Global Mining Standards and Guidelines Group

"Toward Integrated Operations in the Mining and Metals Industry"

Laura Mottola, **Flow Partners**, President and CEO
Ezequiel Muñoz, **Codelco**, Director Safety and Business Continuity, TICA Management
Alberto Caneo, **Codelco**, Head of Unit, Automation Dept., TICA Management
Héctor Cerda, **Codelco**, Head of Emerging Technologies Department, TICA Management
Ricardo Aguilera, **Barrick**, Regional Technological Projects and Innovation Manager
Dylan Bennett, **Teck**, Head of Operational Technology, Chile, IS+T
Sergio Silva, **FMI**, Regional MIS Manager
Gustavo Arriagada, **Anglo American**, Senior Business Improvement Advisor
Fernando Romero, **Anglo American**, Operational Technologies and Systems Manager

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From where did this collaboration initiative arise?

"Global mining collaboration on solutions to common industry problems, needs and technology through standards, guidelines and best practices"

We offer an opportunity to have an open discussion based on sharing experiences, lessons learned.

The productivity problem …

- …has always been looked at from a traditional, mechanistic viewpoint

There are structural factors that are squeezing the mining business – external and internal factors.


Cost competitiveness

CHILEAN RANKING EVOLUTION: CASH COST C1

YEAR 2000		
RANKING	COUNTRY	CASH COST
1	Indonesia	29.9
2	Myanmar	37.1
3	Botswana	41.6
4	Argentina	42.4
5	Chile	43.0
6	Russia	43.0
8	Australia	44.9
12	Peru	50.5
21	USA	60.1
24	China	62.8
29	Zambia	81.7

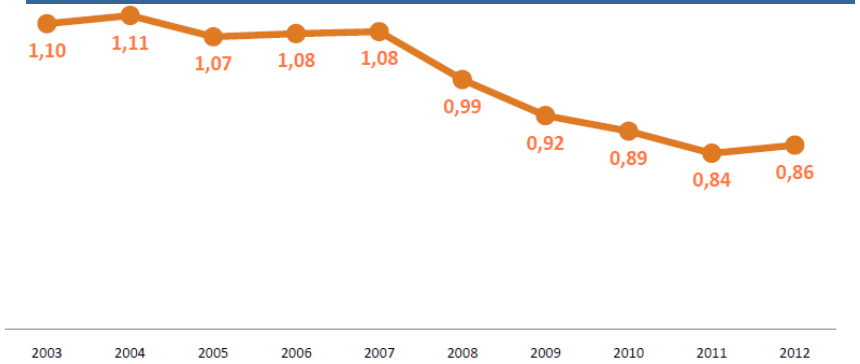
YEAR 2013		
RANKING	COUNTRY	CASH COST
1	Eritrea	8.3
2	Vietnam	71.2
3	Uzbekistan	72.3
4	Mexico	106.1
5	PN Guinea	106.1
7	Peru	111.4
12	USA	157.3
19	Russia	171.6
21	China	174.4
23	Chile	176.5
30	Zambia	211.8
31	Australia	213.0

Decrease of Chilean competitiveness in the global ranking of costs and relative to major producing countries

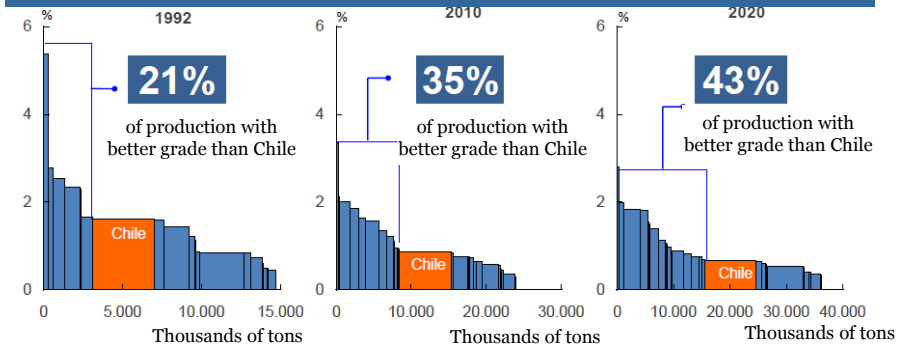
Competitiveness and Productivity,
CRU Copper Conference, Santiago, 8 April 2014


Decreasing ore grade and labour productivity

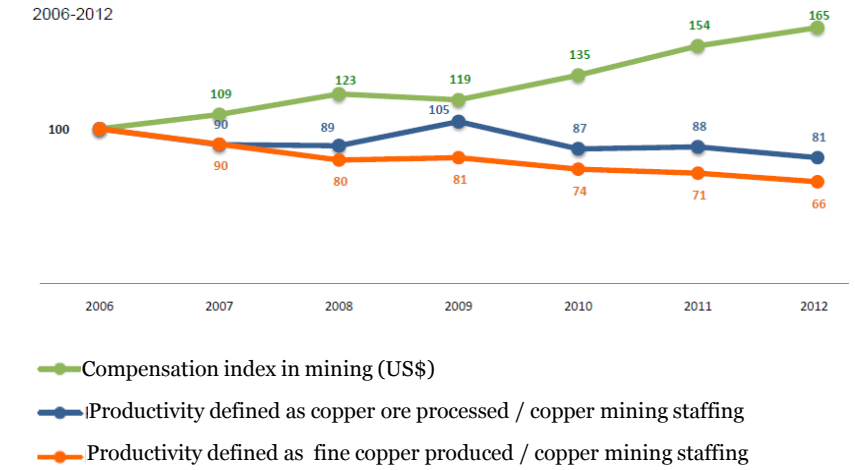
Copper ore grades in Chile, 2003-2012



Average grade by country and respective annual copper production

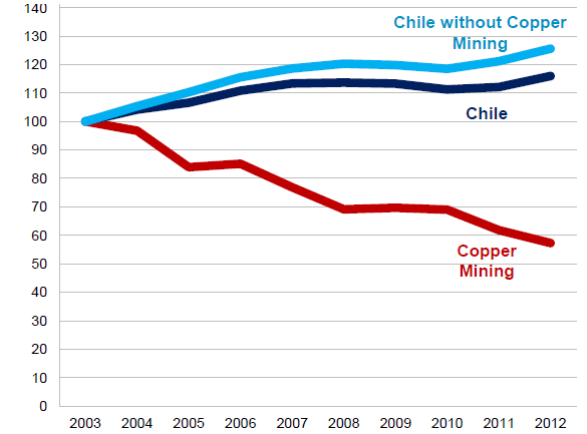


Labour productivity and compensation in copper mining



Development of productivity in Chile

GDP per worker in Chile and copper mining GDP per employee. Index 2003=100



Productivity in mining, aggregate productivity and competitiveness country.

José Pablo Arellano. Central Bank, National Statistics Institute, National Geology and Mining Service, Codelco

Large Scale Mining in Chile: Productivity Challenges, Mining Council, August 2013

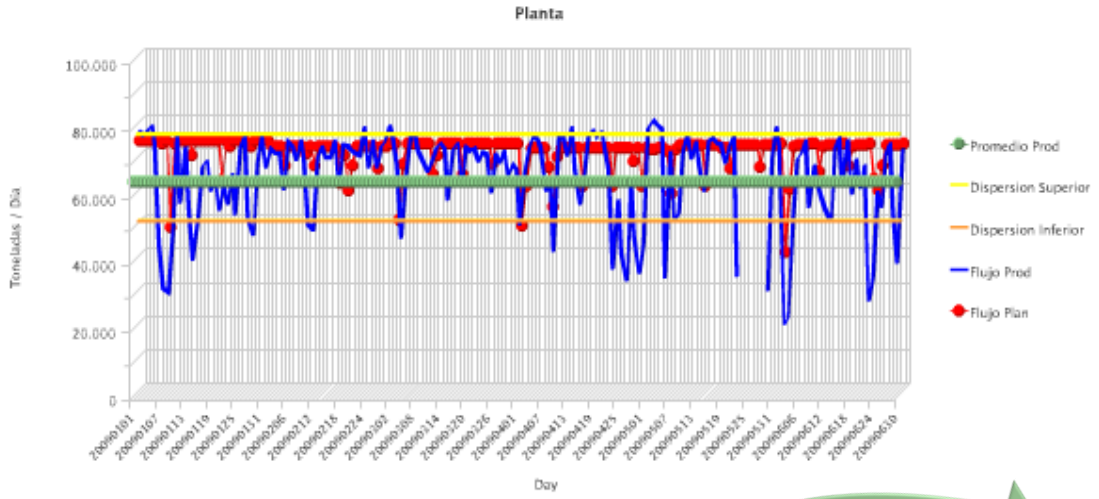
The real problem …

- … is the variability of the production process

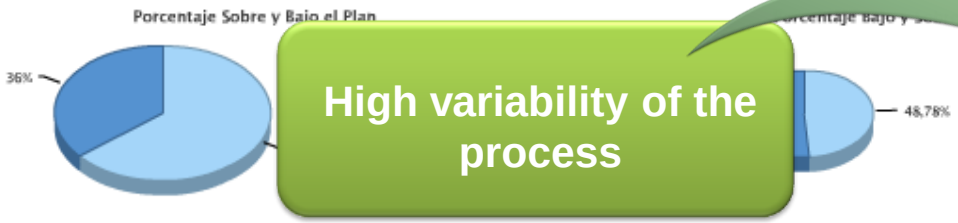
The mining business needs a new outlook and approach to its challenges in order to generate new solutions.

Cost Increases and Productivity Decreases Due to High Variability of the Production Process

The high **variability** of the flow of production is a problem in mining that considerably affects both the levels of production and the costs.

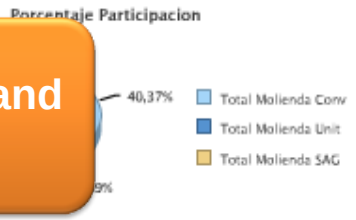


Indicadores de Variabilidad	
Total Produccion(ton):	11.227.031,57
Total Plan(ton):	12.815.836,89
Diferencia Prod-Plan(ton):	**-1.588.805,31**
Promedio Prod(ton):	64.154,47
Desviacion Estandar(ton):	13.228,41
Coeficiente Variacion(%):	20,62
Promedio + DevStd(ton):	77.382,87
Promedio - DevStd(ton):	50.926,06



High variability of the process

Production losses and higher costs

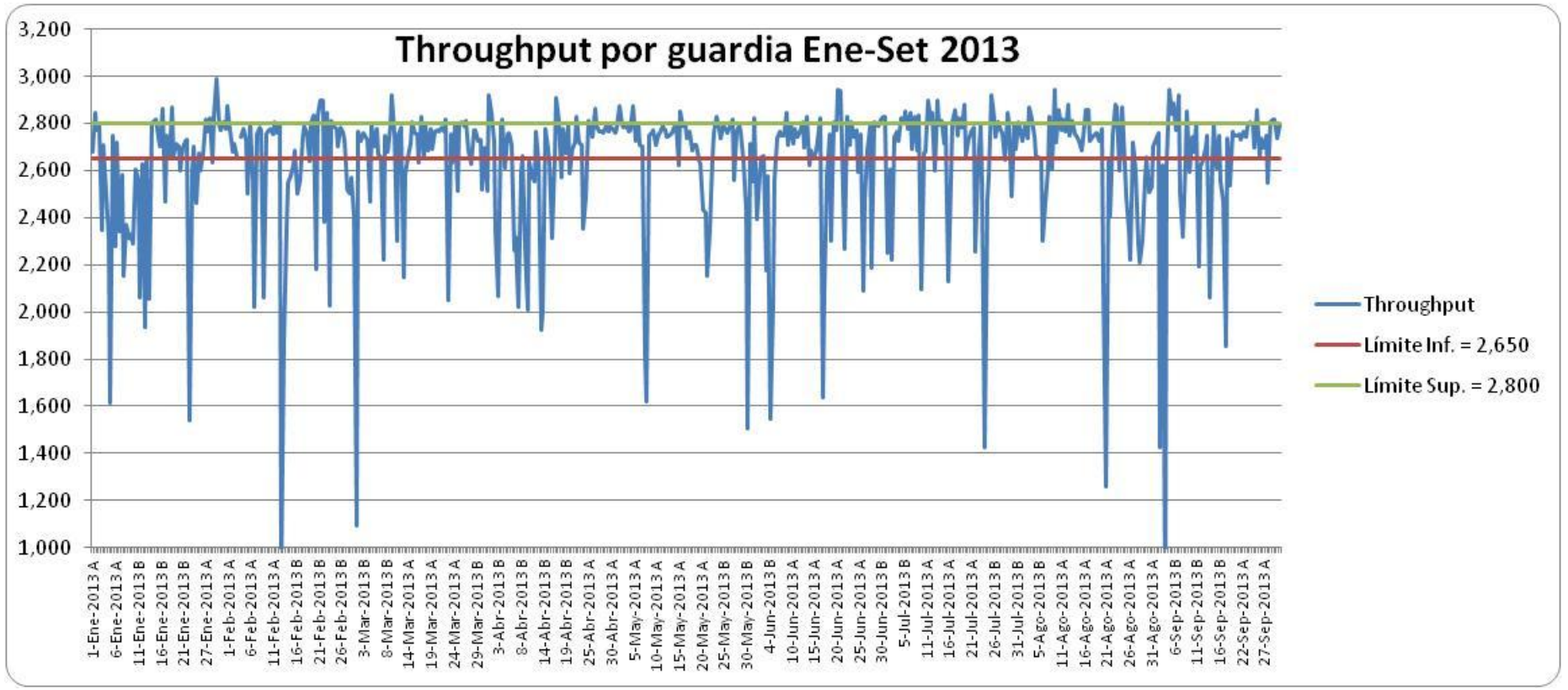


Variability …

- … in the behaviour of the entire mining production process is an emerging phenomenon that has not been addressed because it is not just a physical process and therefore its root cause is not only attributable to its parts.

More attention must be paid to the interdependencies among the parts of the system, looking at the production process holistically.

Analysis of Throughput Variability



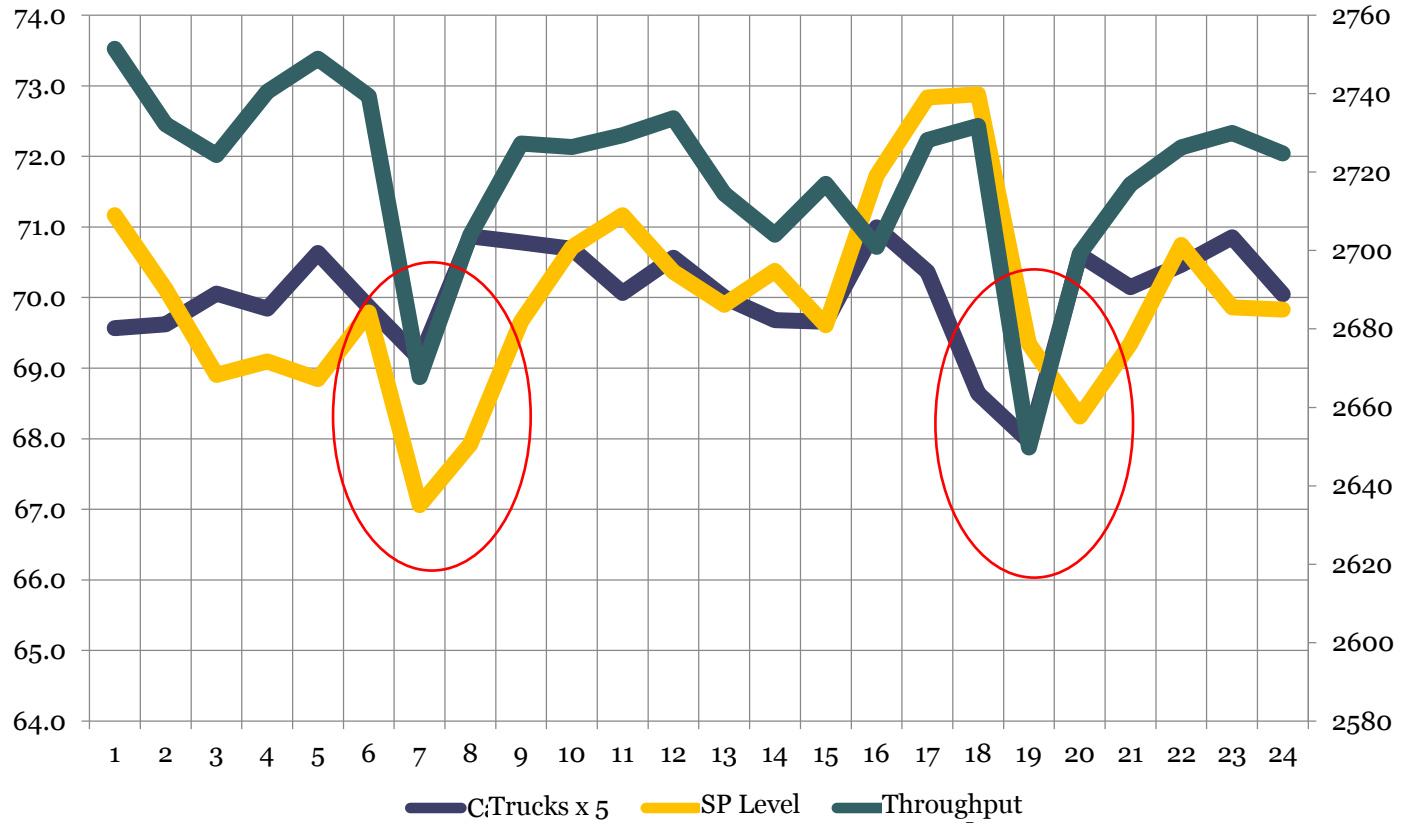
Data by shift:

31.9% of the data is below target throughput, which is 2,650 t/h; the overall average from January to September is 2,635 t/h.

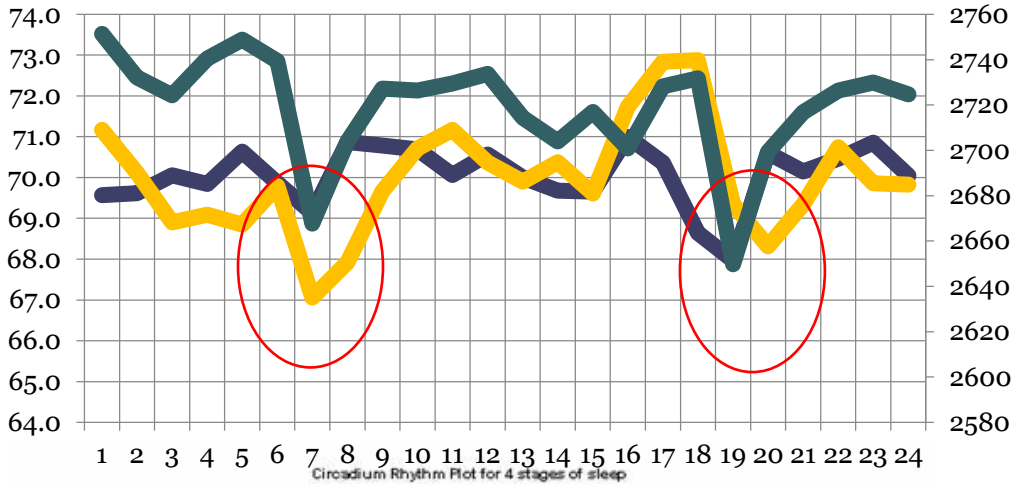
The upper limit is a reference value to identity the variability of the process.

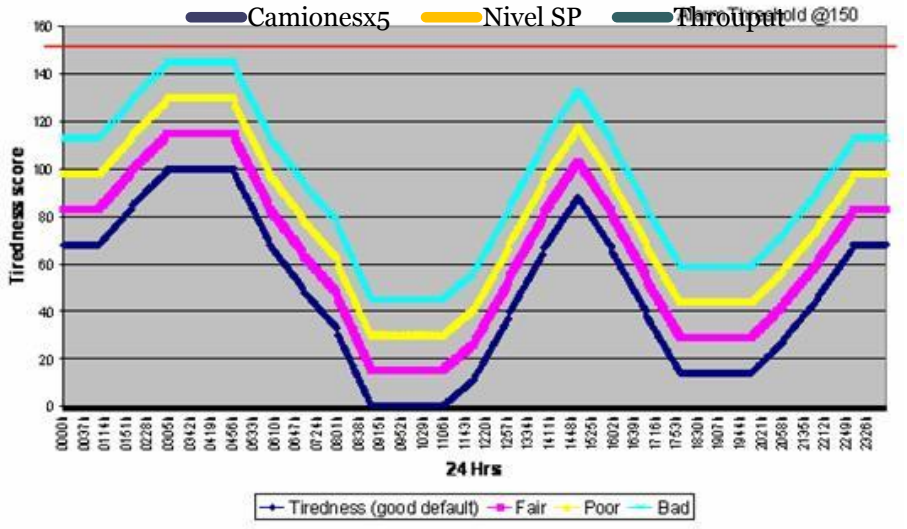
Analysis of Throughput Variability

Variability of Throughput throughout the day, from January to September



Analysis of Throughput Variability





Graph of standard circadian cycle

Our hypothesis

- In order to manage variability of the entire production system, we need integrated operations.

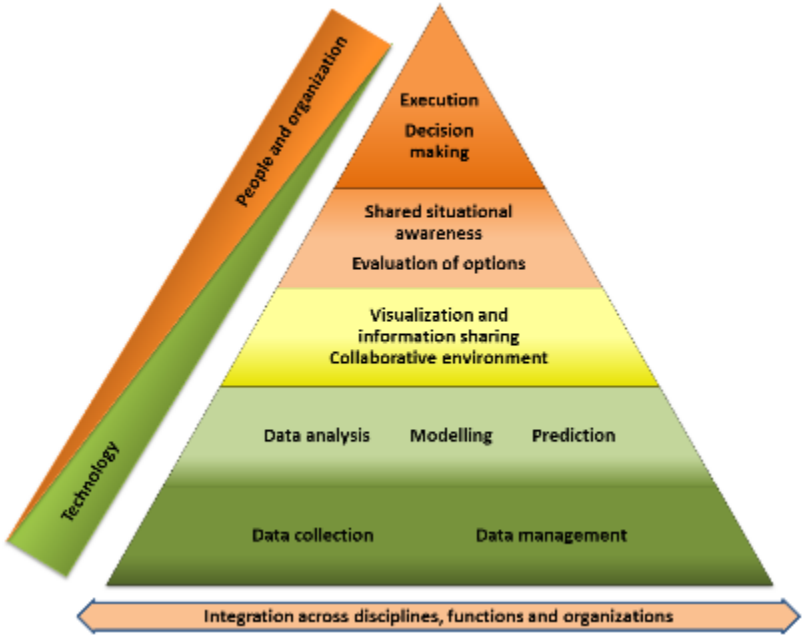
We propose an integrated operations model that verifies this fundamental principle of managing the variability of the entire production process.

Definition of integrated operations

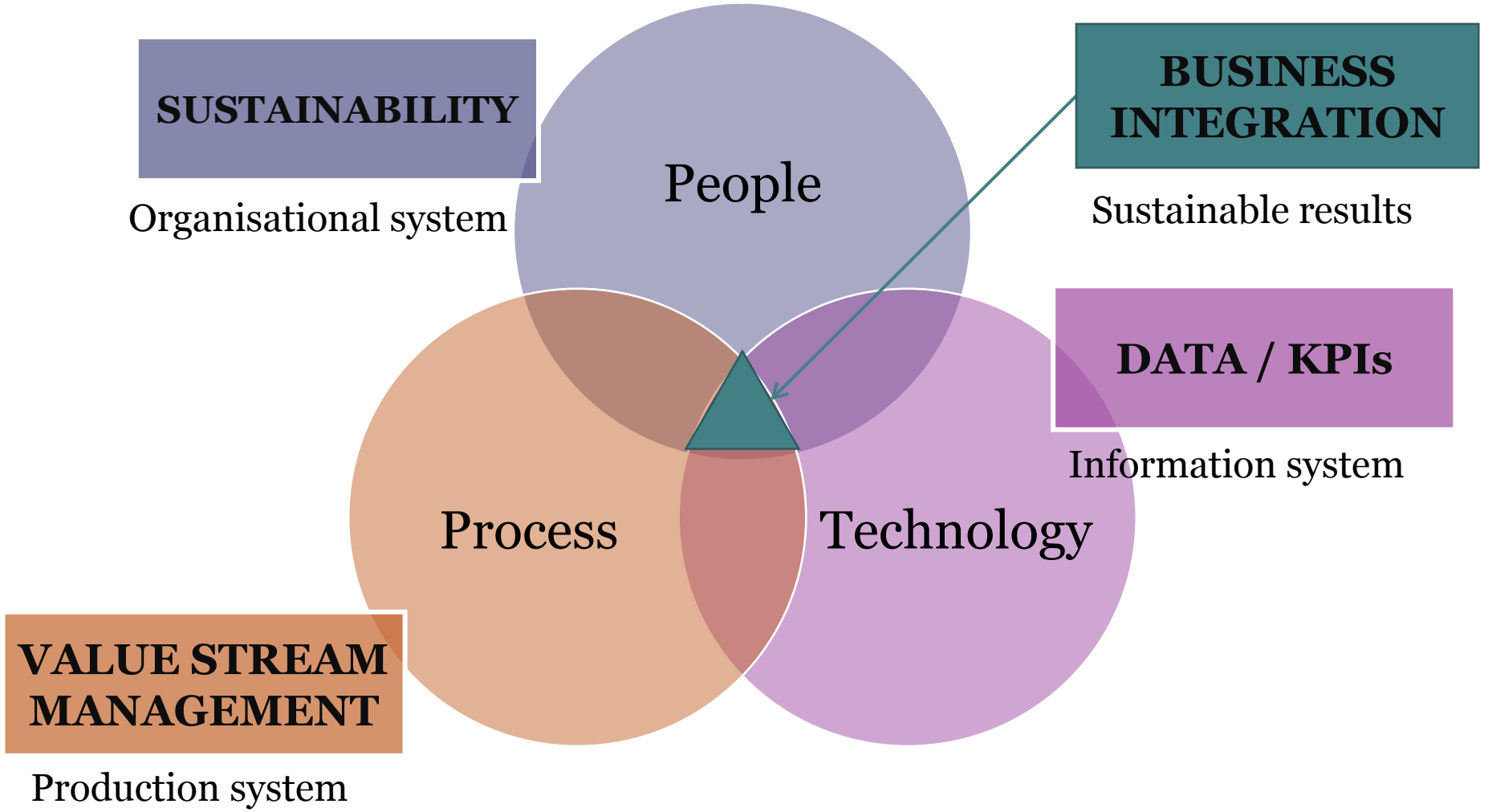
"Integrated Operations (IO) …

- *… is the integration of people, organizations, work processes and information technology to make smarter decisions.*
- *It is enabled by global access to real time information, collaborative technology and integration of multiple expertise across disciplines, organizations and geographical locations."*

Center for Integrated Operations in the Petroleum Industry



Integrated operations through business integration




Barrick Veladero IOC

Primary Crusher

Dispatch

Merrill Crowe

Maintenance

Lessons Learned Barrick Veladero

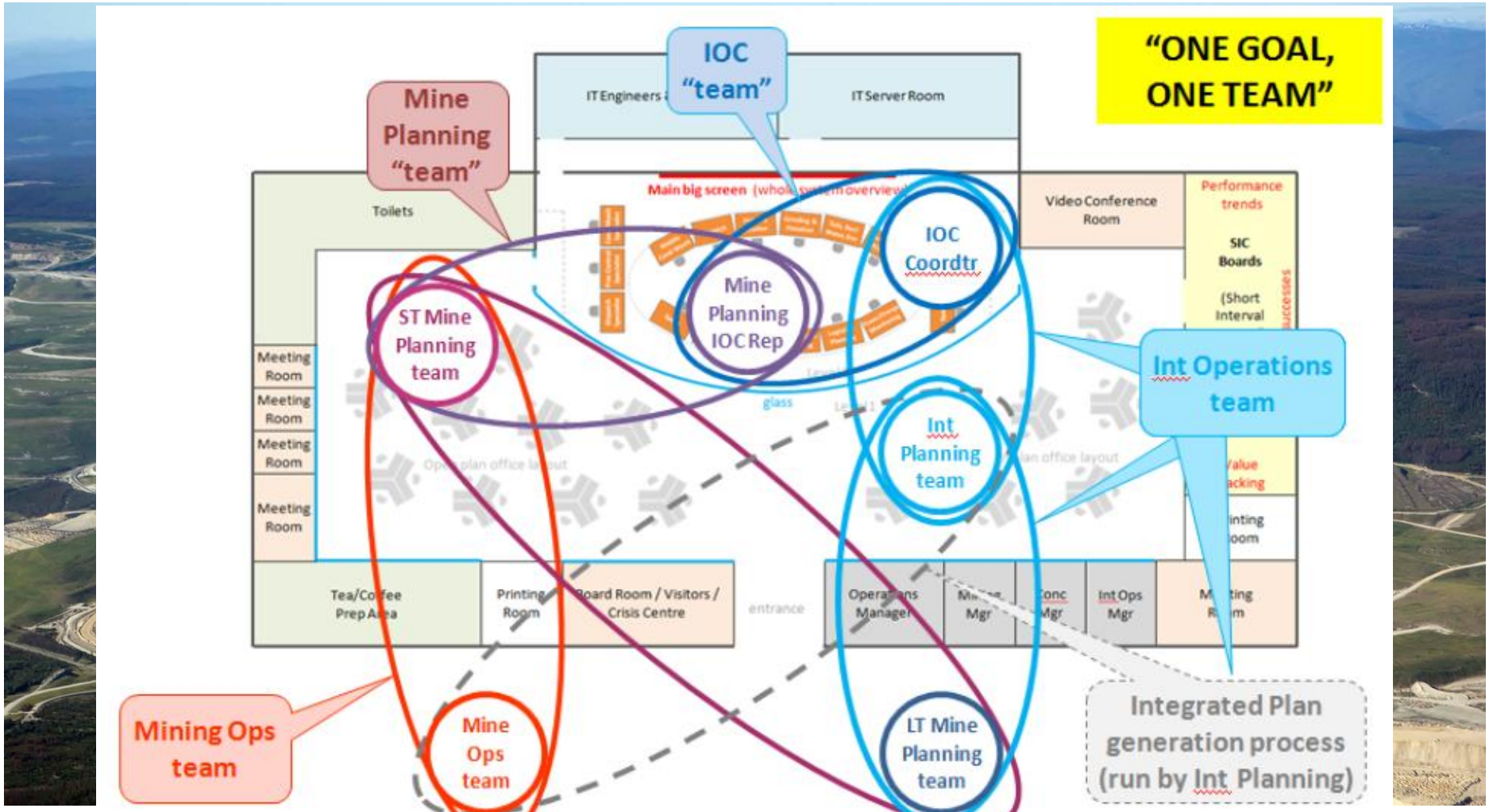
- Centralise all the production areas – “the problem of one affects all”
- IOC in the truck shop, implementation in progress

- Sponsorship from very high-level people in the company, in order not to suffer changes due to particular views.
- The project leader must have the weight in the organisation to be able to interact with the managerial levels involved in order to demand results in time and form.
- Great focus on Change Management, detect those involved and affected, understand their losses and manage them.

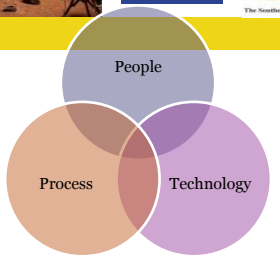
- Project must be part of the overall strategy as a company
- Implies new ways of working, which makes it necessary to create new policies and procedures.
- The mining process must now have a complete view, from start to finish, and not by silos

- Line of communication with high availability and redundancy
- Use forms of visualisation, above all in dispatch, when operators are accustomed to look at the operation.
- Telephones with cameras in order to minimise the impact of face to face communication


Teck Highland Valley Copper IOC



Lessons learned
Teck Highland Valley Copper



- Integrated Operations initiative in progress
- Room for integrated meetings was developed
- Development of “live overview” and “live hotspots” in progress
- Two partially integrated rooms
  - Concentrator plant control room with primary crusher
  - Mine dispatch and mobile maintenance room

- Requires sponsorship at an executive level
- Leader with experience in operations, excellent collaborator, respected
- Leader must report to an operations department
- Frequent involvement of operators from the start

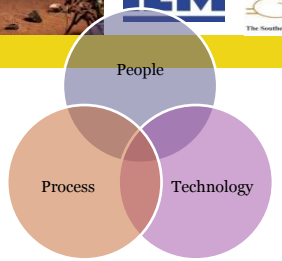
- Implement in small stages in order to demonstrate success early and frequently.
- Processes are required in order to make dynamic decisions in an integrated manner, integrated planning, and integrated business improvement.
- Meetings of the integrated team must be frequent but brief and focuses on the most important topics.

- This is not a technology initiative, but technology is an enabler.
- Integration is required among various systems in real time in order to have a view of the entire operation – solutions available in the market only resolve part of the problem.

Codelco Andina

Lessons Learned Codelco Andina

CODELCO
Orgullo de Todos



- **The transformation process was initiated in order to control the variability of the flow of ore, so as to meet/exceed the annual production plan and capture savings in the order of 300 $ MUS over 10 years, reducing by 1 percentage point annually.**
- The owner's highest representative stated the new rules of the game for systematically encouraging collaboration and fulfilment of commitments in quality and quantity of the flow of ore by time unit, from the final customer to the mine.
- The observer was changed, showing the integrated process in advance and in real time, the variability of the flow of ore, its metric and its economic effects.
- A continuous learning process was generated through the evolving participation of successive technological applications.

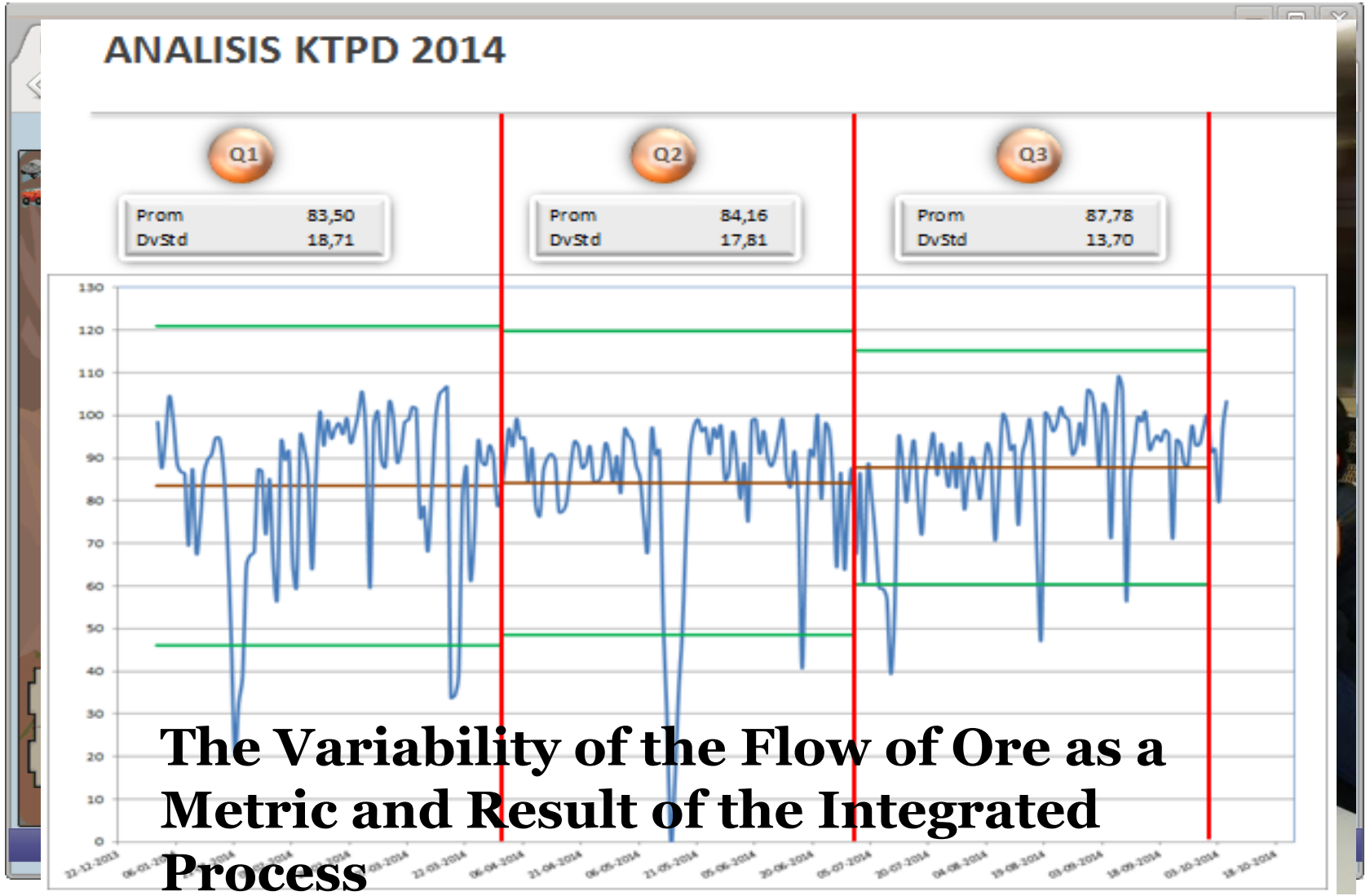
- People are managed based on trust, respecting their dignity, responsible autonomy and as creative agents of know-how.
- Substantially increase connectivity-collaboration-anticipation regarding the identification and subsequent resolution of problems or restrictions that could affect operational continuity
- Give preference to experience as a way of increasing know-how. Need to experiment a priori (simulations, virtual reality, increased reality), using coaching in situ, focused on increasing competencies in transformational learning, management of technological processes and applications, under the scheme of learn-create-act.
- The mind as an emerging phenomenon (more biological-emotional than rational). Empowerment of workers, flat, interdisciplinary and transversal organisations

- The business is visualised, designed and governed in terms of BUSINESS UNITS/PROCESSES instead of functional areas or cost/budget centres in order to optimise the long chain, not the short chain process.
- Short term planning involves all the actors who participate in the production process, giving preference to the participation of the «last planner» who is the person who actually does and knows the task, thereby generating the resulting commitments.
- Integrate the business processes where each sub-process is a customer of the former and a provider of the following, based on contracts that consider the essential commitments in quality and quantity of the flow of ore per unit of time (hour-shift) from the final customer to the mine.

- Integrated Platform of Intelligence on Production, Automation, Tele-operation, Robotics, M2M.
- Have an integrated view of the operation in real time, historical and anticipatory for the line of business, with emphasis on the variability in the flow of production and in synthesis, as a driver of new conducts and increasingly more autonomous production processes.
- Growing stimulus on the generation of simulation and predictive models to drive the change of observation through experience.

CODELCO
Orgullo de Todos

Codelco Andina: Transformation Process



The Variability of the Flow of Ore as a Metric and Result of the Integrated Process

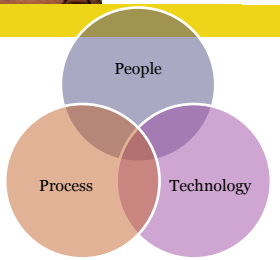
CODELCO
Orgullo de Todos

Codelco El Teniente CI2TM

Integrated Information and Decision-Making Centre for Mining Operations Management
CI2TM

CI²TM Gerencia de Minas El Teniente

Lessons learned
Codelco El Teniente CI2TM



- The personnel who currently work sin the room:
  - Manager of CI2TM
  - CCV Operator
  - Esmeralda Mine Dispatch Operator
  - Teniente 8 Dispatch Operator
  - Teniente 5 South Dispatch Operator
  - Mine Crushing Plant Operator
  - Diablo Regiment Crushing Plant Operator
  - Teniente 7 Roads Dispatch Operator

- Personnel selected are referenced in their process organisation
- Maintain ongoing contact with their origin organisation
- CIO personnel circulate in the field when there are changes in the processes
- The support and commitment from upper management is required
- Personnel in the CIO room functionally report to their origin organisation according to a matrix organisation structure
- There must be perseverance and constancy from the leader and the organisation
- The physical CIO room gives preference to the integration at the level of the people; in face to face the additional trip of the metal train is gained

- Seeks to reduce variability and increase production
- Define a measurable purpose
- Each sub-process of the Mine process must be represented in CIO (physical room)

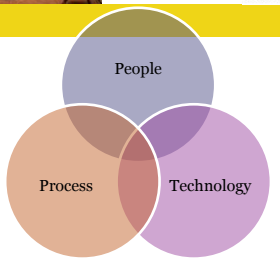
- Use standards (no owned system)
- Have redundancy and high reliability designed in the architecture itself
- Human error-proof technology
- Apply “safety integrity level” (SIL).

AngloAmerican

Anglo American Platinum

Anglo American Platinum 'War Room'
60 Main street, Johannesburg, South Africa

Lessons learned Anglo American



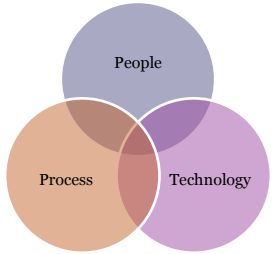
- Centralised monitoring of data from Ore **Processing Plants**. Over 100,000 tags.
- Objective: improve the performance of the metallurgical processes.

- Integrity of the data – one version of the truth (information).
- Capacity for specialised analysis of the metallurgical processes in a centralised manner.
- Visibility of the performance of the processes in real time for the Managers.
- Synergies of expertise by working together.

- Definition of KPI's
- Benchmarking among similar Unitary Operations
- Automated root cause analyses of performance deviations
- Base for opportunities to use APC (Advanced Process Control)

- Prioritisation of **Instrumentation**: MISSION critical, CONTROL critical, INFORMATION critical. Management of automated Instrumentation Assets
- Intensive use of Control Systems
- Energy and Water Management Systems
- Databases in real time (PI System)
- Mathematic algorithms for validating data

Success factors – People



- Consistent sponsorship from senior executives
- Transform the organisation toward a new operations management model
- Development of multi-disciplinary, high performance teams
- Clear accountability, roles and responsibilities

Do not focus on organizational structure, but rather on changing the conversation and a focus from upper management to generate a transformation

Success factors – Processes

- Focus on the entire production process
- Visibility of cross-functional key performance indicators
- Predictive model (looking ahead)
- Common objective – a continuous flow of value

Focus on managing the variability of the entire production system (and not on its parts) in order to highlight the interdependencies and the emerging behaviour

Success factors – Technology

- Effective visualization of information in real time for decision-making
- Accurate measurement in the field
- Rapid and reliable infrastructure
- Storage and analysis of Big Data
- Simulation and predictive engines
- Collaborative decision-making environment

Focus on the integration of the technologies that support the production system and the visualisation of the KPIs that have the most influence on the overall behaviour

In order to advance toward integrated operations

- Objective: Manage the variability of the flow of ore in the entire value stream of the production system in order to meet the production plan in quality and quantity (the commitment to the owner)

Step 1: Upper management states the new rules of engagement.

Step 2: New conversations change the observer.

Step 3: The continuous improvement process generates learning.

Conclusions

- This framework is based on the authors' experience
- We propose looking at the problem in a different way
- Address the situation from an integrated perspective, recognising the emerging phenomenon of the variability of the entire production system
- An adaptive transformation process, more than change management, is required
- Integrated operations do not necessarily materialise in a physical IOC

Are we willing to consider this proposal as a possible way forward to a real and sustainable solution?

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"Toward Integrated Operations in the Mining and Metals Industry"

Let's Talk!
Join GMSG!

Heather Ednie
hednie@cim.org

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