualise, direct and place an explosive on the overhang surface, avoiding employee exposure.

The method currently used to solve this operating problem consists of suspending explosive charges at height using bamboo poles. This operation is known as unblocking trenches and employees are highly exposed to different hazards, such as falling material and explosive handling.

During 2016, we ran tests to place explosives at overhangs up to eight metres at the Diablo Regimiento mine, El Teniente Division, as part of the first industrial validation stage.

**Detecting and extracting uncrushable material in the primary crusher feed:** This system is used to detect and extract material such as shovel teeth, steel sheets, strengthening mesh and beams, so as to reduce stoppage time and employee exposure to operation risks through remote control operations.

During 2016, focus was on developing technology that would detect such material, so we have been making an industrial scale prototype.

**White metal electroleaching:** After this process, the white metal can be treated at traditional hydrometallurgical plants, widely available in our Company. It is currently in the industrial validation stage at El Teniente Division.

**Heap bioleaching of sulphides at room temperature:** it is currently in industrial application at Radomiro Tomic Division. During 2016, engineering work was carried out to adapt facilities so as to expand the use of this technology and achieve the design scale.

**Smelting – refining technological breakthroughs:** they will help to improve operational and environmental performance, based on the predominant technology of our company, the Teniente Converter. During 2016, two key projects were started, use of high-pressure nozzles and development of an expert sensor control system.

### **Automation, telecommunications and robotics**

In 2016 we developed a project for remote operation, from our offices located in Santiago, of all Ministro Hales Division processes: mine, crusher, concentrator and roaster.

We have been remotely operating the above mining processes since April, a unique global experience with excellent results; we now have a more autonomous and integrated operation that is safer for employees. We hope to replicate this initiative at our other division plants.

We also standardised 93% of our concentrator plant control systems, primarily instrumentation infrastructure, communications networks, distributed control systems, operating stations and advanced control systems, to improve operations and to be in line with production plans.

Key milestones during the year:

- At Chuquicamata Division we 767upgraded the ore grade, particle and image analysers. We also integrated the mill, slag remover, thickener and plant control system. As a result, and by migrating the plant control system, we have standardised 85% of the control systems.

- At Ministro Hales, we implemented a vital signs monitoring system (critical signs such as water usage, reactive usage and liquid pressure) for the roasting process and concentrator plant.
- At El Teniente we incorporated an advanced control system at the molybdenum plant.
- At Salvador we integrated the filter plant control system and we digitalised the critical variables of the concentrator plant.

**Integrated Data Centre:** located our the Head Office, its main goal is to analyse the historical data of the unit processes and prepare predictive mathematical models to make decisions regarding specific operating events. We built this centre in 2016 and in 2017 we will address application cases, such as our thickener operations, as well as the concentrator plant data analysis at El Teniente Division.

**Smelting process:** as part of the roadmap to develop advanced control systems, we implemented an advanced control application for the Chuquicamata's three acid plants at, in order to stabilise processes and have a better quality product.

**Robotics:** we integrated two robotic arms to support the copper concentrate sampling process in the trucks at Salvador and the molybdenum concentrate sampling in maxi bags for the Moly plant, improving safety standards as well as sampling data quality and precision.

**High-fidelity dynamic simulator:** in a training environment to efficiently operate and face critical conditions, we developed and implemented this simulator for the roasting operations at Ministro Hales Division. This initiative is in addition to the operator training systems at the concentrator plants; it will also will be applied in other operation areas over the next few years.

### Recognition and agreement

In 2016, The Smart Industry 50 recognised Codelco as one of the “innovators on the leading edge of digital transformation.”

In July 2016, we signed a framework collaboration agreement with Subtel the Office of the Undersecretary of Telecommunications under the Ministry of Transport and Telecommunications. This alliance enables joint work on topics related to standards, projects and communication technologies roadmap.

