

Technical model of Management: “The impact of the decision making in real time in the Open Pit Andina Mine”

René Oliva S, Mine Manager División Andina CODELCO-CHILE.
Eduardo Lagos C, Specialist Engineer in management and mining technologies
División Andina CODELCO-CHILE.

Introduction

The Andina Division belongs to the National Corporation of Cooper of Chile (CODELCO) and operates the Río Blanco deposit. This deposit is located to eighty kilometers from northeast of Santiago of Chile, between the 3,700 and 4,200 meters over sea level. At present time Andina Division exploit the Underground Rio Blanco Mine and open pit Mines as Sur and Don Luis.

Andina it annually produces 240,000 metric tons of fine, contained in concentrated of copper that are raw material fundamental to obtain the refined metal. In addition, it places annually, in the markets 3,100 metric tons of molybdenum.

The Mine Management of Andina Division had developed a Technical Model of Management, based on the value creation, considering: security for his people, their equipment and facilities, the respect to environment and quality.

The contribution to the aggregation of Divisional value by mine management side depends on the Management that exerts via maximization of assets performance and containment of costs.

This work tries to describe how this technical model of Open Pit mine management of Andina Division has operated , showing its logic and results.

Eduardo Lagos C.
Specialist Engineer – División Andina
CODELCO-CHILE
E-mail: elago001@codelco.cl
56-9-94991805

Technical model of Management - Management of Mines

Mine management of Andina Division, bases its Technical Model of Management on the Creation of Value. The value creation is sustained respecting: people safety, the equipment and facilities, environment and quality.

The contribution to added value of the Division by mine management side depends on the performance that this Management makes via maximization of assets performance that they are responsible of, in production logic.

$$\text{Production} = \text{Performance} \times \text{Time}$$

The Mining Operation contributes to the aggregation of value only by efficiency via. Represented for Economic Value Added (EVA)

$$\text{EVA} = [(\text{Price} * \text{quantity}) - (\text{Direct Costs} + \text{Indirect Costs})] - \text{WACC}$$

$$\text{EVA} > 0 \text{ add Value}$$

$$\text{EVA} < 0 \text{ Destroy Value}$$

There are some indications how to generate a greater added economic value, such as:

- To improve efficiency of current assets. This is to increase the assets performance without investing more or increasing assets rotation.
- Increasing the investments in assets that render over the cost of liabilities.
- By means of assets reduction.

In this last matter, to reduce assets, it is advisable to apply measures as, assets rotation, to rent fixed assets, instead of buying them, externalize processes to be able to eliminate the corresponding assets, among others.

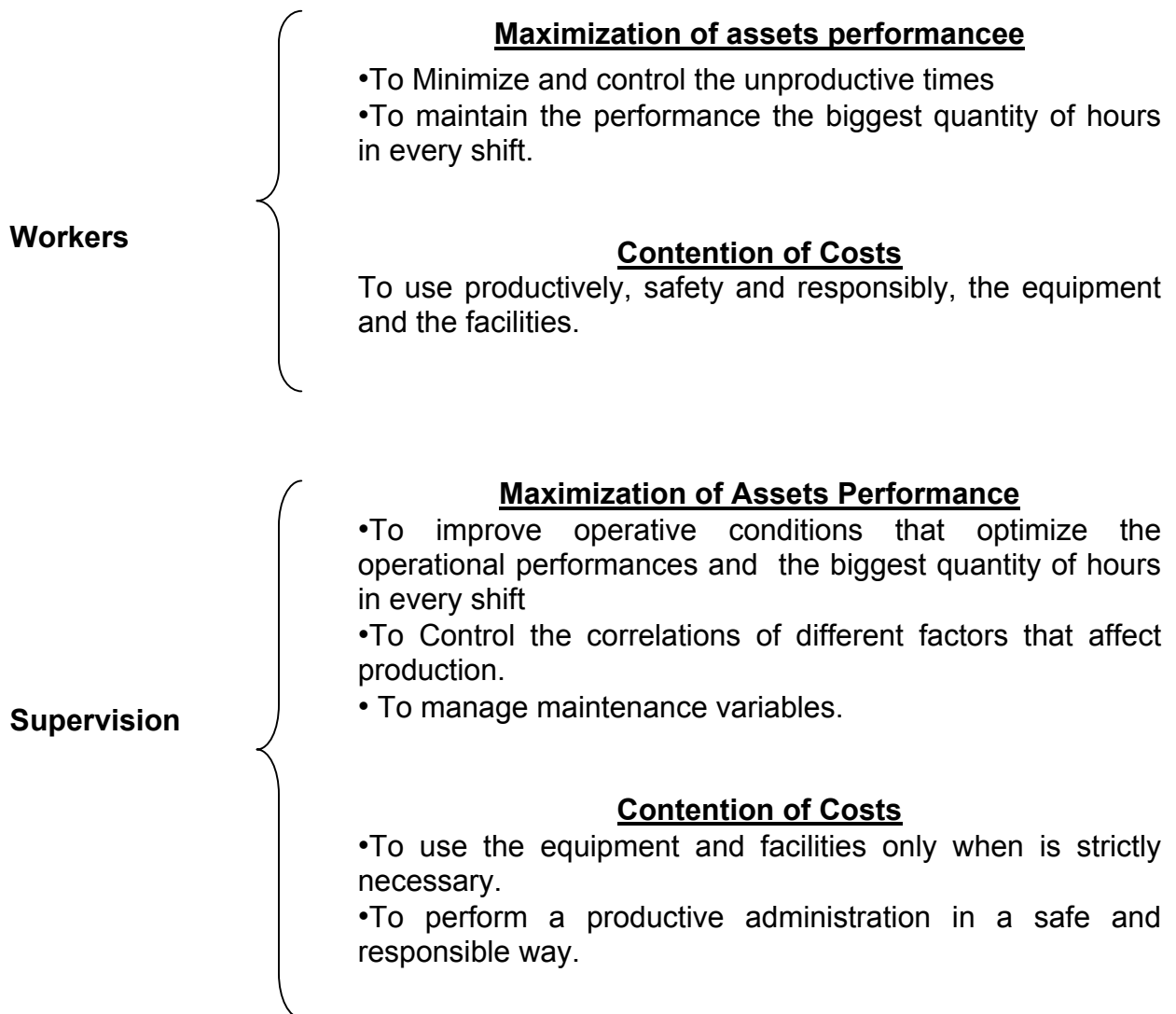
Contribution to the Aggregation of Value

The contribution to the value aggregation depends on the management that exerts as Workers, as well Supervision, focusing in the maximization of the performance of assets and the containment of costs.

The contribution of the Workers is exerted when all those unproductive times are diminished and controlled and they become in effective times, reaching and surpassing the aimed performances required. These performances must stay the greater possible hours in each shift, of this one form materializes their contribution

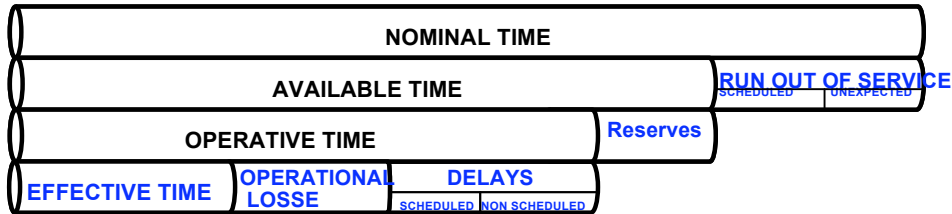
to the performance of the assets. From the point of view of containment of costs, all the activities before described must be made in safe and responsible way, preventing a good use of resources.

The contribution of Supervisors is exerted when the operational conditions are well managed, allowing the improvement of operational performances during the greater possible hours in each shift, controlling the correlation of different factors that affect the production and assuring in this way to maximize the performance of available assets performance and therefore the fulfillments from production Programs for each shift, week and month. Respect to maintenance Programs has to be managed the schedule variation of availability for every equipment fleet and to use this equipment, only when strictly necessary.



Time Distribution chart of Andina Division

It is important to establish a time distribution for equipment, that allows us to measure and manage us.



Time	Definition
Nominal	Total time of the period.
Run out of Service	Time in which the equipment is not available to make its functions due to have faults in its systems or for being given to maintenance or for being repaired.
Available	Time that the equipment is mechanically qualified to work.
Reserves	Time in which the equipment is mechanically qualified to work, but is not being used in operation.
Operative	Time in which the equipment is being used by an operator in some task.
Delays	Times of all the interruptions occurred in the productive process. They are divided in: Programmed delays, those that appear from shift to shift in operation and non Programmed Delays which are those that can or cannot appear from shift to shift operation.
Operational losses	Operative times in which, the interaction that more than a cycle produces delays. Example Shovels and/or loaders with extractions Trucks.
Effective	Time in which the equipment is really making the habitual production for which it was designed for.

Indicators

From the time Distribution chart, the following key indicators are defined:

$$\begin{aligned}
 \text{Availability, \%} &= \left(\frac{\text{Available Time}}{\text{Nominal Time}} \right) \\
 \text{Use, \%} &= \left(\frac{\text{Effective Time}}{\text{Nominal Time}} \right) \\
 \text{Effective use (UE\%)} &= \left(\frac{\text{Effective Time}}{\text{Available Time}} \right) \\
 \text{\%PO, \%} &= \left(\frac{\text{Operational losses}}{\text{time Available}} \right) \\
 \text{\%RES, \%} &= \left(\frac{\text{Reserve Time}}{\text{Available Time}} \right)
 \end{aligned}$$

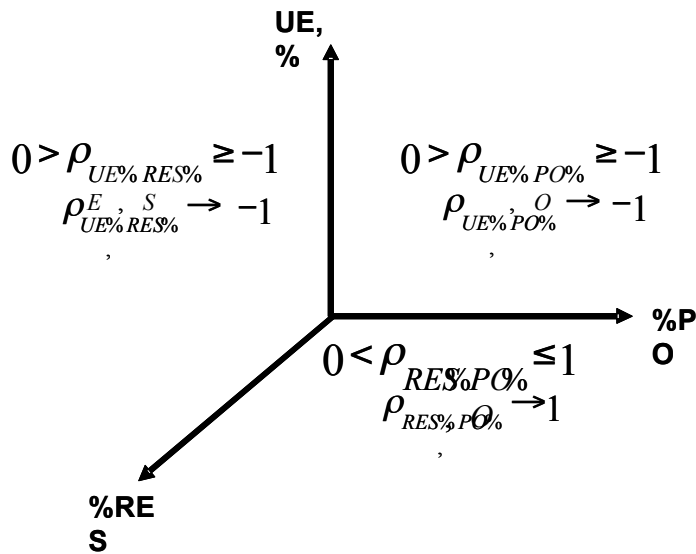
Correlations

For the correct decision making in real time, we must know what is the way we want to work in the different stages where our critical variables are correlated. All the decision making in real time are performed with a dispatch system available in Rajo Mine.

We will use the key indicating of times, the indicators of dispatch system and e statistical variable, the coefficient of correlation, as the tools for decision making in real time.

$$\text{Correlation coefficient} \quad \rho = \frac{Co(x,y)}{v \sigma_x \sigma_y}$$

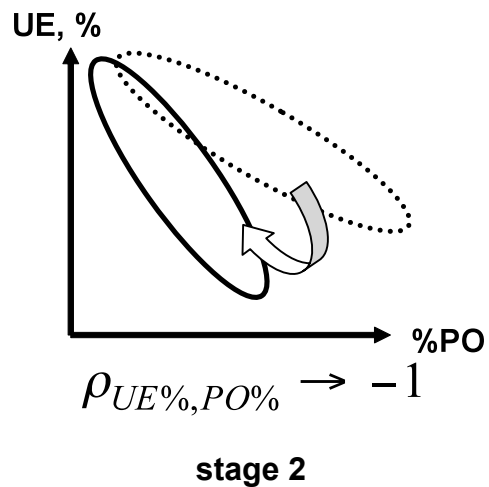
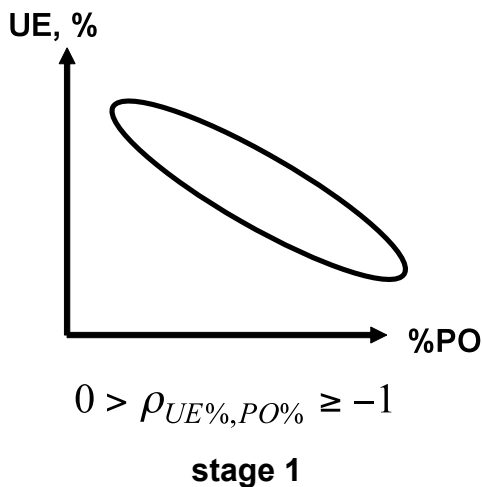
$$1 \geq \rho_{x,y} \geq -1$$



At every moment of the shift in Open pit Mine, it should into account an scheme as the above figure. In order to maximize the Effective Use (UE%) and to diminish as well as the percentage of Operational Losses (%PO) as the one of Reserves (%RES), of equipment times .

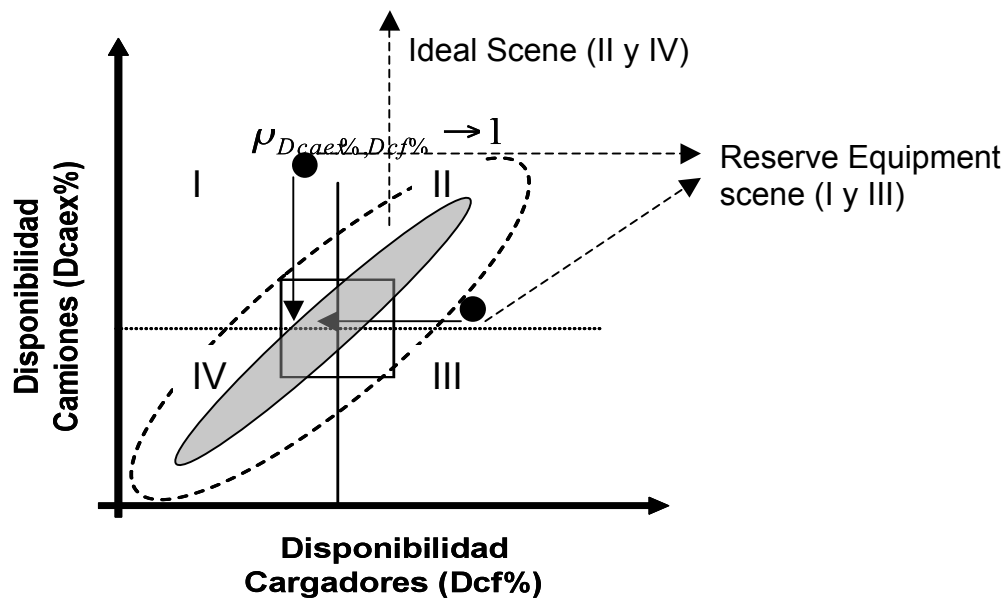
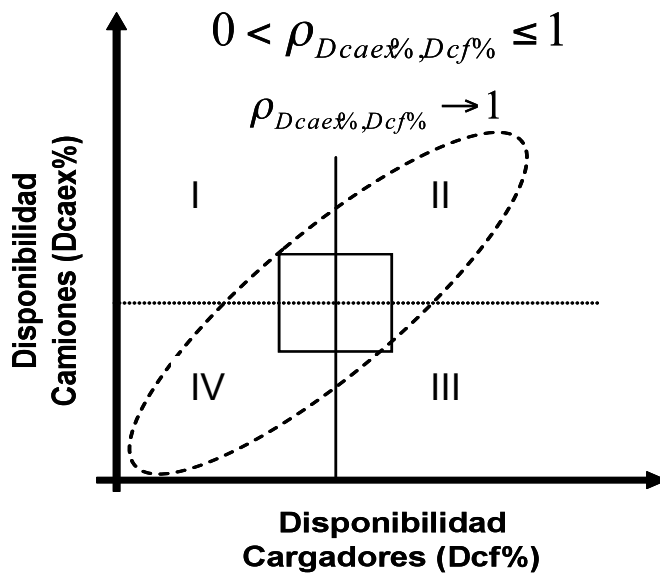
The correlation coefficient gives us information about the relation between two variables, but not of its magnitude. The first stage of this process will be to assure the correlation existence and the second stage will be to take the slope of this correlation to the expected standards.

If we observed the relation between UE% and %PO, it is required as first stage, that both variables are related in negative form and as a second stage that they reach the design values. This process, must be replicated with a negative correlation between UE% and %RES and a positive correlation between %PO and %RES, but it is affected by the existing relation between equipment availability loading and transport equipments



If we make a chart of loading equipment availability (Dcf%) with transport equipment availability (Dcaex%), we can define quadrants, where the correlation of indicators UE%, %PO and %RES, has different behaviors. The ideal work scene is in quadrants II and IV, where in every moment the objective is to maximize UE% and to diminish as well as %PO as %RES. If the relation between the availabilities, is in the values of design, there is a high probability to get plan fulfillment.

If we were in quadrants I or III, the required equipment must be in reserve state, which will allow going back to a well-known scene where we must assure a negative correlation between UE% and %PO.



Efficiency Factor

From the Technical Model of Management, we will define a Factor of Efficiency (b) for Rajo Mine that allows us to quantify the contribution to the aggregation of value from Mine Management of Andina Division.

We will define the factor of efficiency based on the performances, the effective use, the operational losses and the monetary losses of loading and transport equipments.

$$B = \left[\alpha \frac{\text{Real Performance}}{\text{Performance plan}} \right] \left[\beta \text{ Operational losses} + \chi \text{ Economic losses} \right]$$

Thus the factor of efficiency (B), for Rajo Mine, will be:

$$B = \left[0,5 * \left(\frac{\text{Rend Real Caex}}{\text{Rend Plan Caex}} + \frac{\text{Rend Real CF}}{\text{Rend Plan CF}} \right) - (0,5 * (\%PO_{Caex} + \%PO_{CF} + \text{US\$Losses})) \right]$$

where,

Caex = Transport Equipment

CF = Loading Equipment

Rend Caex = (Tons * Medium range)/Effective Hours

Rend CF = Tons/Effective Hours

%PO = Operational Losses Hours/Available Hours

US\$losses = US\$ Economic Losses/US\$ Operation budget

The efficiency factor promotes making a work under a certain standard of performance, by the greater of possible working time in shift obtaining an increase of Effective Use (UE%) by a diminution of the Operational Losses (%PO) and taking care of our equipment and facilities without incurring economic losses.

Analysis of Data and Results

The behavior of three variables will be analyzed, in the period January 2006 - March 2007.

% of Efficiency Factor Fulfillment , FE (B)

% Fulfillment of the Total Cost Rajo Mine

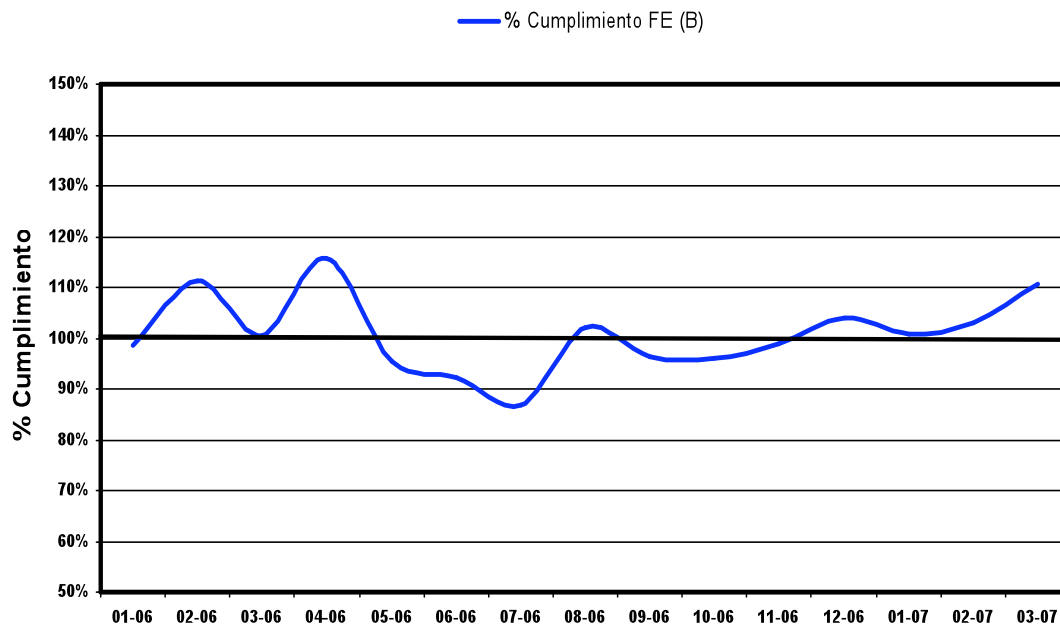
% of Production Plan Fulfillment

% Fulfillment = Real Value/aim Value

The Technical Model of Management was implemented in January of 2006 in Rajo Mine of Andina Division, from the data of this analysis have been reached 15 months of operation under this model.

The first months of application of this model (period of learning) it was considered a strong training fro workers also supervision in the dispatch system

Graph 1:



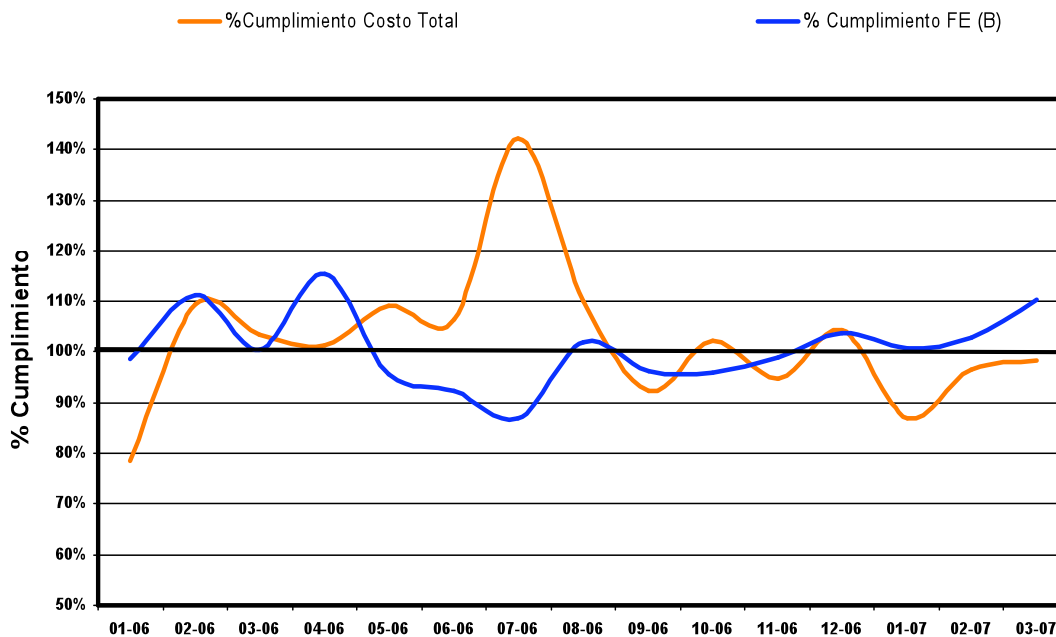
The curve of % of Efficiency Factor Fulfillment, FE (B), it has in its months a variable behavior given by the learning stage, later appears the winter matter associated to Andina Division, to finally reach values with a positive tendency in the last months.

The starting in the right use of the dispatch system along with the performed training qualification shows to us in the first months, variable values of efficiency, mainly due to a low correlation between the effective use and the operational losses in loading and transport equipments.

Loading and transport equipment of Rajo Mine are near their lasting life and the correlation between its availabilities (match shovel-truck) is low, if to the previous thing we added a bad allocation of resources, we are in scenes that do not add value to our business.

The graph allows us to conclude that for the last months of 2006 and the months corresponding to year 2007, it has been managed to internalize and to control in a better way the operative variables, as well the operational losses as the effective performances of loading and transport, that favorably affects in the efficiency factor, showing a positive tendency

Graph 2:



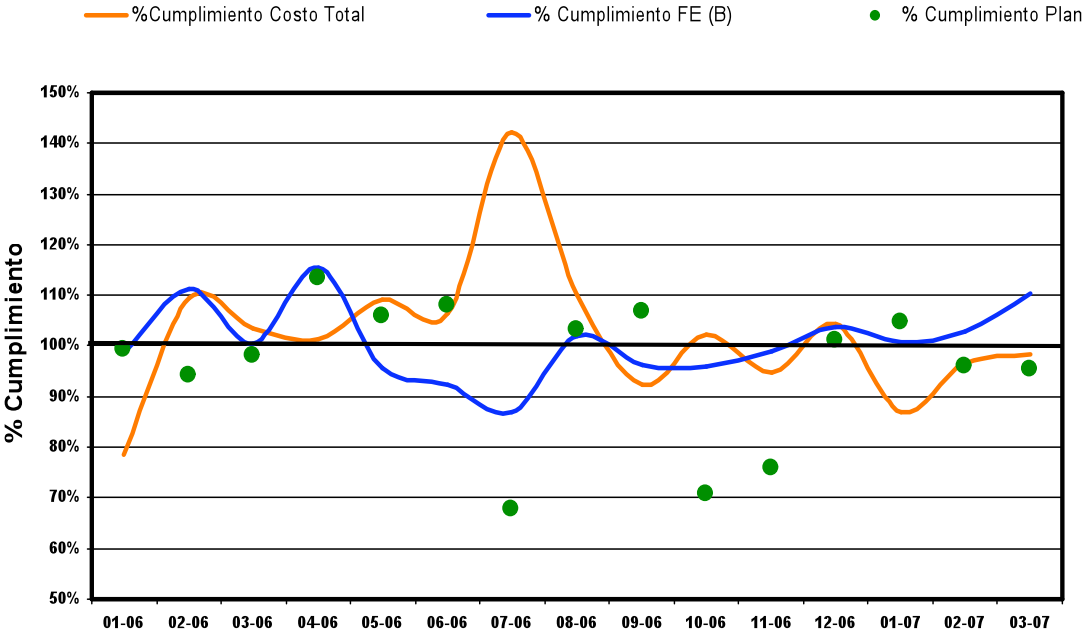
If to the previous analysis we added a second variable, the % of Total Dost Fulfillment, it is possible to notice that in spite of to have obtained high values for efficiency Factor (B), in the first months of application, these points do not have a correspondence with cost.

When advancing in the time within the graph, the unfavorable values for our analysis are appraised and for Rajo Mine operation, that show low FE (B) and high costs, those that are obtained during the winter period in Rajo Andina Mine.

So the challenge is to diminish these high negative points in the winter period that is approaching.

For the final periods of this analysis a control in the associated cost is observed a point of positive tendency of efficiency factor.

Graph 3:



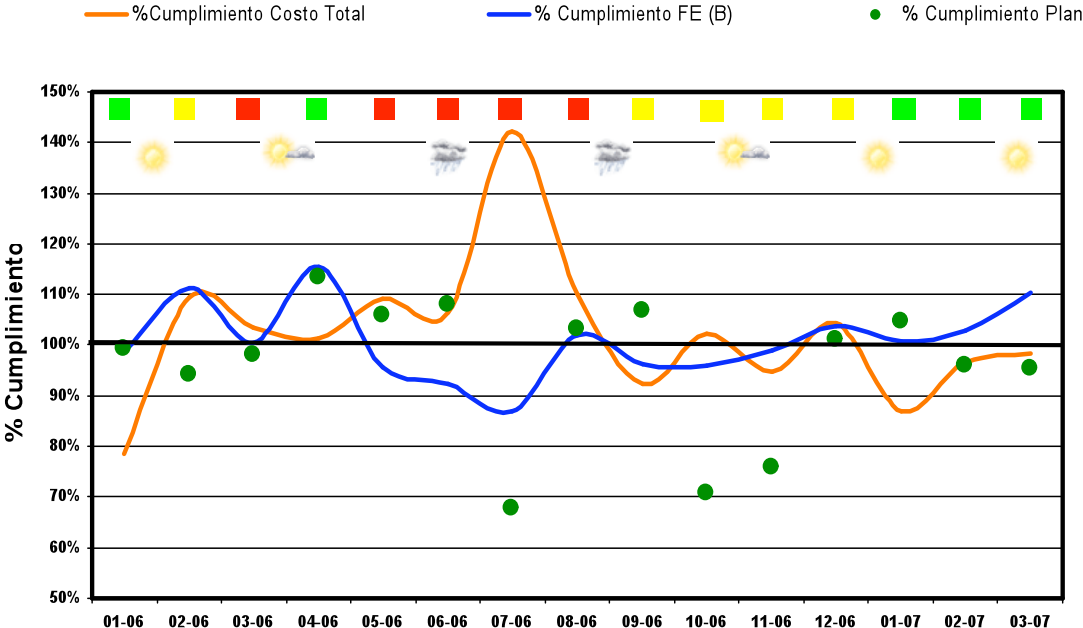
Continuing with the analysis, a last variable, % is added and is the Fulfillment of production Plan. When observing the first period of data, these follow without having a clear tendency, not fulfilling the production plans, but anyway , positive FE (B) is obtained.

Adding this variable, it is observed, for the winter period the no fulfillment with the costs and efficiency aims.

How it is possible to observe, for the last sector of the graph, the efficiency factors are over the 100% of fulfillment, the costs controlled and under the budget, although the production plans were not totally fulfilled, the made production is the best business that it was possible to made in Rajo Mine. For these last months it is necessary to observe the correlation between the loading and transport equipment availabilities.

Graph 4:

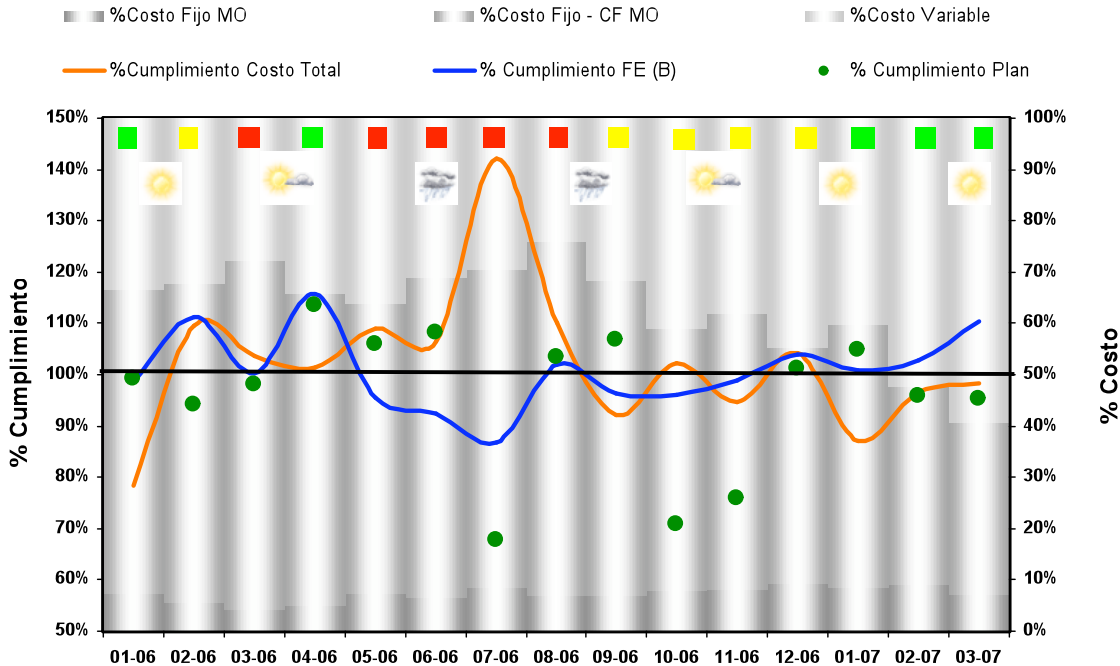
If we could evaluate each monthly data, with an indicating as a traffic light and we added the climatic period, the resulting graph will be like the following one:



With the previous graph, it is possible to be concluded that in summer time, the indicators show aligned favorable tendencies with the model general mission.

Graph 5:

If to the Previous graphical it is added the structure of costs, represented as the fixed costs in labour, fixed costs without labour and the variable cost, it is observed, and that the proportion fixed cost v/s variable cost is reversed.



We are today in front of an implementation of a management Technical Model, in its top expression from its beginning, with an organization over shifted to its application and faced to new challenges of Rajo Mine in the next years. The task is just beginning, but the results at the moment allow us to conclude that the success of this model is based, in a relation people and equipment in balance.

Conclusions

The Business of Mining Operation Adds Value only by means of Efficiency.

The production is a result of an optimal administration of operation critical variables.

The use of dispatch systems, under a correct policy of management aligned with the objective of the mining business, are the key tool to reach the expected results.

The Efficiency Factor is the management tool that Andina Division has decided to use to measure the variable incentives of its workers (Bonds).

The Production can be obtained: with Less Resources or it is possible to be increased with the same resources level; “to do the same with less either doing more with the same one”.

If our objective is to maximize the use of the assets, will be in addition necessary to be the owner of the assets?