CONSEJO MINERO

CAMARA CHILENA DE LA CONSTRUCCION

GOOD PRACTICES IN MINING CONSTRUCTION

Includes Pilot Project Analysis

Productivity Work Board

Mining Council – Chilean Chamber of Construction

2nd Edition - October 2016

Elaborated by the Technological Development Corporation, within the frame of the Study for Factors Affecting Productivity in Mining Construction.

EXECUTIVE SUMMARY

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Letter from the CEO - CChC

The scenario that the Chilean mining industry is facing in matters of productivity poses challenges that are both important and urgent, including the need for defining strategies contributing to optimize processes of administration and management in projects. The task is not small, for it deals with the increase of the industry by ways of recovering competitiveness, its contribution to the country's growth and development.

Having this in mind, the Chilean Chamber of Construction (CChC) and the Mining Council constituted a work board by the end of 2011. The goal was to analyze topics of common interest and advance towards more efficient management models with long-term vision, to be implemented with both clients and contractors when projects come to table.

Out of this joined work, there came a need for identifying factors affecting productivity in mining construction.

The CChC then commissioned the Technologic Development Corporation (CDT in Spanish) to carry out a study based on measurements and analysis of in-site activity in construction projects. One of the conclusions was that, in average, only 49% of measured time corresponds to effective work time. This means that mining construction would present a loss of initial productivity of half its maximum potential. Then, based on these results, the present document was elaborated - Good Practices in Mining Construction -, which aims to boost joined and collaborative work between client and contractor.

This report proposes concrete actions in four large areas: integrated coordination of projects, management of previous activities, operational and logistic planning, and also a regulatory and management framework of human resources. For each of them, specific good practices were identified that, as whole, aim to increase available or effective work time and therefore improve productivity of the mining industry. Then, starting from the results of the Good Practices report, it was decided to begin with a second phase of implementation at a Pilot Program called "Filtering Control System" at Las Tórtolas plant in Colina, 50 km north of Santiago. This implied measuring the baseline, then implementing good practices according to opportunities identified by the tripartite productivity board and finally measure the resulting improvements on specific productivity increase in the project. All of these actions were incorporated in this second edition of the book, where you can go over the important benefits their implementation brought in terms of improvements in work methodology and available time to work and the increase in 'productivity' of 20% in hand labor and 23% in equipment.

It is worth highlighting that it is not enough that companies put their best effort in improving productivity if it does not go hand by hand with public policies eliminating obstacles that go against competitiveness and the necessary flexibility for facing demands posed by the sector. All of which is crucial for achieving the expected results of an activity that constitutes the main engine of the national economy.

We hope this work does not only allow establishing corrective actions in processes but, above all, that in time contributes to create a collaborative work culture creating value for all of those who intervene in the challenge of materializing mining projects.

Sergio Torretti Costa
Chairman
Chilean Chamber of Construction

Introduction letter – Mining Council

Improving productivity, without neglecting safety, is a challenge accepted by the mining industry at a worldwide level. Since the year 2000, productivity has dropped significantly; by misfortune, it has not been until now, when prices in metals have seriously gone down, that the concern for improving productivity has become imperative in the line of business.

Even when it is a challenge worldwide, the decay in productivity in Chile is especially worrying. This is partly explained by natural circumstances related to quality and location of mineral resources but fundamentally due to low labor and capital productivity. This seems manifested in the increase of investment costs in Chile, which have quadrupled from 2003 to 2014. As a way of example, out of the 60 thousand million dollars in the mining projects portfolio for the next couple of years, almost three quarters of it are at an evaluation stage. Additionally, from 2009, Chile went up to have production costs higher than worldwide average, this while remuneration within the national mining industry has had considerable raises and productivity, nevertheless, has dropped.

In this context, improving productivity in construction of mining projects turns out to be fundamental for the industry and its development. So it was understood by partner companies of the Mining Council and the CChC, who implemented a Productivity Work Board with the goal of identifying the primary factors interfering and the measures to revert the tendency. This was undergone by collaborative work done in 2014 by client and contracting companies.

The study was commissioned to the Technologic Development Corporation (CDT in Spanish), which analyzed time loss causes in processes of operation, administration and management of projects. This way it was determined that out of the total working day only 49% represents effective work time. Considering these results, good practices were defined to allow increasing effective time being worked. Along with these good practices, certain productivity breaches were detected, which require to review labor regulations, as a way to avoid limitations to the adaptability in productive processes and the optimization of use of human resource.

This Report on Good Practices in Mining Construction is gladly presented to you. A more productive mining sector is fundamental for not losing leadership in the worldwide copper mining industry, for maximizing contributions to the State, for maintaining dynamism surrounding the industry and keeping the level of welfare the sector offers. The Report on Good Practices in Mining Industry is, without a doubt, a contribution in this aspect, based on a collaborative model, with common objectives and following logic of obtaining improvements with benefits to be shared.

Finally, I thank for the work of all of those who participated in this joined Project, to the members of the Mining Productivity Board, and particularly the team at CChC and the Technologic Development Corporation for their support.

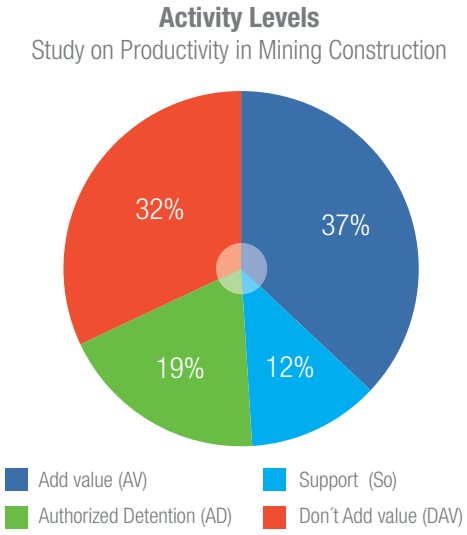
Joaquín Villarino Herrera
Executive President
Mining Council

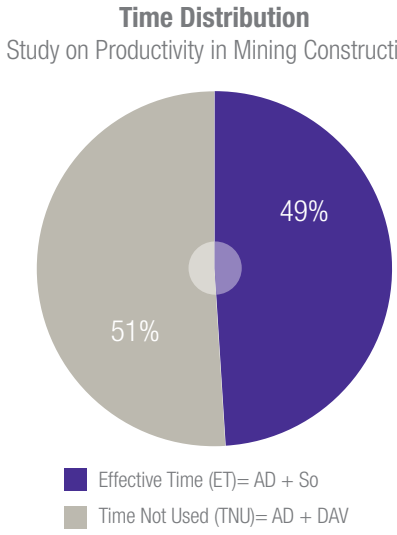
EXECUTIVE SUMMARY

The present report on good practices is the result of analysis in the topology of six projects monitored which were part of the **"Study of Factors Affecting Productivity in Mining Construction"**, hereinafter called the "Study". Likewise, information from the TDC (Technological Development Corporation – CDT in Spanish) project measure database has been incorporated, regarding this matter.

Results of the Project from all 6 measures are summarized as follows:

ACTIVITY LEVELS – MINING PRODUCTIVITY STUDY



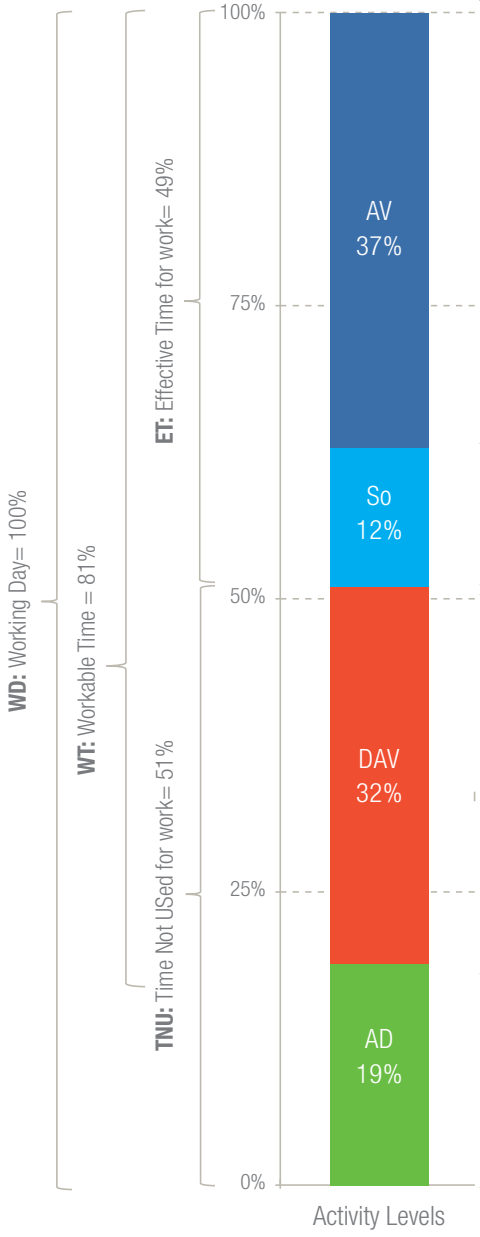


In the following page, a diagram is presented with a summary of concepts, indicators and results of measures in all six projects of the Mining Productivity study. The main Activities explaining or composing each Activity Level are detailed, to then indicate -in the last column- which are the General Good Practices recommended in the present report, allowing to improve the activity levels measured.

(*) NOTE: The present report on Good Practices is a complement to the Final Report on the study of 'Factors Affecting Productivity in Mining Construction' and its respective "Technical Memoir".

ACTIVITY LEVELS, INDICATORS AND GOOD PRACTICES ASSOCIATED

Study of Factors Affecting Productivity in Mining Construction 2015



ACTIVITY LEVELS	ACTIVITIES	GOOD PRACTICE
AV Add Value	1. Execution of the activity 2. Preparation of materials 3. Movement of materials at the work post	
So Support	1. Distribution of materials 2. Activities Before / After 3. Housekeeping 4. Instructions during the shift	GGP 5 GGP 4 GGP 11 y 12
DAV Don´t Add Value	1. Planning Problems 2. Methodology and Flow Problems 3. Supervision Problems 4. Operational Problems	GGP 2, 4, 5 y 9 GGP 2, 3, 10, 11 y 12 GGP 9, 11 y 12 GGP 4 y 5
AD Authorized Detentions	1. Necessary operational transit* 2. Shift Start Speech 3. Meal** 4. Safe Protocols (HCR, AST, PTS, among others) 5. Client´s Authorized Detentions	GGP 6 y 8 GGP 7 GGP 8 GGP 7

*: Logistic type transit related to arrival and leave to and from the work post or associated to transit from and to meals.
**: Only in cases when meal time is attributable to the shift according to the existing regulation or when meal time is greater than authorized.

General Good Practices (GGP – BPG in Spanish), acting directly over times – So, AD and DAV – these can be translated into an increase in times that Add Value – AV –.

Undoubtedly, a noteworthy fact is that just **49% of time measured represents Effective Work Time,** meaning, activities that Add Value in addition to Support activities necessary for an adequate production. In other words, measurements indicate that the mining construction industry would have a loss of initial productivity reaching almost half of its maximum potential.

It is crucial to consider that the situation might turn even more complex, in the sense that 'activities that add value' can bring along a series of inefficiencies in the process of value chain, which are not necessarily pointed out with Activity Levels readings, for example: errors in design and engineering, since this methodology only perceives effects at an operational level.

The main recommendations in the present document, as well as the report on Factors Affecting Productivity in Mining Construction, highlight the need to establish a **joined and collaborative work** among the Mandating party, its representative (EPCM, ITO, other), and the Contractor, hopefully from the initial stages of the project, which is when the greatest impacts regarding savings in costs and deadlines are achieved, focusing towards:

- Defining, Establishing and Monitoring a joined and permanent **Productivity Measure System**, based on key performance indicators and KPI's in projects, allowing to define metrics and improvement factors, as well as impact of corrective measures implemented.
- Conforming a **Productivity Board** whose objective is to analyze key performance indicators, KPI's, determine basal causes of productivity loss and take corrective actions on behalf of a common goal: to deliver the Project with best time and cost. This board should be preferably defined and incorporated in the contractual bases, so its actions and decisions are bound.

To successfully implement the previous proposals, it is necessary to incorporate **tools and integrated coordination methodologies for projects**, particularly those regarding **short and mid-term planning**, which is one of the main causes for 'don't add value' times detected in measures of operational levels. Even when the operational planning activity is carried out as a last instance by the Contractor, participation of all parties within the Project is extremely relevant, as a way to achieve trustworthy commitments and liberation of restrictions (specially engineering and key supplies) that could be connected to the fulfillment of the program.

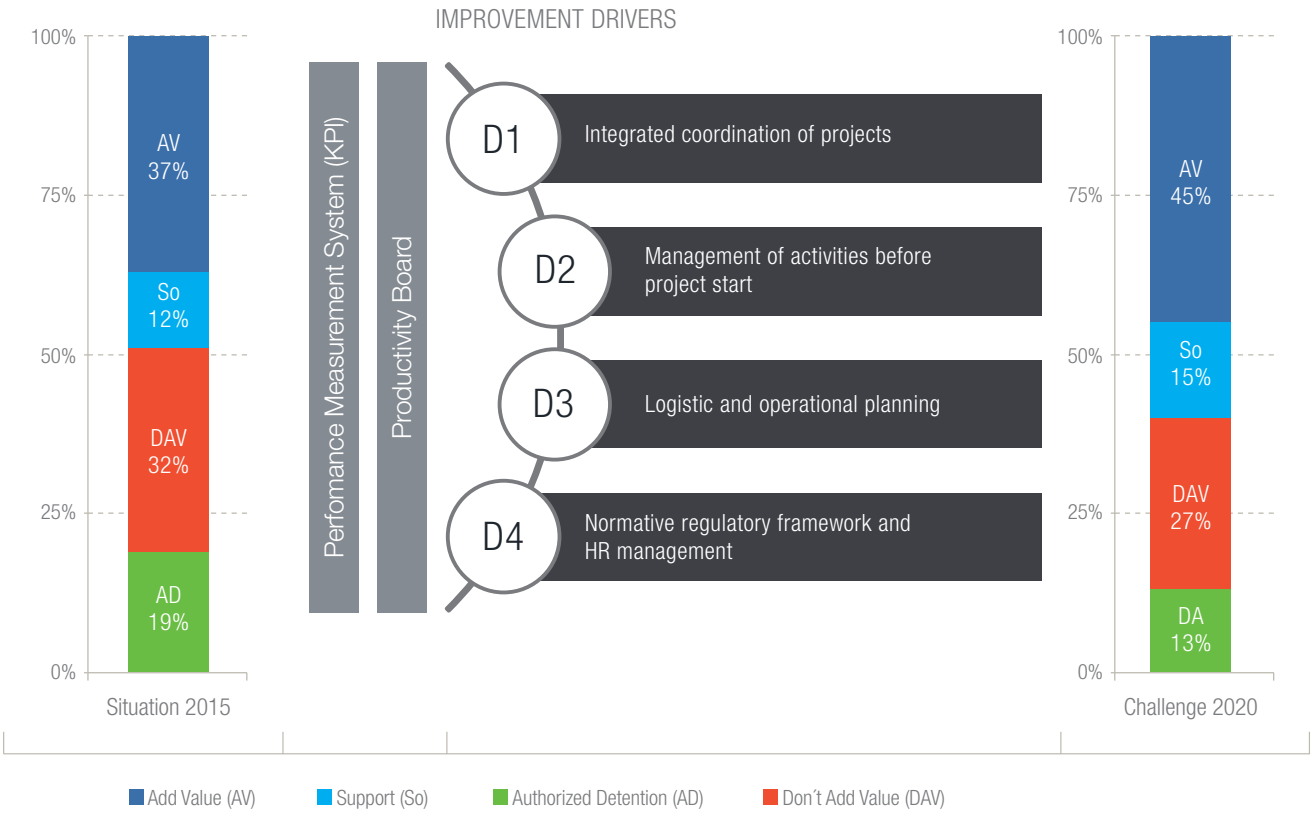
Another certainly relevant set of factors which must be dealt with in a joined manner among all parties within the Project are those related to the such called **Authorized Detentions**, reaching **19% of a workday's total time** in the case of projects monitored.

And the last, but not the least, it is required to work as a sector, particularly between the Mining Council and The Chilean Chamber of Construction, in general actions pointing to diminish the **effect of regulatory and work-related factors** having direct impact on losses in competitiveness conditions when compared to other countries, such as shift systems, additional demands for working in heights, barriers to multi-functionality, stiff labor flexibility, among others.

Considering all the before mentioned, the next page holds a summary chart with an Improvement Strategy for Activity Levels in 2020, grouping actions and Good Practices to develop within the frame of 4 Improvement Drivers and 2 transversal strategies. Likewise, Challenge 2020 for sector Activity Levels is planted out.

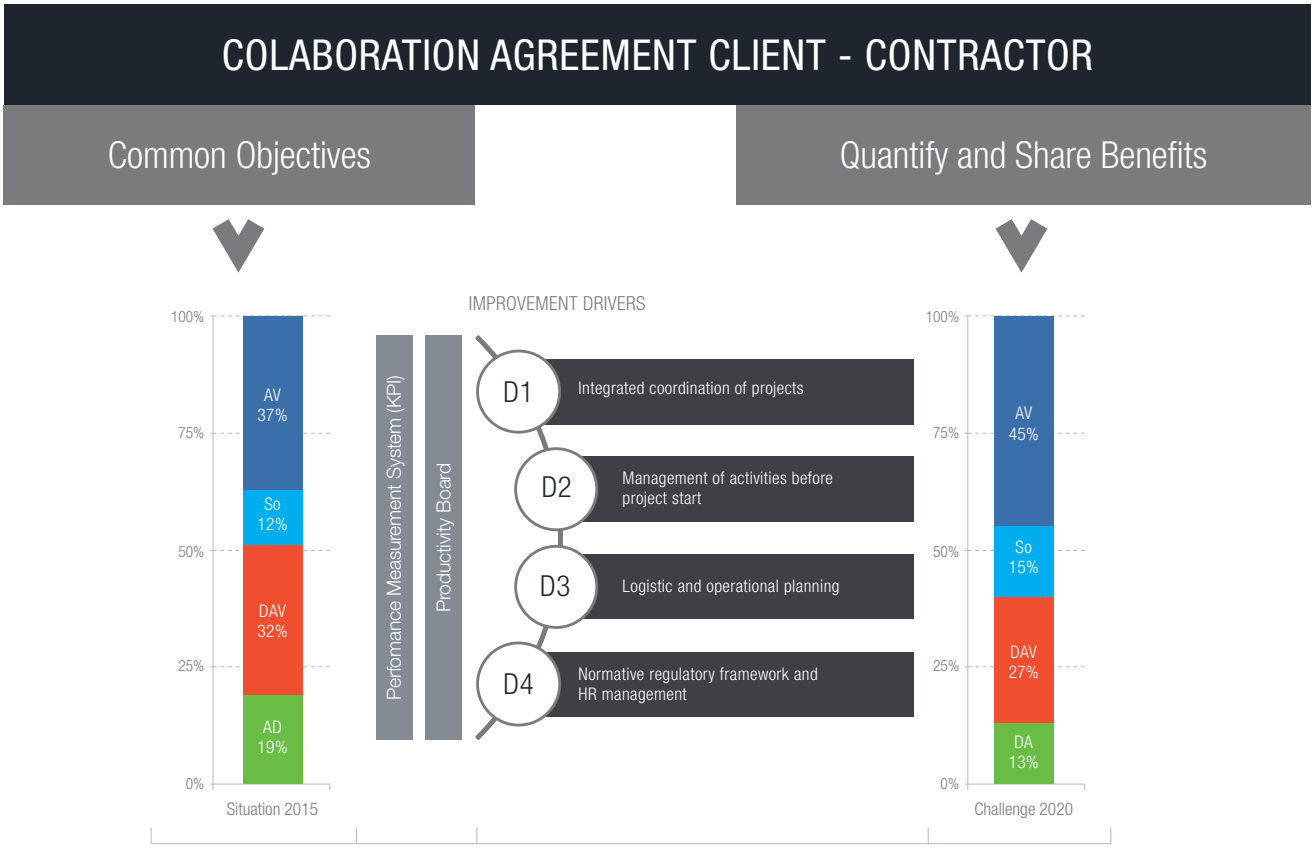
IMPROVEMENT STRATEGY AND ACTIVITY META LEVELS 2020

Study of Factors Affecting Productivity in Mining Construction 2015



Without a doubt, the starting point is establishing, permanently and systematically, a **Key Performance Indicators Measure System (KPI)** along with the creation of **Client-Contractor Productivity Boards** on each Project.

Such productivity boards must work under an approach privileging collaboration and trust, based on common objectives and following logic of **sharing benefits** harvested from actions taken within the frame of the project.



POTENTIAL ECONOMIC IMPACT BEHIND THE FULFILLMENT OF CHALLENGE 2020

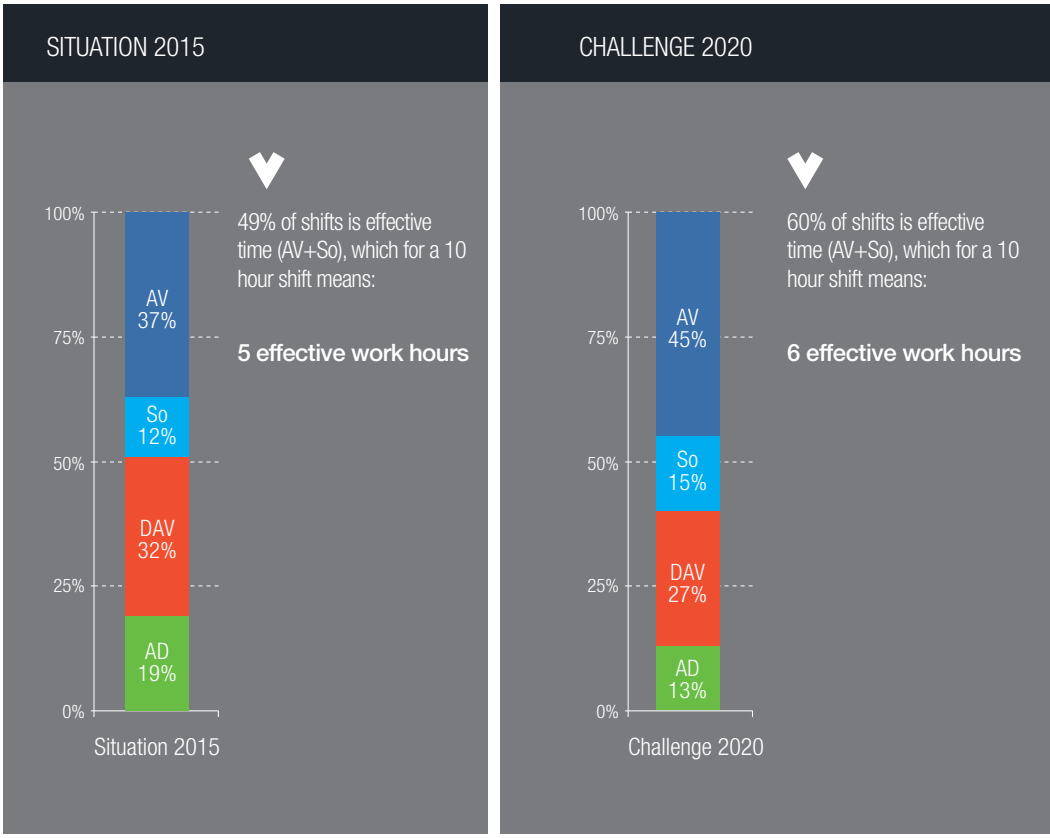
In order to look for a relation quantifying in economic terms the potential impact that implementation of Good Practices would have for accomplishing Challenge 2020, some assumptions have been taken related to market figures and background information given by this present report.

One of the scenarios to begin the exercise with is that related to man hours (HH in Spanish) and the cost these represent in annual values. Because of this, and based on investment flow projections for the mining industry over the next few years, it will be considered to put on an average annual investment for mining projects reaching MMUSD 10,000, out of which an estimated 60% is related to construction activities exclusively. On the other hand, it is foreseen that an average 30g% of this investment is associated to HR, meaning an equivalent of MMUSD 1,800 per year.

That being said, and considering an average cost for the company of USD 30/MH, we have that the mining industry spends nearly 60 million on MH per year solely in construction.

Taking the estimated quantity of MH per year, it is possible to calculate **potential savings that fulfillment of Challenges 2020 would have regarding the increase of effective time from 49% up to 60% during a working day.** All of this without accounting variables such as the output that improvement in the global performance could mean.

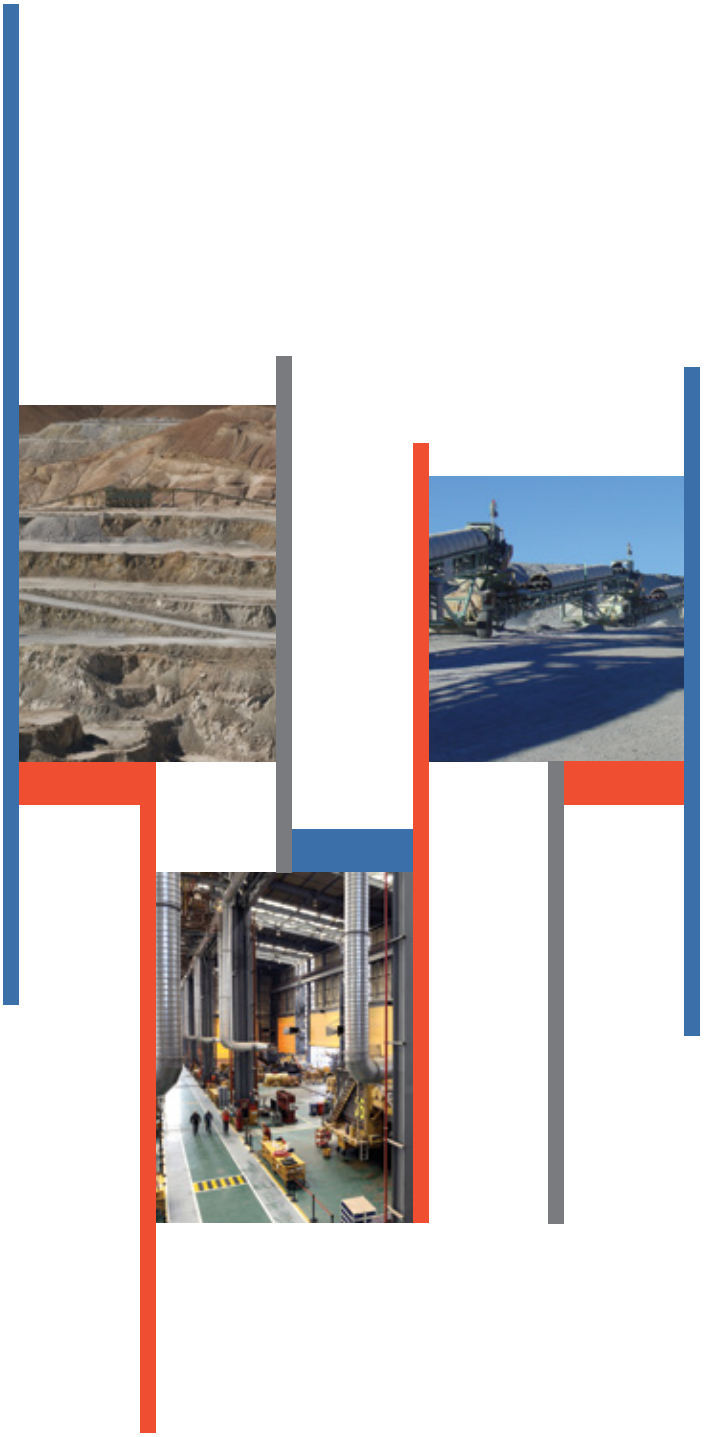
As an example, an impact over a 10-hour-shift is presented (being any), quoting some previously shown charts as follows:



Then, for the same work in situation 2015, the achievement of Challenge 2020 implies that there would be a 20% more in available MH (6 instead of 5 hours). Therefore, potential savings would be:

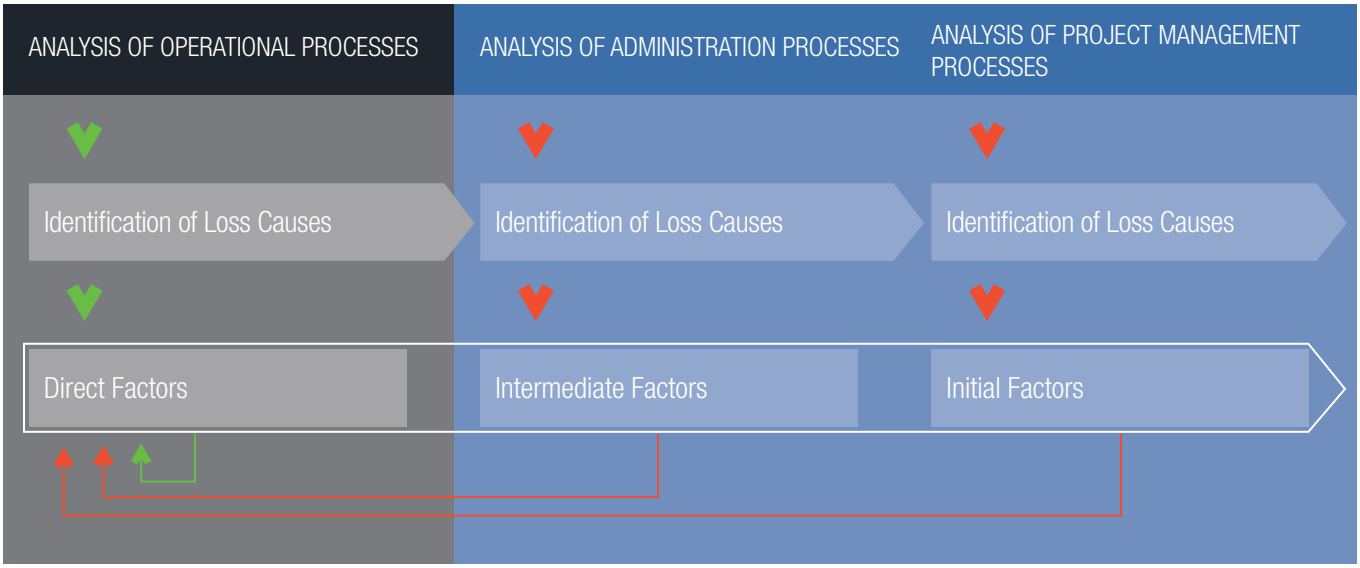
- **Over 10 million USD in MH**
- **Over 300 million USD**

It is worth mentioning that the analysis focused exclusively on the increase in available shift or effective work time, and not on the worker's performance.



REACH AND METHODOLOGY

Understanding the varied visions existing around productivity and different approach areas (cost, deadlines, performance, Etc.), it is necessary to distinguish three key dimensions for process research, such as: Operation, Administration, and Project Management.



The operational area is dedicated to execute the Project and the optimization of resources, reflecting also on losses or profits, meaning that the operational area is where you can physically see inefficiencies of all operational processes, acting as the great thermometer when the time for investigating parameters and factors come.

The Project administration area is related to all support activities required by the operational area, such as administration, Technical Office, Supply, Engineering, certification, Etc.

The Project management area, represents the area handling the definition of concepts and strategic processes at a higher level orienting the development of all phases and stages within a Project. They regard to linings at a directive and organizational corporate level, defining procedures among the different entities, organizations and human teams involved.

The **Reach** of this study is mainly focused on the **Project Operation Area,** meaning it will measure operational processes sat the

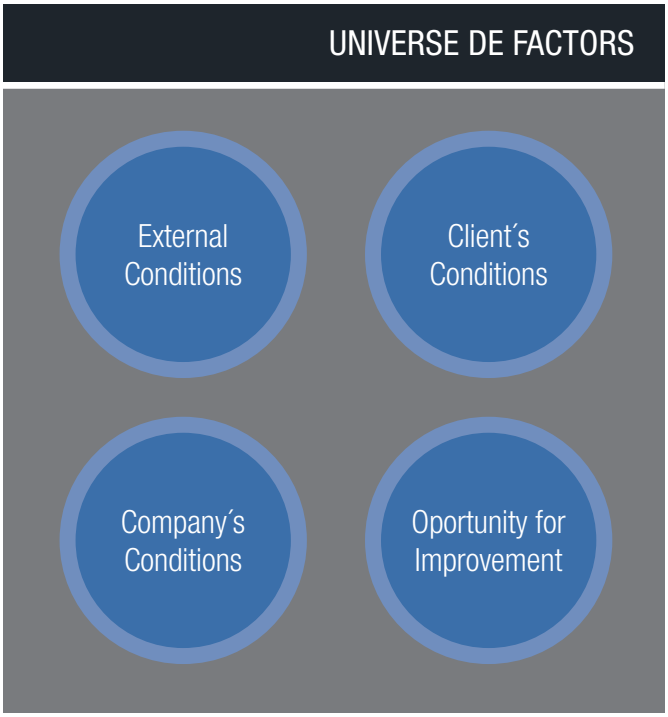
work front, taking a **Methodology** measuring Activity Levels and Loss Causes, considering human resources as well as the most relevant machinery in the constructive process as analysis and sampling units.

For a total and complete understanding of which are the main factors and causes of productivity loss, additional studies will be required aimed to determine the **causes in administration and project management processes.**

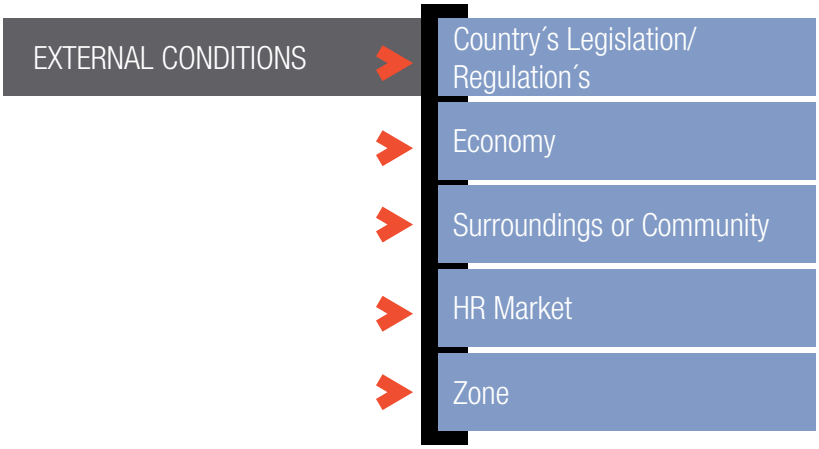
The initial measurement in operational processes allows having a first diagnosis over the **final effects of productivity loss in productive tasks**, but many times it does not allows interfering automatically and directly over the main or basal causes underlying the effect under analysis.

For advancing in the analysis of **basal causes** – administrational and Project management processes – it is crucial to have collaborative work among each of the actors involved in the mining construction activity: client, engineering firms and contractors.

On the other hand, and within the frame of the **universe of factors considered**, the study analyzed and identified in a gross form aspects regarding **external conditions** surrounding projects and main participants, not going into deeper analysis of such factors, but their impact may be significant in some cases.



AMONG EXTERNAL CONDITIONS THE FOLLOWING CAN BE MENTIONED:



GOOD PRACTICES MINING PROJECTS

Starting from the Study on the six projects of mining construction, plus collected information from interviews and analysis of finished projects, it is proceeded to distinguish the best practices detected in projects, classified into two large groups; accordingly:

- **GGP - General Good Practices:** related to better use of the shift through strategic decisions. These can have relation with the Project, refer to shifts o worker's performance.
- **GPA - Good Practices by Activity:** related to the better use of certain specific items conforming the Project.

In this report only good general practices will be presented, with details of practices per activity for subsequent specific reports.

GGP – GENERAL GOOD PRACTICES

The first basic element for generating a Good Practices Program in projects has to do with the implementing a **Productivity Measure System In-site**, based on concepts measuring Activity Levels, Performance, Loss Cause Analysis and a set of KPI's.

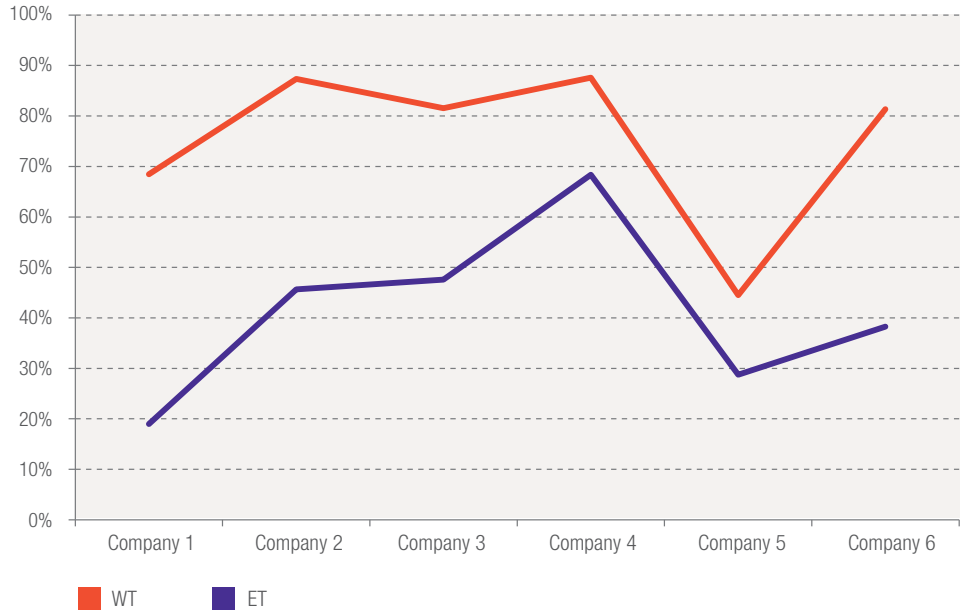
It is fundamental for the main actors in the contract to participate in a coordinated and collaborative way, meaning, the client, engineering firm, EPCM, contractor. To reach this, it is proposed to set up a **Productivity Board** with representatives of each of the parties, whom are to be jointly responsible for the measurement and improvement of productivity under the contract, at levels of operational as well as administration and management processes.

It is recommended to define Workable Time indicators – WT – and Effective Time indicator – ET – as global indicators delivering the first approximation about the project's degree of efficiency. It is necessary to report to the different organizational levels within the Project, whose value rests conditioned to the joined effectiveness of planning made and the extend of integrated coordination existing for the project, as well as the degree of understanding in the field. It is recommended that projects consider these parameters as the indicators with greatest relevance in productivity.

It is recommended to have special emphasis about establishing permanent measurement and analysis systems regarding WT and ET within each of

EFFECTIVE TIME (ET): ADD VALUE + SUPPORT= AV + SO

October 2013 to March 2014



Effective Time (ET): Add Value + Support= AV + So
Workable Time (WT): Effective Time + Don´t Add Value= TE + DAV

the projects or construction sites, as a way to establish common parameters of analysis for both client and contractor regarding the effectiveness of processes involved in the planning, coordination and management of the project.

By quantifying the significant loss of available hours in WT and ET (real time destined to work), and then analyzing the basal causes at the levels of project management and administration, only then conditions will be proper to for analyzing the effectiveness of both workers and equipment when it comes to performance at a particular activity.

The great loss of productive hours not worked, reaching 19% of a Total Working Day in the study (Picture 1), due to different factors within the mining industry, has generated a loss effect acquired and accepted in the market. Generally, shift and hourly work systems for construction and service contracts in with different mining companies are established under criteria of compatibility with the client's operation. Being this a valid consideration, at the moment of assessing lost hours by shift, work hours, lodging, meals, transportation, Etc., they are not considered to optimize the cost of unused resources, versus evaluating an option to optimize and provide the workers with this time as a benefit that can be translated in performance improvements, changes in social conduct and commitment to the company.

Best practices related to work shifts are often meant to also tap regulatory and strategic matters regarding distribution of human resources within the Project.

Next, a summary is presented, containing General Good Practices detailed in the present report, grouped by Improvement Driver, highlighting which of the participants of the project has a greater impact over it, or more control.

DRIVER	GOOD PRACTICE		CLIENT	ENGINEERING	CONTRACTOR
1. Integrated Project coordination	GGP 2	Complete and in-time information about engineering and availability of Key Supplies		■	
	GGP 3	Methodology and Technologies		■	■
	GGP 6	Optimization of Transit and Start and End of the Shift	■		■
	GGP 7	Focusing Start, Safety and PTS Speeches	■		■
	GGP 8	Monitor Meal and Transport Times	■		■
	GGP 9	Effective Coordination for Shift Rotation			■
2. Administration of activities previous to project start	GGP 1	Reduction in Certification Times	■		
3. Operational and logistic planning	GGP 4	Improvement in processes of planning and resource administration	■	■	■
	GGP 5	Logistic Improvement for work site and Supply			■
4. Regulatory Frame and human resource management	GGP 10	Poli-functionality	■		■
	GGP 11	Efficient use of Specialized Personnel			■
	GGP 12	Improvement for training staff personnel			■

The graphic indicates who would have greater relevance or capacity for changing and implementing the Good Practice, without leaving aside that in most cases are a matter of joined work among all participants.

A second presentation of the Graphic allows indicating the **Activity Level on which each party would act or participate in the Good Practice**; numeration corresponds to sub-activities presented on page 4 of this report, about results of Activity Levels.

DRIVER	GOOD PRACTICE		RELIES ON		
			Support	Authorized Detention	Don't Add Value
1. Integrated Project coordination	GGP 2	Complete and in-time information about engineering and availability of Key Supplies			1 y 2
	GGP 3	Methodology and Technologies			2
	GGP 6	Optimization of Transit and Start and End of the Shift		1	
	GGP 7	Focusing Start, Safety and PTS Speeches		2 y 4	
	GGP 8	Monitor Meal and Transport Times		1 y 3	
	GGP 9	Effective Coordination for Shift Rotation			1 y 3
2. Administration of activities previous to project start	GGP 1	Reduction in Certification Times			
3. Operational and logistic planning	GGP 4	Improvement in processes of planning and resource administration	2		1 y 4
	GGP 5	Logistic Improvement for work site and Supply	1		1 y 4
4. Regulatory Frame and human resource management	GGP 10	Poli-functionality			2
	GGP 11	Efficient use of Specialized Personnel	3		2 y 3
	GGP 12	Improvement for training staff personnel	3		2 y 3

GGP 1

Reduction in certification times

GGP 2

Complete and in-time information regarding Engineering and Key Supply availability

GGP 1

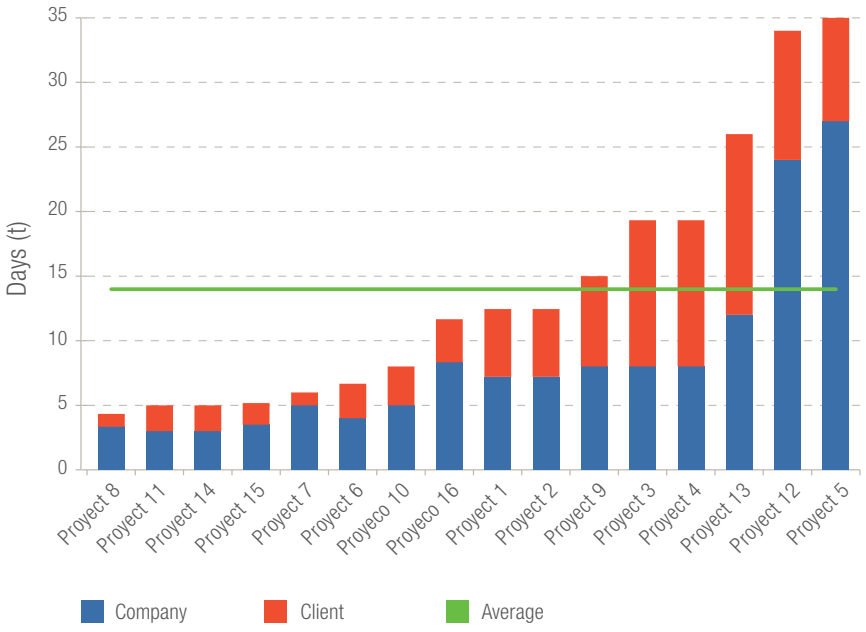
Reduction in certification times

DRIVER 2

A great aspect mainly influencing the start of a Project is that related to necessary certification time for both people and machinery.

CERTIFICATION TIME PROJECTS 2009 TO 2014

Direct Human Resources



As shown in the Chart, the average validation time is close to 14 days, where time invested by the contracting company and the client are 8.4 and 5.6 respectively, to validate a worker since the signature of the work contract until he or she is finally to operate within the productive process. It was considered that the time for the client starts the moment a folder containing all documentation is presented and it ends when the client enables its admission.

Having evaluated the differences existing for the process of certification of workers and equipment among the different mining companies and their high variety, it is necessary to produce some sort of **degree of accreditation in requisites and contents** for training and induction courses. For this, it is required to find an inflection point between requirements which are transversal to the industry and those specific which are proper of each client – admission standards, certification, training, others -, that allows reducing the loss of resources being lost in the industry today, both time and cost.

One of the aspects being reported as a major loss by contracting companies corresponds to standby, transportation costs and lodging to attend induction and training courses of Mining Companies, which are usually lectured by external certification organisms. Also, the effect or impact over the costs of the Project is inversely proportional to Project timelines, having a highly relevant impact on short-term projects. If we add the seasonal nature of mining contracts, its discontinuity over time and the high rotation of workers among contractors, clients and contract topologies, we can deduct that many workers use a high percentage of their yearly potential work to admission accreditation processes.

GGP 2

Complete and in-time information regarding Engineering and Key Supply availability

DRIVER 1 | DAV 1, DAV 2

Considering the great amount of Fast Track projects present in the industry nowadays, there is a relevant incidence of Engineering Development and Supply factors running under the client, over the productivity in mining construction contracts, finally reflecting when carrying out activities in a planned and programmed way, as well as direct losses in productivity.

It has been detected that, according to typology in projects, these aspects can generate significant productivity losses due to the lack of briefing by the contractor and key information to go ahead with task planning and programming, as well as the progress of work. All of the before mentioned is translated into resource losses for both the contractor and the client, as a product of delays or gaps in information when handing out detail-engineering Projects and timely supply delivery; man hours, machine hours and administration hours invested during standby for explanatory records or supplies. Additionally, the **lack of engineering information** as well as **time deviations in key supply delivery** from the contractor, finally implying **higher costs and time for the Project** basically because of losses of resource available and planned for such tasks, and not feasible to be assigned and programmed to other productive activities.

As a way to acknowledge and monitor the impact of these factors, it is proposed as a Good Practice to generate **key performance indicators reflecting completeness of engineering and key supply availability monthly.** This should be reflected upon RFI's or Request for Information being generated and solved in a joined effort by the client, engineering firm and contractor. All of which can be translated into man hours, machine hours and administration hours invested and losses during standby for explanatory records or key supplies for each of the participants, and their effect over the cost and time in added terms.

A fundamental KPI to monitor, besides RFI number, has to do with the percentage of plans delivered, the number of standby activities due to lack of engineering and the number of stopped activities because of lack of supplies upon agreed deadlines according to joined planning.

In the case of RFI related to engineering, many times they refer to problems detected in the moment the task is being executed, which must be stopped, having to relocate personnel assigned to it while in hold for a solution or explanation, which can take days, weeks or even months. This bends task programming, breaking the sequence and working pace, many times forcing to leave tasks pending to later retake them, generating non-productivity and inefficiency growing exponentially as these situations spread in number.

Summarizing, a direct loss in cost and time pro the Project in its whole, since the final result will always be an increase in work and resource to finish the Project.

Because of this, it is also recommended as a Good Practice to have **indicators regarding the increase of tasks, input and supplies in each project**, in contrast to those planned out, in cases derived from modifications in projects and engineering. This information, without a doubt, will have a direct co-relation with PF values obtained.

Without leaving the previous aside, it is worth paying special attention to the impact that delay in the delivery of other minor supplies may have, since these can directly affect the sequence or activity flow in the Project, generating direct effects in Don't Add Value times.


PELIGRO
ESPACIO CONFINADO

GGP 3

Methodology and Technologies

GGP 4

Improvement of Planning and Resource Management processes

GGP 3

Methodology and Technologies

DRIVER 1 | DAV 2

In the execution processes of all analyzed projects, there are lost times associated to the methodology being used and also technology behind it.

These DAV times are specific in these two aspects, since these **losses are inherent to the process itself**, and it is required to undergo a deeper analysis to carry out improvements principally aiming towards the performance of the work mass and equipments.

These losses cannot always be optimized directly. In some cases the best option is to **make significant adjustments or modifications to the methodology in use** and, on the other hand, to also evaluate the implementation of **new techniques and tools** for incorporating new technologies. Thus, losses will turn into productive times since the occupational time or working time would increase. Another expected effect might as well be a no-change in production, but with a minor work mass or resources used.

For deploying new technologies, **a global understanding of the process is key**, for avoiding punctual productivity increases which finally could have an incidence in a increase real productivity of the whole process. Therefore, it is advised as a Good Practice **to study the processes and activity levels for the critical line of tasks and activities of the project**, as a way to focus efforts and studies of methodological changes and incorporation technological innovation.

GGP 4

Improvement of Planning and Resource Management processes

DRIVER 3 | DAV 1, DAV 4

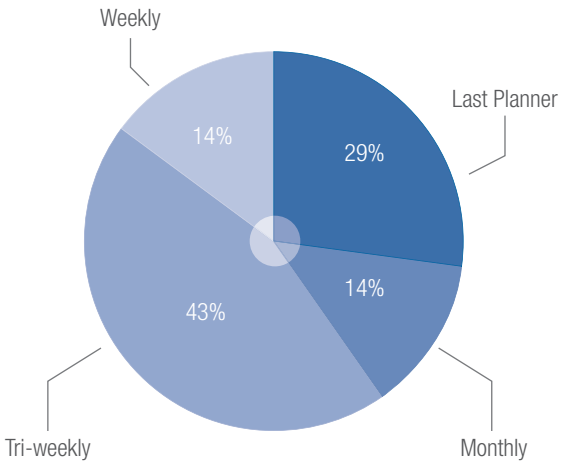
According to the analysis of causes about times that don't add value measured in this study, planning problems represents around 13%, **being one of the most relevant aspects analyzed.**

Based on it, it was researched how operational planning was approached, in terms of the relation of participation and communication among work teams, relation between planner and programmer, participation of work teams in planning and coordination of tasks, Etc.

Likewise, within the Project, after generating a gross definition of phase and resource distribution for the execution of a task, generally it all comes down to one or several Gantt's, using different programming tools, to later execute a follow-up by means of varied standardized methods; all of this handled by the Technical Office by professional programmers. Generally, large amounts of resources are invested on advance reports for the client and the administration, not leaving much time for the pursuit of solutions to problems concerning time projections and resource distribution for meeting costs and deadlines.

It is recommended as a Good Practice **to implement methodologies and tools for Mid and Short Term Planning**, LastPlanner type, in which main operatives of each task and specialties participate, as a way **to ensure the identification and liberation of restrictions** necessary for meeting commitments and planned activities.

PLANNING TOOLS



It is worth remembering that many of the causes in planning problems have to do with modifications or lack of engineering and Project information, effect that is intensified by weaknesses that may exist in the operational planning.

Regarding resource management, making the best use possible of times within the shift goes hand by hand with the quality of the accomplishment of the task planned; it is so, that in projects with a high accomplishment of the weekly program, less amount of lost time is appreciated.

Analyzing the main causes in planning, it is advised **to pay special attention to the following activities of non-productivity** that present a greater negative impact over the shift:

Description	Comment
Task assignment	Workers without instructions generally observed at the beginning of the shift and the start of works in the next shift.
Lack of previous activity	Attributed to operational planning problems regarding tasks to be executed during the day, where previous activity remains unfinished, such as non-assembled scaffolds, foundation sealing, assembly overflow, among others.
Safety protocol	Mainly related to flaws in the process of personnel admission into the Project, impacting in the difficulty of them to work by not meeting requirements of the Occupational Health and Safety Department (SSOMA in Spanish). Some situations detected are: • Workers without induction of specialization courses for their position. • Workers without PPE's due to lack of warehouse supplies (shoes, helmet, gloves, among others).
Standby equipment	Exclusive cause of processes with intensive use of machinery, such as underground mining or soil movement. It is applied to equipment detained at the front waiting for a greater work volume.
Work team overstaffing	It contemplates punctual situations where overstaffing for a specific point is observed.
Changes in work-post	Relocation to another work-post, which becomes a problem when the worker relocates continuously.

GGP 5

Improvement in Site Logistics and Supply

GGP 6

Optimization of Transit at the Start/End of the Shift

GGP 5

Improvement in Site Logistics and Supply

DRIVER 3 | DAV 1, DAV 4

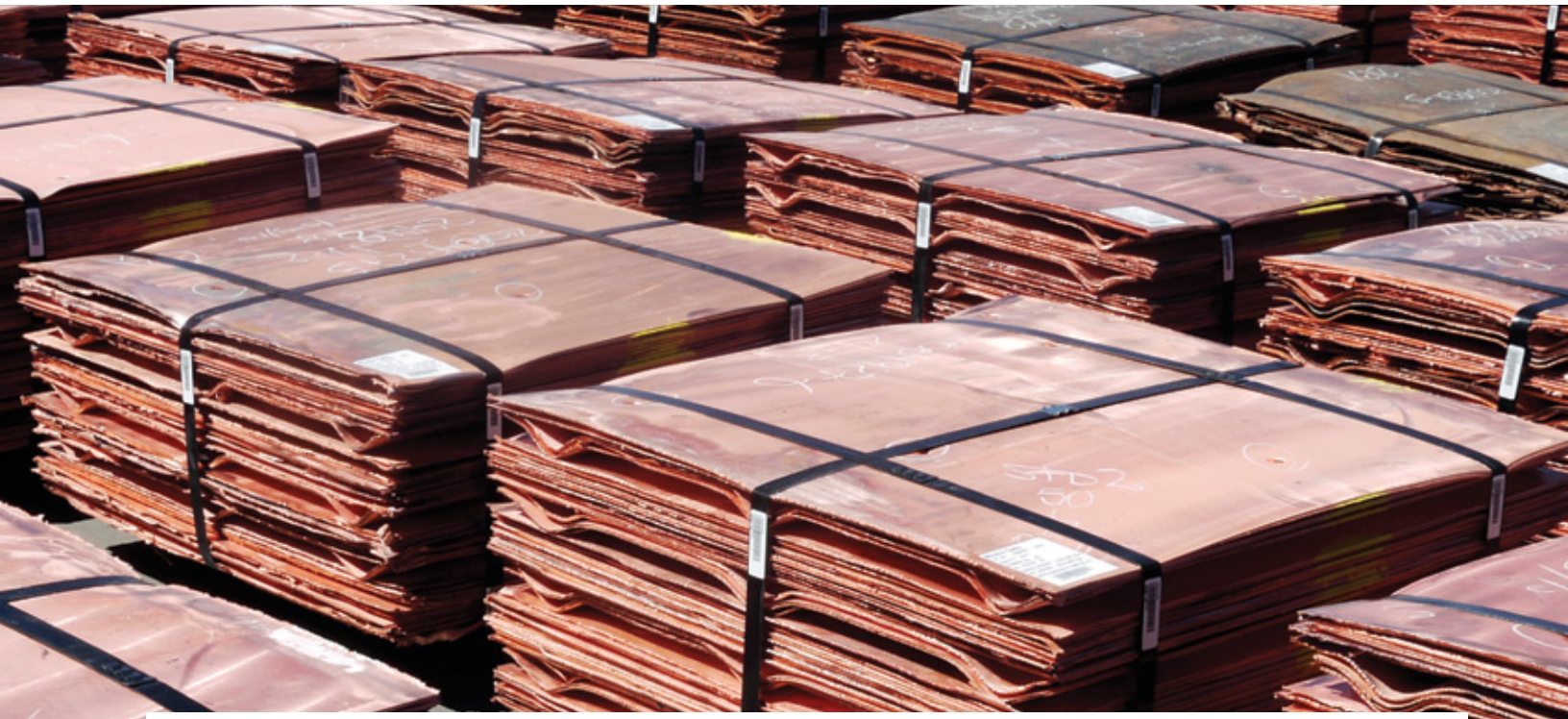
During the operation of projects there are loss causes that directly affect resources, especially human, which reflects over machinery in turn. Thus, supply logistics and later stocking at the work fronts are highly relevant aspects when it comes to operational efficiency.

Once key supplies have been analyzed –see GGP 2-, it is time to focus in the lack of medium impact materials, such as fungibles (nails, adhesives, solder, Etc.) or service materials (formwork, scaffolds, tools). Even when their impact is considerably minor when compared to key supplies, the total of time loss and inefficiency can turn out to be significant in a project with intensive stocking of this sort of materials.

WAREHOUSE ASPECTS

It has been determined to set out a group of good practices in projects belonging to the CDT database which would help mitigate the impact, improving coordination between supervision and operational coordination, and warehouses / material storerooms:

- Anticipate material requests by the supervising personnel and foremen.
- Elimination of manual tickets (they are not automatically discounted from the system), being replaced by on-line order systems.
- Consider regular delivery times and plan and schedule accordingly.



- Warehouse must ensure materials frequently used, having a minimum stock.
- Usage of the concept material kits.
- Transformation of the Warehouse into a Dispatch Center anticipating the entrance of work teams.

ASPECTS REGARDING STOCKPILING AND INTERNAL DISTRIBUTION

The most common problems regarding stockpiling (temporary) and the later distribution to the work front have to do with distance of stock from the work front, the lack of supply or the waiting for material confection for its later installation. It is advisable to consider the following recommendations for such situations:

- Plan tasks previously, thus avoiding the constant transit for individual pieces to stock yards.
- Once the required material has been quantified, bring the necessary stockpile to the work post.
- Plan support machinery for movement of heavy materials (formwork, scaffolds, iron, among others).

SINGULAR ASPECTS OF LOGISTICS

A particular case of logistics that must be taken into account is that of bathrooms within the project. It has been observed in the field that having chemical toilets near the facilities and work fronts diminishes significantly the absence from work posts. For this reason, some situations have been identified which could boost an increase in times at the work post:

- Enough toilets for the target sector or front; calculation of demand.
- Permanent cleaning and hygiene and; workers will go somewhere else if they are not clean.
- Location near work posts, especially in extensive processes or those with permanent advance.

Average, absences from the work post under this concept vary between 3 to 18 minutes.

GGP 6

Optimization of Transit at the Start/End of the Shift.

DRIVER 1 | AD 1

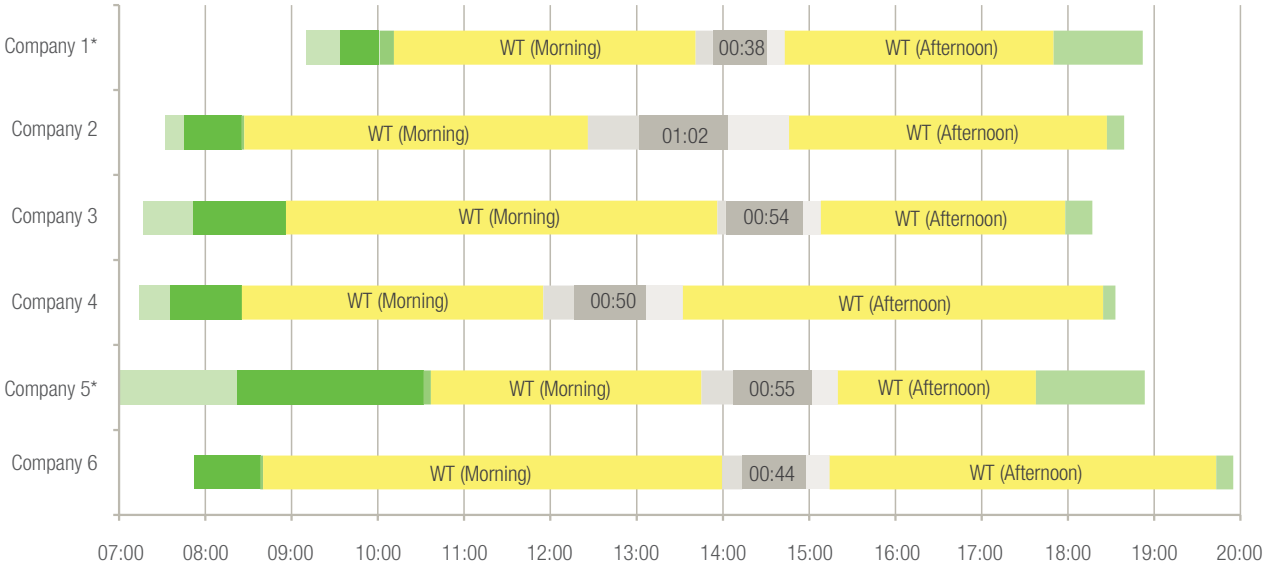
Another aspect that affects the execution of the Project is that of transit, both at the start and end of the shift.

It is necessary to analyze and quantify specific time losses for each Project, resulting from activities considered as Authorized Detentions -AD- and Support -SO-, given **the incidence and variability** found in the measurements. It is appreciated that **more time than really necessary is used for previous**, intermediate and later activities pertaining work, such as initial activities, transit, meals, early leave from work post, Etc.

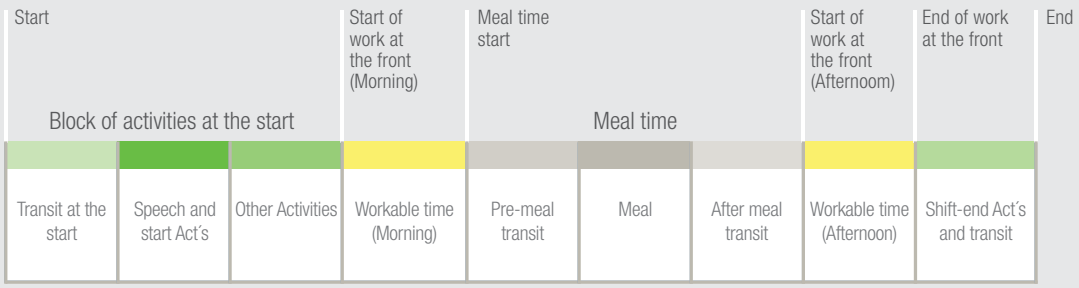
Even when these activities are catalogued within activity levels as

TIMELINE CHART FOR PROJECTS UNDER EXECUTION (PE)

Hand Labor (2013 - 2014)



Graphic: Temporary distribution of the working day, for projects in the study.
(*) Companies 1 and 5, projects of underground mining development.

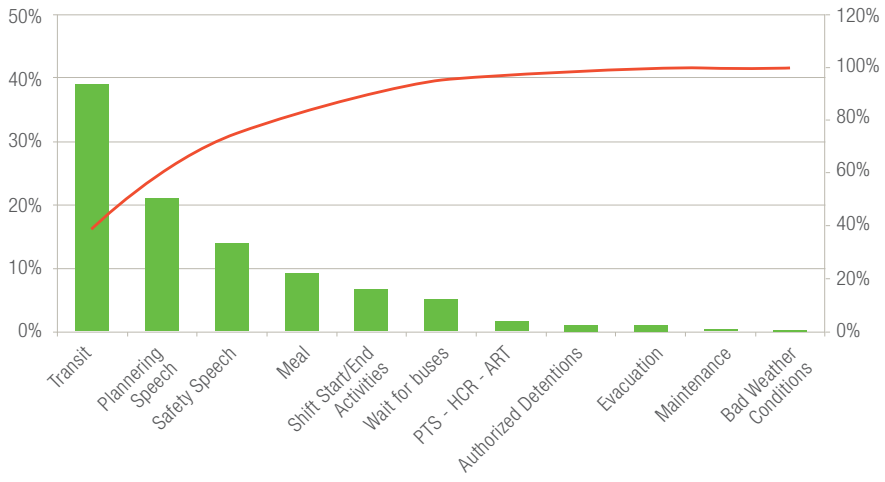


AD and SO, they have their own inefficiencies and times that Don't Add Value -DAV-; therefore, it is wise **to analyze the implicit DAV's within the AD's and SO's** and aim to optimize them.

Transit within shifts corresponds to times of Authorized Detention and they represent an important variable to consider in projects, since they can oscillate between 5% and 21% of a working day. This transit covers 39% of all authorized detentions, as appreciated in the following chart; an important value if it is considered that higher percentages are observed in those projects where transit occurs within the working time (see companies 1, 3 and 5 of the graphic "Timeline of projects under execution").

DETAIL OF AUTHORIZED DETENTIONS HAND LABOR - PROJECT CChC

October 2013 - March 2014



In those projects lasting over 6 months and with moderate activities of work-post rotation it i**s recommendable:**

- Evaluate logistic system and process regarding initial personnel transit and supplies.
- Homogenize arrival of workers to where they change clothes or suit-up.
- Arrive 10 to 15 minutes before shift start to deployment site.
- Match arrival of workers with the work-post (if they come equipped).

This could generate savings during a working day from 15 to 45 minutes. These recommendations are mainly applicable to tasks that are not of the underground type, in which the necessary logistic and infrastructural aspects can be managed.

In projects lasting less than 6 months, it is estimated that making adjustments to transit times are not translated into significant impact, given the implementation costs involved.

All in all, and as a *Good Practice*, it is a must for each Project or contract, **to study processes regarding logistic transport management, coordination and communication** flow to make them efficient and establish down-to-earth goals to improve them.

GGP 7

Focus Speeches at Shift Start, on Safety and Safe Work Program (SWP)

GGP 8

Monitor Meal and Transit Times

GGP 7

Focus Speeches at Shift Start, on Safety and Safe Work Program (SWP)

DRIVER 1 | AD 2, AD 4

t is understood as shift-start speeches all of those related to initial instructions on safety aspects and shift planning, happening before executing any activity; these, the same as shift-start transit, are a sub-group of Authorized Detentions.

Ranges for such activity vary from 4% to 18% on a working day, although the sample shows that 50% of the companies assign 7% of a working day to these activities, meaning half of the companies use at least 36 minutes of a working day to plan and carry out their safety procedures at the start of it.

Regarding safety speeches, it was detected that in some cases there were 45 minutes used daily for this activity, when it should actually take from 5 to 10 minutes.

Transit at the start	Speech and start Act´s.	Other activities	Workable time (Morning)	Pre-meal transit	Meal	After - meal Transit	Workable time (Afternoon)	Shift - end Act´s. and Transit

It is necessary to study current standards in order to propose solutions that **unify and simplify work criteria and procedures**; for example, in these aspects:

- Assignment of responsibility,
- Risk condition check,
- Site release,
- Approval and rejection of procedures and protocols,
- Analyze singularities in a working day (stopping the process), so they can be performed during the speech.

On the other hand, **drafting and approval of safe work** protocols must be an activity not necessarily requiring detention or hold of the workers. This is why in some cases it is advised to assess the early entrance of the supervisor and safety commissioned to the work front.

It is also recommended to make a **correlation between the accident rate and risk conditions versus the type of shift, activities and specialties**, as a way to spot the optimal necessary time for daily safety speeches in the different type of tasks.

GGP 8

Monitor Meal and Transit Times

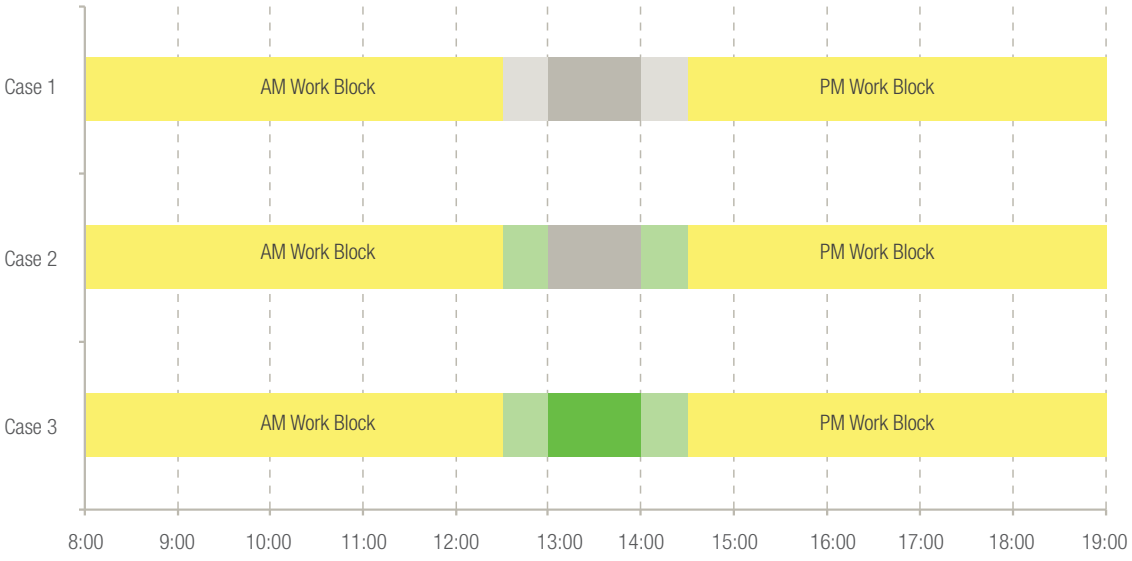
DRIVER 1 | AD 1, AD 3

he Labor Office has established in its administrative jurisprudence, in bill 5244/244 from 03.12.03, that time meant for eating stipulated in article 34 of the Labor Code, must be accounted from the moment the worker leaves the work post for such purpose.

For this reason it turns out to be a matter of relevance the handling of transit times before and after meals, as well as the time of the meal itself. The study proposes three options for distributing these times.

CASES OF ATTRIBUTION TO THE SHIFT

Meal and transit



Cases	Attribution to Shift		
	Transit	Meal	Condition*
N° 1	No	No	Favorable
N° 2	Yes	No	Intermediate
N° 3	Yes	Yes	Non-Favorable

*From the point of view of the increase in shift available for work

Type	Attributable to Shifts	Time Classification (1)
Transit	Yes	Authorized Detention (AD)
Meal		
Transit	No	Uncategorized (2)
Meal		

(1): Classification according to the 4 levels of use pointed out in the study and reinforced in this document (AV, So, AD, DAV).

(2): Non-remunerated time not corresponding to any time category, and therefore does not affect shifts.

Because of all this, it is imperative to look for solutions mitigating transit times, due to the great impact MH's will have in the overall project. Without a doubt, any implementation will be amortized over time. Some examples of Good Practices are: mobile diners, different meal times, optimization of fleet size and transport cycles, among others.

Particularly regarding mobile diners, these allow reducing transit times to dining rooms; nevertheless, its use depends on the spaces available in the field, and their impact would beneficial in cases of transit towards diners above, for instance, 30 min. of the shift if attributable to the shift.

It is recommended to at least evaluate the impact of the total MH loss for each project during the remaining timeframe:

(MH daily lost x N° Workers_Average x Ramaining_Days_Project x $MH average)

GGP 9

Effective Coordination of Shift Transition

GGP 10

Poli-functionality

GGP 9

Effective Coordination of Shift Transition

DRIVER 1 DAV 1, DAV 3

Considering time lost produced by the necessary coordination of activities and tasks between shifts, it is suggested to make an **overlap of supervising personnel and a deferred entrance for general personnel**. This should reduce loss in operational flow and continuity presented today for such reason.

Another interesting option to consider and evaluate when feasible, is the **separation of the shift into two work teams**, which can overlap in their shift over time. As an example, if the work system is 15x15 and there are two work teams per shift with a gap of one week, in practice there would be a permanent coordination and continuity in activities.

On the other hand, in continuous work in which 24 hours are covered, a daily impact in the process is produced by shift change, which will be accumulatively greater than the impact of shift transition produced during leave, that is less frequent. In turn, in longer shifts the impact of initial uncoordination is reduced, which would be distributed in more or less days in relation to the selected shift.


CHILE
capacita
NO
MAS

GGP **10**

Poli-functionality

DRIVER 4 | DAV 2

Even when this aspect was not directly measured in the study, there is a **potential for improvement in productivity** that could result in the implementation of work poli-functionality, for machinery operators as well as for the different tasks and specialties carried out by workers.

This could somehow reduce DAV times directly associated to personnel not executing any productive or support activity, be it because of problems in planning, methodology or process flow. This would directly impact on a reduction of MH's, via **a process of adjustment in the conformation of team sizes.**

One of the main differences in the conformation of work teams in countries with high productivity in mining construction precisely points to a smaller size, being one of the main systemic distinguishing factors the existence and promotion of poli-functionality in workers. This, hand by hand with high qualification and working skills, as well as a remuneration system associated to the performance of each worker.

This is one of the main challenges at a systemic and regulatory level, which has been posed by all consulting entities analyzing the problem of mining productivity, particularly labor productivity, including McKinsey & Company. Likewise, it is a known problem by the work board made up by the Mining Council and the Chamber of Construction, acknowledging that there is a closed definition of tasks in contracts and the legal framework of work safety makes poli-functionality difficult. Also, last year CODELCO's President recognized that "'for certain tasks, Chile requires up to three times more personnel than in developed countries.

GGP 11

Efficient Use of Specialized Personnel

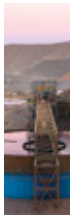
GGP 12

Improvement in Training and Courses for existing personnel

GGP 11

Efficient Use of Specialized Personnel

DRIVER 4 | DAV 2, DAV 3



In several projects it has been spotted that many of the tasks of material and equipment supplying are executed by qualified personnel, who would spend an 8% average of their working time in this type of support tasks versus activities that add value. According to measurements made so far, it is estimated that in a 12 hour shift 1 hour of qualified workers is wasted daily.

Good practices associated to this factor are described as follows:

- Warehouse assumes a role of dispatcher or distribution, with daily anticipated planning according to requirements issued at previous daily work closure.
- Having specific crews in charge of supply and distribution of materials to the work front.
- Standardized procedures known by all the personnel for processes of material supply at the work front.

GGP 12

Improvement in Training and Courses for existing personnel

DRIVER 4 | DAV 2, DAV 3

Before executing any program of massive training, it is important to focus efforts in determining which processes are critical or massive in resources requiring an intervention; this way, resources are being focused in areas that potentially present a greater impact on production.

Nowadays there is no clear consensus on which are the productivity parameters ruling the market; consequently, each company creates its own indicators, besides the required by clients. Therefore, it becomes necessary to have a greater detail of processes for each activity allowing to clearly determine the sub-processes of the specialty in order to understand what kind of course or training is required by the personnel or the line of command.

All of this is only possible if there is a formal system of activity record (MH report), designed to obtain this information and in turn process it in way that allows making decisions based on the resource cost that analysis reports.

At the moment of setting up a training program it is recommendable to quantitatively determine what are the needs of the project considering at least:

- Work Volume
- Labor Force
- Critical specialty or with greater intensity
- Detailed resource expenditure according to specialty.

PILOT PROJECT RESULTS

“Filtering Control System at East Wall of Tailings Dam” at Las Tórtolas, Los Bronces - Anglo American

Pilot Program for Good Practices in Mining Construction

"Filtering Control System at East Wall of Tailings Dam"' at Las Tórtolas, Los Bronces - Anglo American

OBJECTIVES

The Report on Good Practices in Mining Construction generated in June 2015 with the aid of the Mining Council, the Chilean Construction Chamber and collaboration of CDT, and included as part of the analysis in the Study of Factors affecting Mining Productivity, recommends implementing a series of practices within mining construction projects, aiming towards increasing the effective labor time during a shift and boosting productivity.

The main objective of the Pilot Program for Impact Evaluation about Good Practices in Mining Construction is to determine the potential impact of such good practices at levels of activity within a project, attempting to isolate the effects that implementation may carry along.

Picture 1. Panoramic view of the execution zone for the Pilot Program

II. REACH

The selected Project, named "Filtering Control System" is located at Las Tórtolas plant, in Colina, 50 km north of Santiago.

As a part of the construction and growth of the east wall of the tailings dam at Las Tórtolas, whose objective is to cope up with a topographic low located in such place, the development of a sub-project is also under execution, being named "Filtering Control System". This sub-project contemplates an injection curtain, a cut-off trench, wells with instrumentation, monitoring wells and roads.

The project started in October 2015 and finished, according to schedule, in August 2016 based on a continuous double-shift work (day and night).

III. METHODOLOGY

The general methodology required, in first place, the creation of a Tripartite Productivity Table (Good Practice Zero), constituted by the mandating party, the construction contractor and the engineering firm, which thoroughly analyzed all issues surrounding the Project taking a focus on reducing time loss and improving productivity. The baseline was established by taking an initial measure of the activity levels of the project in study, to later proceed with an analysis of all possible Good Practices to apply (from the Mining Productivity study – CChC/ Mining Council), with the objective of accomplishing a reduction in time loss. After the implementation period of good practices selected for the pilot program (approximately 3 months), a second measure of activity levels took place: its end was quantifying a real increase in available work time and improvement of productivity.

IV. BASELINE

4.1 Formation of the productivity table

At the beginning of the pilot program a Productivity Table was constituted, joined by:

- Mandating party: Anglo American.
- Contractor: A holding by Excon & Soletanche Bachy.
- Engineering: Arcadis.
- Collaborator: CDT.

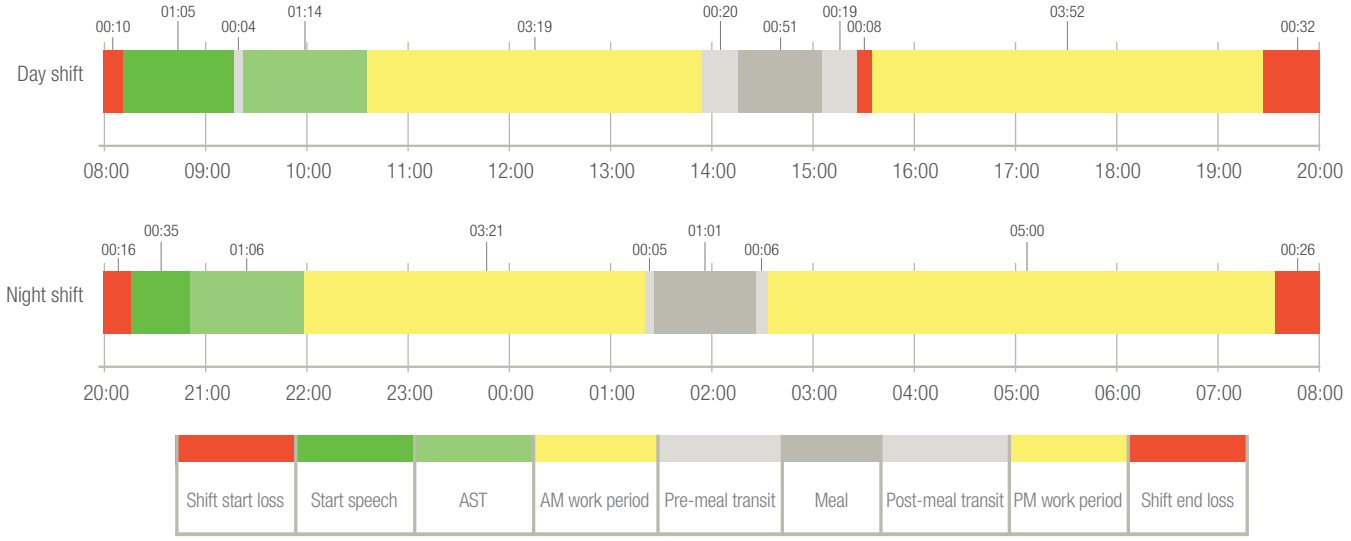
In the frame of the Productivity Table, the kick off was given by a revision of possible issues surrounding the Project, even before starting the study of the baseline. The Table worked as an instance for mutual work among participants of the Project, with focus on topics that could affect productivity, going beyond the usual operational or coordination aspects treated in a normal meeting involving clients and contractors.

4.2 Baseline measurement

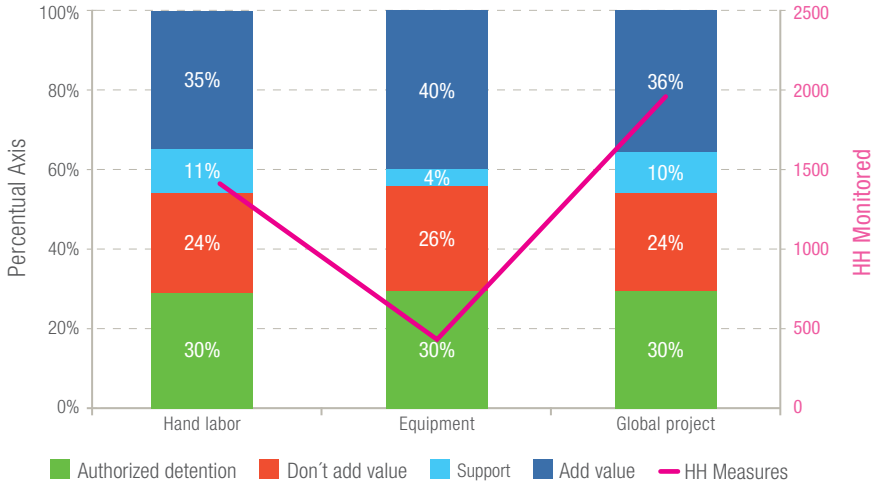
The first measure was taken in February 2016 and went over a period of 4 days. The measures took place for 24 continuous hours covering night and day shifts, monitoring 32 people and 4 pieces of drilling equipment.

4.2.1 Time line

The analysis of results allowed determining time distribution throughout the shifts. The next chart shows the result of the 4 working days monitored:



Picture 2. Average Time Line per working day



4.2.2 Distribution of activities in a working day

Likewise, the analysis of results allowed determining activities all throughout the working day. The next chart shows an average distribution of the 4 working days (8 twelve-hour shifts) observed:

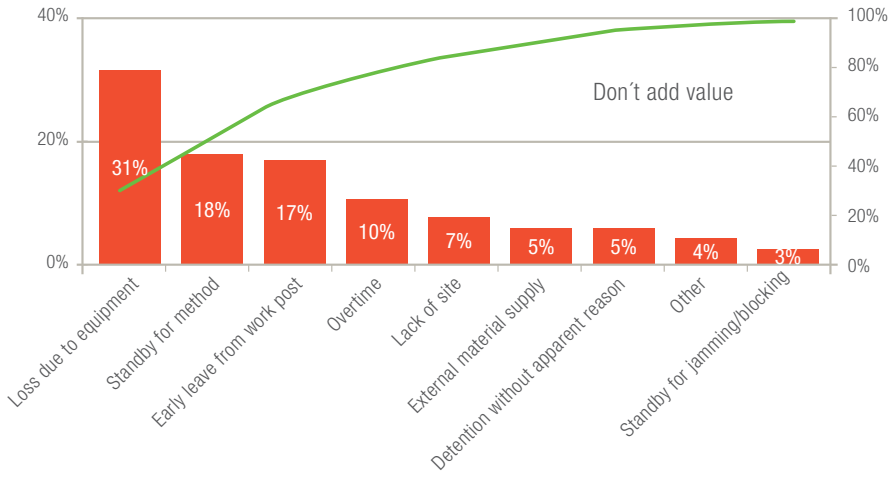
Picture 3. Activity levels at the Baseline

4.2.3 Cause analysis

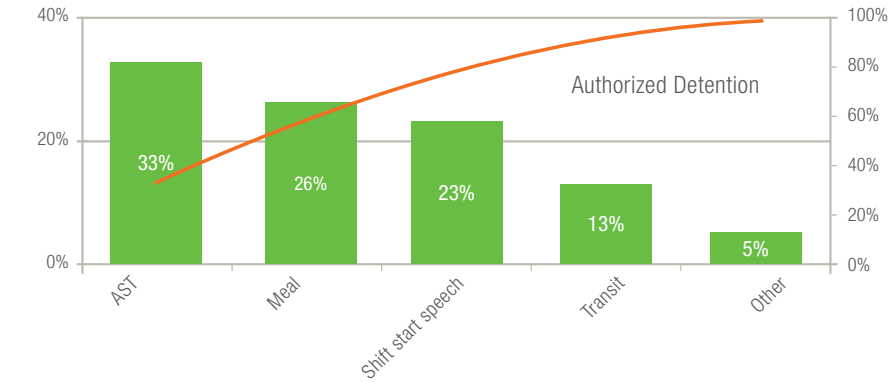
Methodologically, with the goal of increasing times that add value (AV), an analysis was carried out targeting the main causes for loss, considering time loss as well as Authorized Detentions (AD) and Support (So).

Regarding the causes for time loss, the following chart shows that main losses are of a methodological nature. **Loss due to equipment** and **Standby for method** are common in drilling procedures and are specifically produced by bar-jamming/ blocking in the probe.

The next chart shows the distribution of activities related to authorized detentions, stating **AST** filling as the most relevant time within the group; **Shift Start Speech** also proved to be significant:

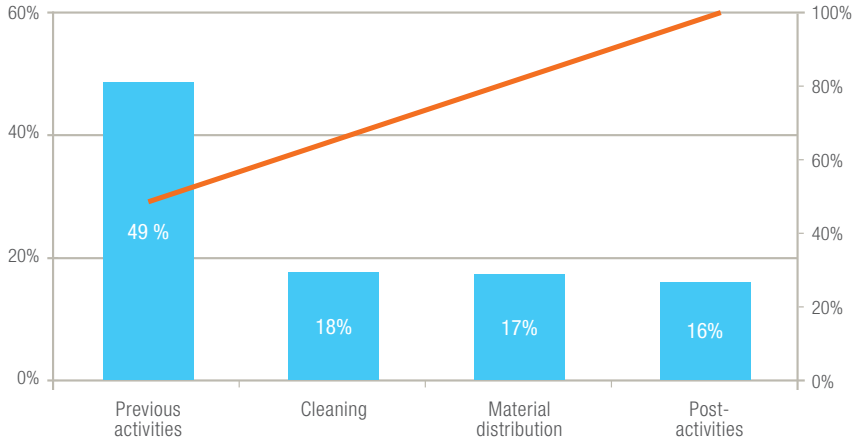


Picture 4. Loss causes at the Baseline



Picture 5. Authorized detentions at the Baseline

Regarding the opening of support times, even when they represent a pretty standard percentage for this type of projects, this chart shows **previous activities** to have the greatest impact in this classification:



Picture 6. Support at the Baseline

V. IMPLEMENTATION OF GOOD PRACTICES

The Productivity Table analyzed in detail all losses of productive time identified in the study, determining which were a priority so as to overcome them by means of Good Practices. Consequently, the following Good Practices were agreed to be implemented, taking the Manual of Good Practices in Mining Construction as a reference:

BPG 3: Methodology and Technology, to reduce the high "Don't Add Value" associated to "drilling bar jamming".

BPG 4: Improvement in Planning Processes and Resource Administration, to reduce the "Don't Add Value" associated to coordination issues in the field.

BPG 7: Focusing Shift Start Speeches, on Safety and PTS, to reduce the high authorized detentions associated to long safety speeches and filling of AST documents.

Accordingly, these measures were implemented:

- The Productivity Table analyzed the drilling methodology to face problems related to tool-rescue maneuvers due to bar jamming. Soletanche Bachy, working along with Arcadis, studied a proposal for a method change which was later analyzed and approved by Anglo American.
- Also evaluated were the frequency and reach of speeches at the start of the shift made by the contractor and the mandating party, optimizing their execution with more concise speeches and scheduling contents according to issues being coped with at the project.
- The process of preparation and generation of AST's was revised to evaluate a less extensive format which could cover the same reach required by Anglo American's Safety and Environment Management System.

These initiatives were implemented during 3,5 months in a consistent form, carrying out formal follow-up meetings, monthly scheduled, on behalf of the Productivity Table.

VI. MEASURES POST IMPLEMENTATION OF GOOD PRACTICES

The second measure, post implementation of Good Practices, took place in the month of May 2016 and also lasted 4 days. The measurement went on for 24 continuous hours along night and day shifts. The same activities as at the Baseline were monitored, covering 34 people and 4 pieces of drilling equipment.

6.1 Time line

The chart groups the timeline graphics resulting from the measurements of each shift, normalized to 12 continuous hours each.

Picture 7. Comparison of Timelines in both measurement

The distribution of times post implementation of Good Practices varies significantly within the shift when compared to the measurement at the baseline, appreciating an important time reduction in work kick-off, as well as a shorter time at the Starting Speech and AST preparation (General Good Practice 7).

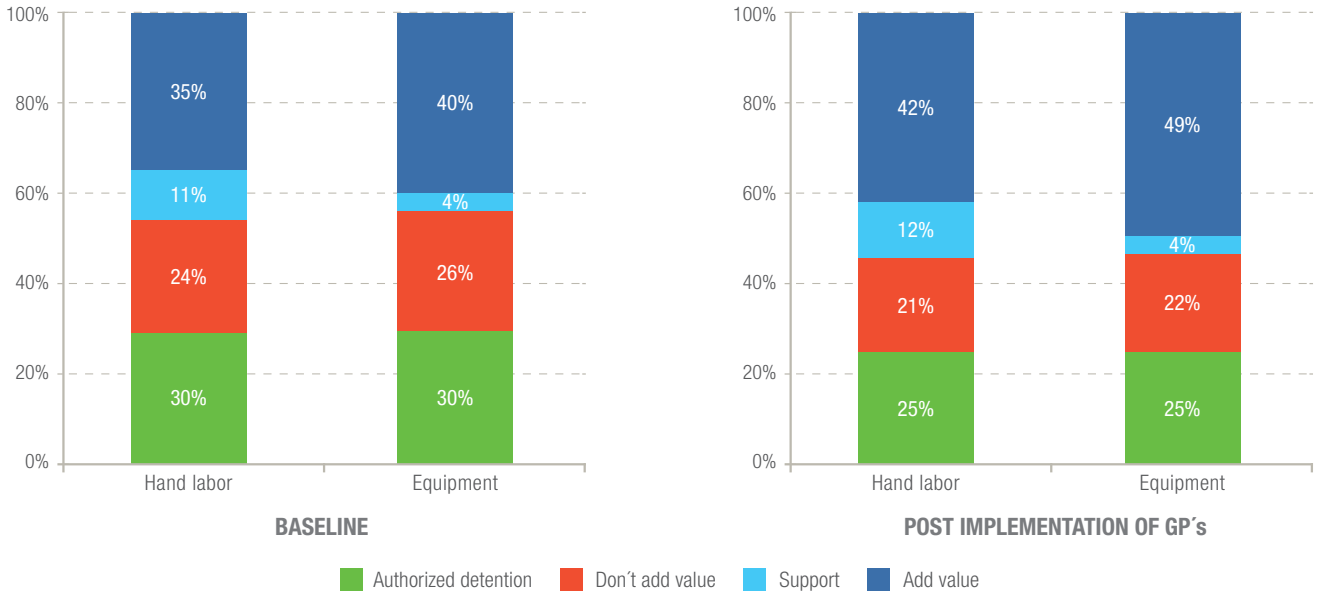
On the other hand, it is observed that the available working time in the day shift is higher than the one at night, contrary of what happened in the measurement at the baseline. This is explained by the change in shifts, meaning the team destined to work nights at the initial measurement was now working days, a situation also noticed in the losses at the end of the shift, which remained rather similar to those of the original shifts, which evidences that no improvements were made in this aspect.

All in all, from the initial 7 hrs. 11 min. available to work during day shift before implementing Good Practices, it went up to 9 hrs. 01 min. (1 hour 50 minutes of profit). Also, the night shift went from 8 hrs. 21 min. up to 8 hrs. 57 min. (36 additional minutes). Average, available time for work was increased in more than an hour post implementation of Good Practices.

6.2 Distribution of times on a working day

The following charts show activity levels all throughout a working day, for both Equipment and Hand Labor, comparing results before and after implementation of Good Practices:

Picture 8. Comparison of activity levels



It was concluded:

- The "add value" activities went from 35% to 42% in hand labor and from 40% to 49 % in equipment.
- A reduction in authorized detentions is also appreciated, going from 30% to 25% in people as well as in equipment.
- The "don't add value" times were reduced from 24% to 21% in people and 26% to 22% in equipment.
- The proportion in support times was unaltered.

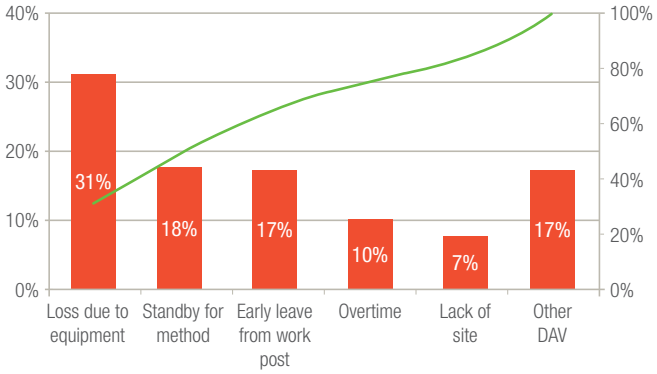
6.3 Cause analysis

Variations in activity times and loss causes were comparatively analyzed, focusing on hand labor mainly.

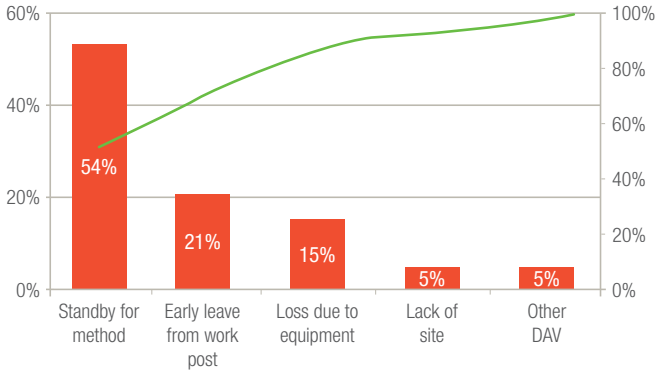
6.3.1 "Don't add value" causes

Given the change of methodology in the Project (General Good Practice 3), the distribution of "don't add value" causes varied, replacing Loss due to Equipment by Standby for Method as primary cause, situation that resembles market behavior.

Picture 9. Comparison of DAV causes



BASELINE (DAV 24%)



POST GOOD PRACTICES (DAV 21%)

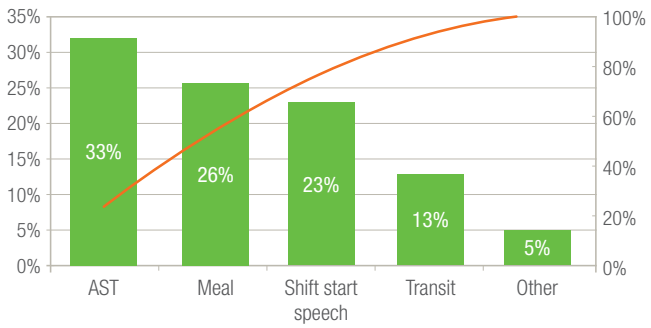
For time losses that "Don't add value", a 19 min. total reduction was accomplished:

Measure	Baseline	Post GP's
TOTAL DAV	02:50	02:31

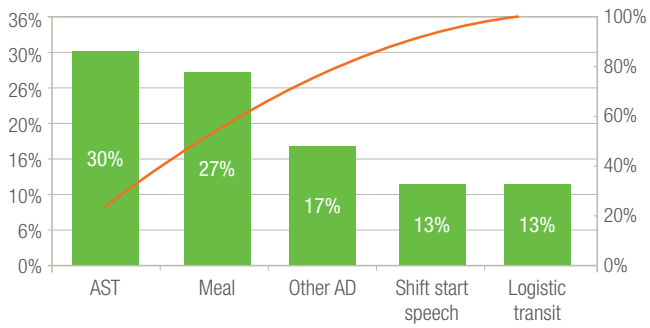
6.3.2 Authorized detention causes

The distribution of authorized detention causes varied, as appreciated in the chart:

Picture 10. Comparison of AD causes



BASELINE (AD 30%)



POST GOOD PRACTICES (AD 25%)

By implementing General Good Practice 7, the initial speech was considerably reduced, coming closer o market behavior.

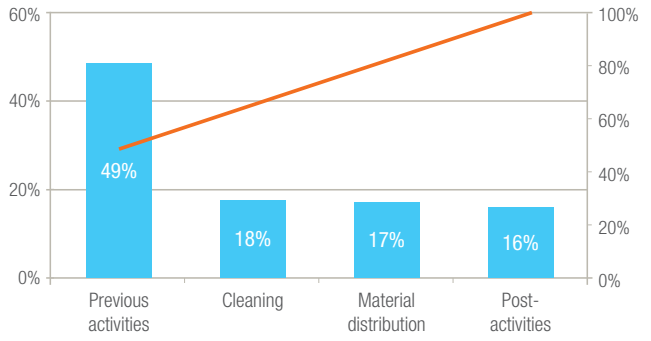
As for time losses regarding AD, a 36min. total reduction was accomplished:

Measure	Baseline	Post GP's
TOTAL DA	03:36	03:00

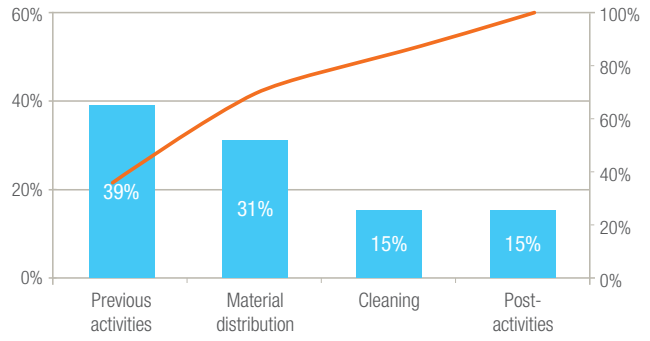
6.3.3 Support causes

Regarding support times, practically no variation was generated in percentual values comparing results before and after implementation of Good Practices; nevertheless, there was a change in activity distribution, situation possibly explained by the change in methodology:

Picture 11. Comparison of support causes



BASELINE (SO 11%)



POST GOOD PRACTICES (SO 12%)

VII. CONCLUSIONS OF THE PILOT PROGRAM

Finally, it is concluded that the conformation and functionality of the Productivity Table generated important input to the Project from the very beginning, since common problems were able to be discussed openly on behalf of the Project, difficulties that under different circumstances would not have been analyzed. Likewise, the categorization between "mandating company" and "contracting company" was put behind to lead to an integrated work of a "productivity table".

The Productivity Table allowed analyzing constructive processes from a perspective different to that involving simple evaluation of performance or work advance, highlighting activities that didn't add value to the production line or that constituted time loss factors during the shift, in both human resources and machinery.

Spite of the relatively short time of implementation for Good Practices, and thanks to the fact that the focus was centered on causes that produced more time losses in the project, great benefits were obtained:

- Improvement in work methodology, which opened to solutions once discarded due to a lack of quantification of impact in problems in processes.
- Improvement in available work time and increase in productivity of 18% in hand labor and 20% in Machinery.

	Hand labor	Machinery
Effective time before implementing Good Practices	46%	44%
Effective time after implementing Good Practices	54%	53%

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