Boss 50 – A Fast Track Project in the Democratic Republic of the Congo

Alan Lathwood

Boss Mining, Kakanda, Democratic Republic of Congo

Corresponding author: alan.lathwood@ergafrica.com

In 2015, Boss Mining as part of its improvement strategy embarked on a project to treat the undersized ore then being discarded from the crush and wash plants, via a tank leach circuit. This circuit would move Boss Mining from a nominally 34 ktpa copper cathode operation to a 50 ktpa copper cathode operation. On completion, the final project cost, including several scope changes amounted to USD 53m at a capital efficiency of USD 2300 per tonne of copper produced, excluding any provision for by-product credits. Construction was completed in 10 months and final commissioning and ramp-up in 12 months thereafter. This paper describes the history of the project from inception to final ramp up "*warts and all*" describing the highlights and difficulties that a project team experienced undertaking a fast-track project of this nature in the Democratic Republic of Congo.

INTRODUCTION

ERG Africa Boss Mining operates the Luita hydrometallurgical facility located at Kakanda in the Democratic Republic of the Congo (DRC), treating malachite and heterogenite minerals to recover copper as electrowon cathode and cobalt as a hydroxide precipitate. The operation incorporates heap leach, solvent extraction and electrowinning processes for recovery of copper as an electrowon metal with cobalt hydroxide being produced as a byproduct. In preparing the sized ore for the heap leach operations, the undersized ore fraction at a particle size distribution P_{80} of 625 µm is discharged to a fines storage facility, for later processing. Historically, this discharged ore fraction carried with it approximately 30% of the copper and cobalt contained in the run-of-mine (ROM) ore feed to the front end of the process; with changing ore types being processed, this fraction has risen to as high as 50% of the copper and cobalt contained in the ROM ore fed to the crushing plants.

In 2015, several strategies were identified to improve the profitability of the Boss Mining operation with the main aims to:

- improve the throughput of the plant via treating the fines that were currently being lost;
- recover the crush and wash fines that had previously been discarded;
- improve recoveries of the plant;
- improve the quality of the copper cathode.

The above improvement strategies were lumped together into a single project termed the Boss 50 Project.

PROJECT COSTING AND APPROVAL

To fast track the project, in Q3 2015 the project was costed at block flow sheet level (Figure 1) and capital expenditure (capex) was approved to place orders on the EPC (Engineering, Procurement, Construction) contractor to undertake upfront engineering and for the purchase of the long lead items, specifically the horizontal vacuum belt filters; final project approval was received in December 2015.

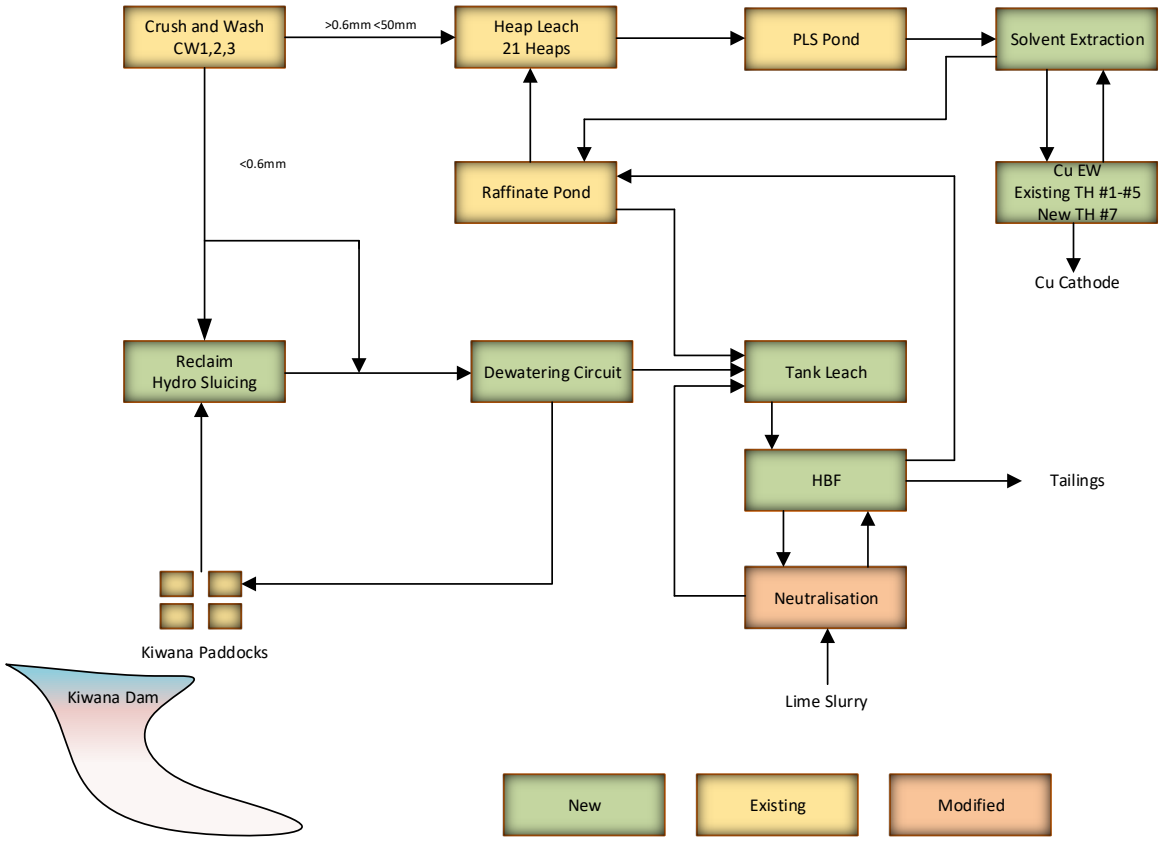

Figure 1: Boss 50 block flow diagram (cobalt precipitation circuit omitted).

PROJECT EXECUTION STRATEGY

The execution strategy at the time of the project approval was one of an EPC strategy whereby eight major packages would be placed into the market place and an EPC would execute the design, fabrication, installation and commissioning.

An aggressive schedule of 12 months had been proposed for the project, providing for six months for construction and six months to first copper cathode production. At the end of January 2016, however, with the project failing to gain traction, a review of the owner's team was called for. The following were quickly identified:

- the original owner's team was understaffed and lacked the requisite skills to undertake a fast track project of this nature;
- the Project Execution Plan (PEP) was not in place (it was assumed that the EPC contractor would develop this);
- there was no Control Budget Estimate (CBE) in place, other than the estimate developed from the block flow diagram (it was assumed that the EPC contractor would develop this);
- there was no detailed schedule for the project (it was assumed that the EPC contractor would develop this);
- the EPC contractor had minimal hydrometallurgical experience.

With the clock ticking, a revised strategy was implemented and a new EPC contractor with hydrometallurgical capabilities and team members with experience of working on projects at Boss Mining were appointed (ProProcess). The ERG owner's team of eight people was then integrated with the ProProcess engineering team of ten engineers and designers.

With the change in focus, the following work flows were all paralleled and completed in the succeeding six-week period:

- process design packages were developed for each of the WBS (work breakdown structure) areas;
- where possible, detailed engineering design activities were initiated;
- a Level 4 schedule was developed, based on the combined team's knowledge and experience;
- procurement packages were identified and compiled and issued to the market place for enquiry. Where applicable, dummy bills of quantity (BOQ) or the best available information was utilised. This was done to speed up the procurement process so that the team could complete the tender adjudications and chose the contractor whilst the design and bills were being finalised;
- earthworks commenced and terraces were constructed;
- camp facilities were brought on-line utilising an established facility at Boss that had been under care and maintenance;
- the CBE and PEP were developed to required level of detail.

Capital Cost Estimate

In early March 2016, a revised CBE was presented to the company management, reflecting a cost escalation of 29% over the original estimate. This reflected one of the earliest learnings from the project and inherent risk in fast-tracking projects. In a fast0track environment, additional rigour should be applied in developing appropriate cost contingency, to match the level of detail available in preparing the cost estimates. In this instance, the contingency applied was too low to match the costing of major equipment at a block flow level.

Schedule

The project schedule indicated construction completion in September 2016 with commissioning only in November 2016. To improve on the schedule, the strategy that was adopted was to utilise plant and equipment purchased for internal projects that had not progressed. This included the Metalkol RTR Project that was at the time on care and maintenance, and the Boss Mining Concentrator Project that had been stopped. With this strategy adopted, the time line illustrated in Figure 2 was developed.

Having received the initial approval to proceed with the project in December 2015, by May 2016 the project was effectively back on track with the delivery of the first long-lead items (the horizontal belt filters).

ENGINEERING

The engineering for this project was done by ProProcess with the directive that, where possible, the project was to utilise specifications and drawings that were available in the ERG Africa Group. Three-dimensional (3D) models were generated for all process areas; isometrics were generated for in-plant piping so that spools could be fabricated in South Africa. The remainder of the piping was to be site run from general arrangement drawings. All electrical rack installations were red lined on the general arrangement drawings and then site run.

The engineering team completed all of the design IFC (Issue for Construction) drawings within five months, including over 350 isometric layouts, examples of which are provided in Figures 3 to 5.

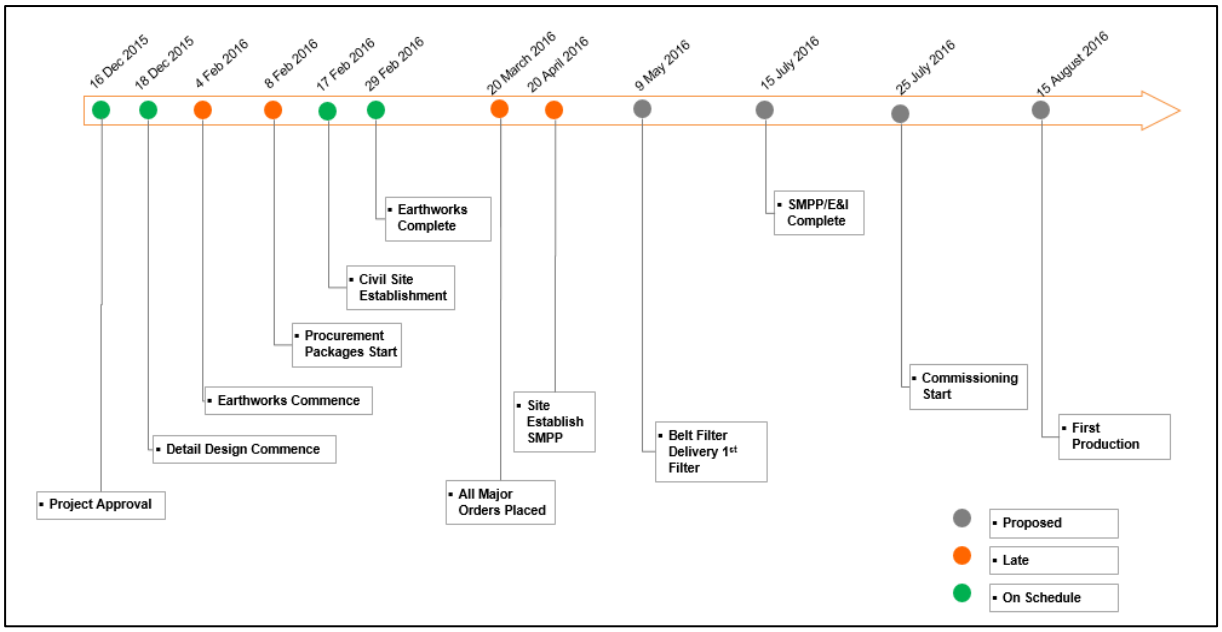

Figure 2: Boss 50 Time Line – April 2016.

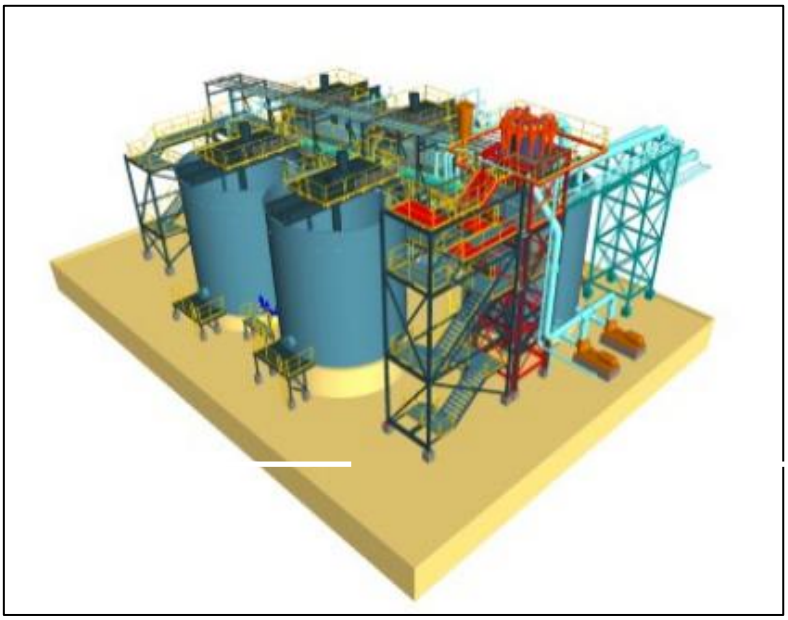

Figure 3: Boss 50 3D tank leach circuit.

PROCUREMENT AND LOGISTICS

With all "*Fast Track Projects*" quick turn around on procurement and logistics is the key to the success. Initially the requirement for 82 packages was estimated, however, the final count of orders placed amounted to 259. With this number of procurement packages for the project, the procurement turnaround activities proved to be a challenge. The tendering process was managed by the project team and typically the team ensured a turnaround of less than one week for the smaller packages to three weeks for the more involved packages, these activities being under their direct control. However, when it came to the placement of orders into the Boss Mining financial systems, alongside current operational requirements, this proved to be a challenge. Initially project requisitions took on average 35 days to travel through the approval cycle before orders were generated. Once this was

understood, the team developed procedures to expedite the orders through the system, reducing the turnaround to less than 10 days. The need to have separate project systems in a brownfields project environment was highlighted.

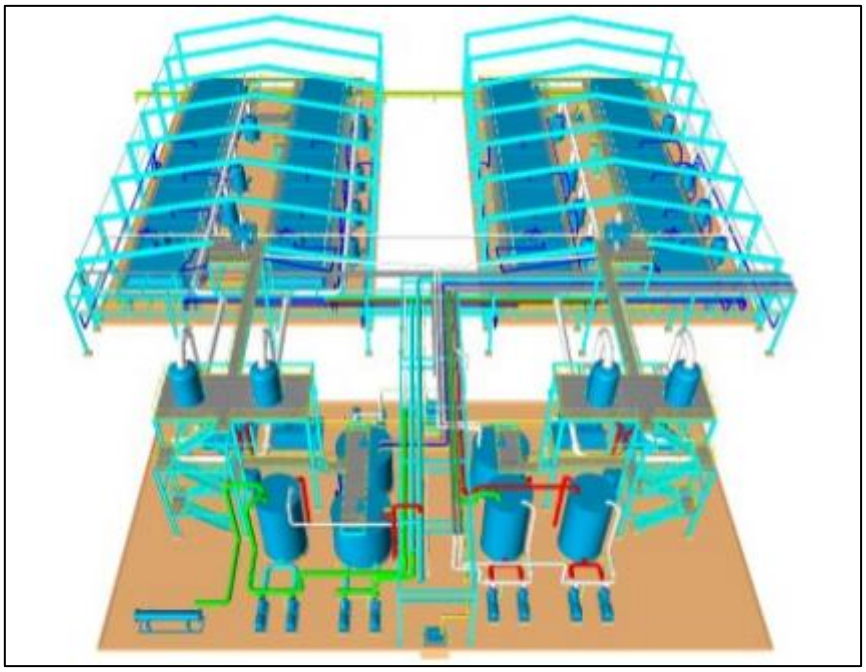

Figure 4: Boss 50 horizontal vacuum belt filter circuit.

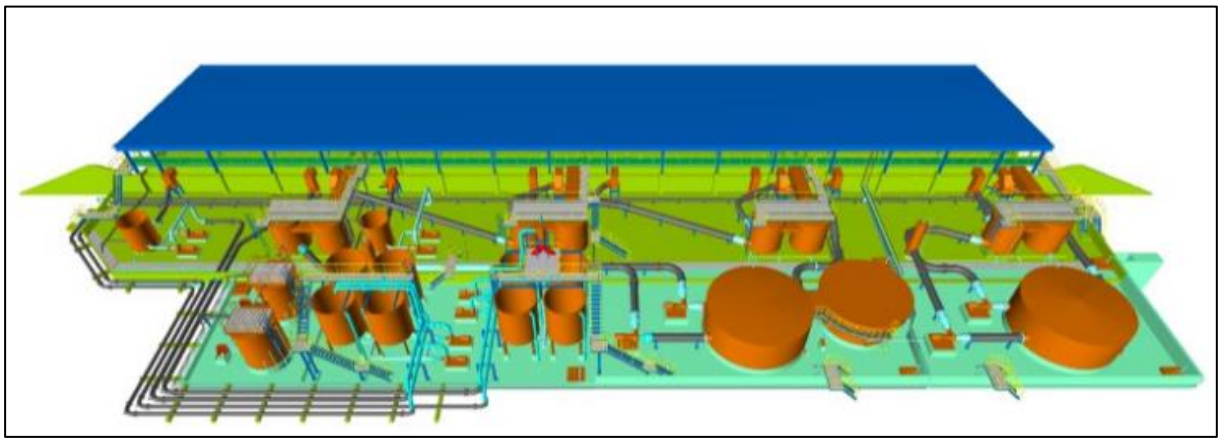

Figure 5. Boss 50 solvent extraction circuit.

The next challenge was to ensure that approval for the "*Exoneration list*" by the Minister of Mines in the DRC was progressed. Without this approval all equipment would be subject to 35% to 40% importation duties; with the approved list the duties are only 3.5% to 5%. This approval can take up to three to four months and it is thus imperative that this list is presented to the Minister timeously to take advantage of the allowed reduced tariff structures.

Understanding the logistics requirement for the DRC is highly advantageous: the trucks transporting purchased equipment to site have to travel through three countries and six border posts. The project team utilised ERG Africa's existing logistics infrastructure and transporter to ensure that this ran smoothly. The total number of truck that used to transport material and goods was 246. The team

managed to keep the average transport days to between 14 and 16 days. This required constant communication with both the transporter and the clearing agents.

The inclusion of a bonded area and customs officials on site is also advantageous, so that trucks can be offloaded and material can be cleared and delivered straight to site for installation rather than waiting for the customs officials to visit site and then clear the materials.

CONSTRUCTION

The construction commenced with earthworks in February 2016. This was done in-house utilising Congo Cobalt Corporation, an ERG Africa company. The civil works commenced in April 2016: the contract was split between local contractors, namely KIBOKO and SAFRICAS. SMPP works commenced in June 2016; the contract was awarded to Group 5. The electrical and instrumentation (E&I) installation was done by the owner's team with the assistance of Sync System who supplied the engineers and technicians.

Having established the construction teams on site, the drive for early production escalated. In June 2016 there was a push to get the Leach, HBF and Reagent plants on-line under the banner of "Early Copper", to assist Boss Mining in meeting production targets. This was achieved by the end of September 2016, however, this was at the expense of delays in construction of associated equipment and infrastructure, the impact of which was felt later on in the implementation programme.

A further learning for the project team was to provide for early production planning when setting up project schedules, to avoid disruptions later in the project that will ultimately have a negative effect on the overall project timing.

Final construction completion of the solvent extraction (SX) plant was achieved by the end of November 2016, marking the end of construction and start of commissioning.

Progression of the construction is illustrated in Figures 6 to 8, highlighting the time sequence in a fast-track project.

Figure 6: Boss 50 leach circuit construction progression.

Figure 7: Boss 50 horizontal belt filter circuit and Kiwana thickener construction progression.

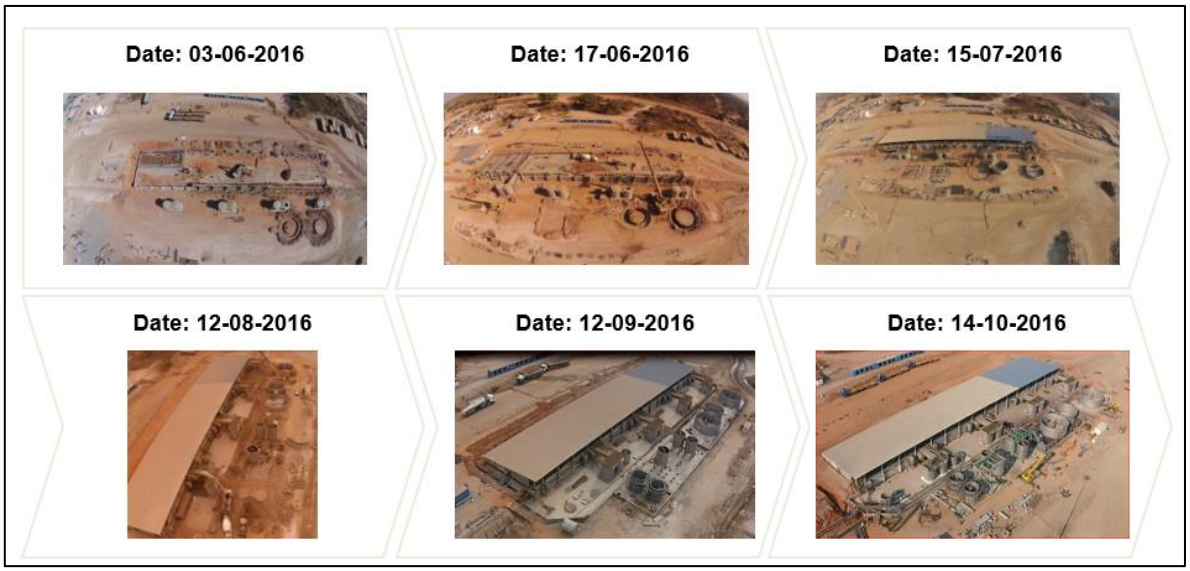

Figure 8: Boss 50 solvent extraction circuit construction progression.

Safety

In this project, significant emphasis was placed on all aspects of safety, recognising the fast-track nature of the project. The project was completed with no recorded medical treatment cases and no lost time injuries.

Table I shows the safety statistics that were achieved with over 1,000,000 manhours worked on the project with a peak manpower loading of 1105. [G5 was the biggest contractor on site; the number of recorded instances reflected in Table I is in line with statistics recorded for all other contractors on site over the same period].

Aligned with the safety statistics, the construction statistics shown in Table II were recorded.

Table I: Boss 50 safety statistics.

Department/Contractor	FAI	MTI	RWI	LTI	Fatality	PD	NM	Total Injuries	Total Incidents
HO	0	0	0	0	0	0	0	0	0
Boss 50 Project Team	0	0	0	0	0	3	1	0	4
Booss Mining	0	0	0	0	0	0	0	0	0
CCC	0	0	0	0	0	1	0	0	1
KIBOKO Construction	1	0	0	0	0	3	1	1	5
SAFRICAS	0	0	0	0	0	2	1	0	3
G5	4	0	0	0	0	1	2	4	7
Fibre Wound	0	0	0	0	0	0	0	0	0
CSI	0	0	0	0	0	0	0	0	0
Sync Systems	0	0	0	0	0	0	1	0	1
ABB	0	0	0	0	0	0	0	0	0
A&T	0	0	0	0	0	0	0	0	0
Bus Bar Installations	0	0	0	0	0	0	0	0	0
Bus Bar Installations	0	0	0	0	0	0	0	0	0
Global Paints	0	0	0	0	0	0	0	0	0
Muska	0	0	0	0	0	0	0	0	0
Total	**5**	**0**	**0**	**0**	**0**	**10**	**6**	**5**	**21**

Table II: Boss 50 construction statistics.

Description	Quantity
Concrete	4766 m^3
Plate work	495 t
Structural wteel	790 t
Piping	29 884 m
Electrical	48 940 m

COSTING AND SCHEDULE

"*Fast Track Projects*" are also subject to the standard project principles and constraints of cost, schedule, safety and quality. This project was no different: the safety and quality were well controlled and managed. The cost based on the initial approved budget was not well defined and accurately costed and this was addressed in the early stages of the project.

It must be noted that in order to push the project along, extended hours needed to be worked and, under such circumstances, there is often rework to be done as a result of rushed engineering. Once properly defined, on this project there was minimal rework required; however, extended unbudgeted hours were worked to pull back the schedule and minimise escalation as a result of scope growth.

Table III provides an overview of the cost breakdown of the project and relevant cost ratios

Table III: Boss 50 construction statistics.

Description	Cost (USD '000)	Ratio to mechanical equipment	Ratio to project costs
Civil	6,600	0.60	0.12
Mechanical	11,100	1.00	0.21
E&I	55,100	0.46	0.10
Piping	2,300	0.21	0.04
SMPP	17,600	1.59	0.33
Owner cost	10,500	0.95	0.20
Total	**53,200**	**4.80**	**1.00**

COMMISSIONING AND RAMP UP

The commissioning and ramp-up of the plant followed the McNulty #2-type curve. Factors contributing to this were:

- operator training was delayed, resulting in issues during commissioning;
- the ramp-up of the plant was constrained by the Crush and Wash plants' inability to supply the undersized fines feed to the tank leach plant, at the capacity of the tank leach plant. This was as a result of delayed approvals in the final design;
- the Kiwana fines hydrosluicing project, introduced late into the project to provide for an alternative feed source, was delayed due to imposed capital constraints outside of the project;
- the operating philosophy pertaining to the water balance between the Crush and Wash Plants and the Leach circuit was difficult to maintain. Modifications had to be done to the dewatering circuit and cyclone overflow thickener to resolve the problem.

Of significance, where there was novelty in the process design, these sections of the project ramped up within the defined schedule. Delays were incurred where decisions around more common pieces of equipment were not frozen until well into the construction phase.

The plant reached design throughput in Q4 2017, some 12 months' post-commissioning.

CONCLUSION AND KEY LEARNINGS

The Boss 50 Project has, in terms of economic performance, been a success story for Boss Mining, enabling the nameplate capacity of the plant to be increased from 2200t/month to 4100t/month, aligned with a significant improvement in product quality. Against a financial measure for net present value (NPV)/Capex ratio of 2.0 for project approval, the project delivered a ratio of 2.5.

The following key learning points are noted:

Front End Loading

- Do proper upfront planning on cost estimates, delivery of project timelines, feasibility of commissioning dates and promises on delivery in application documents;
- Operational readiness must not be overlooked, this includes activities such as training, purchase of spares, maintenance contracts, etc.;
- Brownfield projects should properly assess interfaces with existing operations and infrastructure requirements;
- Perform adequate upfront design and engineering (min. 30%) to ensure a greater accuracy on the cost estimate;
- Scope should be fixed and not changed during execution. If scope changes are required, these should be approved by the appropriate decision maker, as stated in the project charter;
- Scope and schedule changes should be assessed by the impact on project budget before they are approved.

Project Execution

- All major equipment should be tendered prior to project approval;
- All direct and indirect costs must be allocated to the project; this should include the owner's costs as well;
- Clear communication channels to be established between negotiation team and site/ procurement/legal teams to ensure one consistent message from order to delivery to final payment'
- If fast-track project is required, then separate approval systems have to be set up for the team to place orders quickly, including contracts, etc.'
- Project manager should have delegation of authority (DoA) defined;

- Owner's team should be adequately staffed (including planner, accountant, and cost engineer);
- Choose the right team.

Without exception, all those who participated on the Boss 50 Project can walk away with heads held high. The civil works were undertaken by a local DRC workforce and were exceptional. The SMPP contractor had utilized over 80% local DRC labor. The E&I was installed by a local DRC workforce with only four expatriates assisting.

ACKNOWLEDGEMENTS

Acknowledgement is given to ERG Africa Management, not only for permission to present this paper but also for entrusting me to undertake, at the time, the execution of their biggest project in the group.

The involvement of all team members and contractors who stood up to the challenge are also acknowledged, to name a few:

- Civil contractors: Kiboko and Safricas;
- SMPP contractor: Group 5 Projects and Group 5 Small Works DRC;
- E&I contractor: Sync Systems;
- Engineer: ProProcess;
- Acid proofing: Trinidad.