Article Category: PROJECT PARADE

Winner of the Project Management Excellence Award (PME) 2001 and the International Project of the Year (POY) Award

Mozal Smelter Project breaks records against all odds

Louise van Niekerk

The Mozal Smelter Project in Mozambique is a worthy winner of the Project Management Excellence (PME) Award for 2001! This US$1,3 billion project built in an under-developed country, finished under budget and well ahead of schedule, is believed to have set a world schedule record for construction of an AP-30 single line aluminium smelter. To top it all, this was achieved despite the additional challenges of working in adverse conditions in Mozambique, especially in view of the floods early in 2000. When choosing a winner the Project Management Institute South Africa who organises the annual PME Awards, took all these factors into consideration.

The Mozal Smelter Project entailed the design, procurement and construction of a new green-field aluminium smelter at the Beluluane Industrial site in Mozambique. Some 17 km west of Maputo city centre, the site covers 140 hectares or the equivalent of 340 soccer fields. Full provision was made in the design of the smelter for future expansion to add additional potlines in order to double the smelter capacity. The project design office was located in Johannesburg, South Africa.
The owner of the smelter is Mozal Sarl with the shareholders being Billiton (47%), the Mitsubishi Corporation (25%), the Industrial Development Corporation (24%) and the Government of Mozambique (4%).

Magnitude of the project

With an original budget of $1,3 billion and an aggressive schedule of 31 months to first metal, the owner cast the first aluminium ingots 25 months after formal go-ahead in June 2000. Thie hand-over was four months ahead of schedule and the saving on budget was $100 million.

The challenge to achieve this was even greater in view of the fact that no existing infrastructure, such as power, water, roads and communications, capable of supporting the construction or the long-term sustainability of the operating smelter, was available. Unfavourable geotechnical conditions, aggravated by flooding and rain damage, didn't make things any easier.

Furthermore, the project took place in a third-world country recovering from over two decades of civil war and with no experience of industrial projects of this magnitude. The local labour force was unskilled and required large-scale training and safety induction. Debilitating diseases such as malaria and HIV/Aids among the local

population aggravated these conditions. The fact that Portuguese is the language understood most widely in Mozambique, as opposed to English in South Africa, often hampered communication with the labour force.

In addition to the main project, a new berth and facilities at the Matola Harbour, was also included in the scope. As the project was constructed in an under-developed country, it was furthermore necessary to provide required infrastructure and services. This included mine clearing, road access, a construction village for expatriate labour, housing for smelter operations personnel, power supply, potable and industrial water supply and a sewage treatment plant.

In addition to these challenging conditions, international funders of the project required that first-world standards were applied to the project in terms of environmental, quality and safety considerations. In many respects these are more demanding than are normally encountered in South Africa.

Commercial production of primary aluminium is carried out by the Hall-Heroult process. This means aluminium oxide (alumina), refined from bauxite ores, is reduced electrolytically. The process takes place in a carbon-lined reduction cell, referred to in the industry as a "pot". Alumina (AI2O3) is dissolved in molten electrolyte at approximately 960°C. Carbon anode blocks are immersed in the molten electrolyte bath and are consumed during the reduction process.

The project team

SNC-Lavalin EMS (SLE) is a joint venture consisting of Canadian-based engineering/construction company SNC-Lavalin and a South African company, Engineering Management Services (EMS). The latter is the project management arm of the Murray & Roberts Group. SLE was awarded the Engineering procurmeent Construction Management (EPCM) contract for the implementation of the Mozal smelter project from concept through to facilities handover to the Owner's Operations Team (MPT). SLE worked jointly with the Owner's Project Team throughout all phases of the project. In particular, the respective SLE and the Owner's Management Team organisations were closely aligned to obtain maximum efficiency and ensure optimal communications.

The SLE Project manager reported directly to the owners' general manager, directing a strong matrix organisation consisting of area management, functional departments as well as their supporting staff and audit management positions. The project manager had ultimate responsibility for all aspects of health, safety and environment, quality assurance, scope control, budget control and risk management.

The strong matrix organisation method was fully implemented in the design office and on site, empowering each area manager with full budget, schedule, and quality and safety accountability within their area. Functional managers provided technical direction and allocation of engineering, procurement, construction, pre-commissioning and other support resources to the area organisations. All managers reported directly to the Project Manager.
Early involvement of the owner's operations team led to excellent interfacing between the project team and operations. Operations representatives regularly reviewed O & M, safety and other operating criteria in conjunction with the SLE pre-commissioning personnel.

In support of the design office in Johannesburg, the site and harbour offices in Maputo, as well as various remote sites, a specially customised version of the integrated project management software tool, PM+, was implemented.

The importance of people

The project was broken down into six areas, each under the control of an area manager who was responsible for all aspects of that area. The six areas include reduction, casthouse, carbon plant, power and automation, general facilities and the harbour.

Successful execution of a project of this magnitude required a number of special management methods. The management approach of the SLE and owners' project teams included several "best practice" elements.

Close alignment of the SLE and owner's project teams to optimise performance and communications was instrumental in achieving a seamless and transparent interface between the two teams to support the fast-track nature of the project.
In order to provide on-the-ground management during the critical completion of the construction and hand-over phases, the complete project management team and key design personnel relocated to site on completion of the design phase.

All aspects of work execution was covered by the vigorous development, implementation and monitoring of a comprehensive set of project procedures. These procedures were continually evaluated and upgraded to meet working project requirements.
Highly successful industrial relations results were achieved on the project thanks to the development, negotiation and implementation of a comprehensive project labour agreement (PLA). The PLA between Mozambican trade unions and Mozambican and South African contractor associations prior to the start of work, covered definition of trades, skill levels, wage rates, working hours, daily operations and procedures for dispute resolution. As a result less than one half of a percent of the 24 million total man-hours on site was lost due to industrial action.

The implementation of a training plan for Mozambican labour ensured sufficient trained labour would be available to meet the stringent requirements. More than 70% of site labour, which peaked at 9 000, were Mozambican. Over 5 500 of them were trained in various construction trades over the course of the project.

The need to upgrade existing management plans and induction and awareness programmes for occupational health and safety, malaria and HIV was recognised early in construction. A successful set of policies and procedures as well as special initiatives including industrial theatre was implemented. Specifically the project LTIFR (Lost Time Incident Frequency per million man-hours worked) was brought to a low of 1,7 by project completion – a world-class achievement.

In order to maximise all means for local empowerment and participation of local firms, the project team worked closely with the owner's Mozambican Affairs department. A linkage programme was established in association with the Investments Promotion Centre (IPC) to assist local business.

To facilitate early engagement of the environmental approval process, an Environmental Impact Assessment (EIA) study was commissioned early in the

Feasibility Study Phase. This reduced potential for project delay and bad community and government relations. The results met World Bank Standards.
When working in a foreign country good relations with government liaison groups are crucial. At the outset of this project, relations were established with several such groups ensuring overall communications, rapid approvals and resolution of specific project issues as they arose.

Project scope management

Construction of the project was divided into two phases. Phase 1, which comprised the Feasibility Study Phase, was to finalise the detailed scope of work. Phase 2 comprised the execution phase of the scope of work. A target of two-and-a-half years to first metal from start of this phase was agreed on.

Phase 1 was completed in September 1997 with the feasibility report being delivered to Mozal. The study included a comprehensive value engineering exercise, which reviewed design features of the existing Hillside Aluminium Smelter in Richards Bay, KwaZulu-Natal, as well as "best practice" features incorporated from experience with applicable world-wide smelter operations. Computer simulation of various processes was included as part of this exercise.

The project start was delayed while Mozal finalised certain financial and lending issues. In this "interim phase", SLE continued to refine certain aspects of the project and completed studies to obtain better project performance. This phase continued until April 1998.
During this period a detailed six-level Work Breakdown Structure (WBS) was finalised to define each element of project scope. Following the WBS definition, a Code of Accounts manual was developed. Appropriate engineering and solicitation of market pricing was conducted to ensure an approximate 10% cost estimate accuracy.

On 1 April 1998, the project schedule and cost estimates were "frozen" as the Execution Baseline, initiating the Execution Phase.

Scope change control was linked directly to the project trend evaluation programme. The original scope definition for the project was very accurate and the original Baseline Budget of $1,3 billion increased by less than 2,5% over the course of the project.

Project quality management

Quality assurance was addressed by establishing ISO 9001 accredited project management procedures, work instructions and quality assurance systems. These were successfully used in the project with various revisions being made to accommodate changes for continued compliance and improvement in project performance.

When the South African Bureau of Standards (SABS) audited the Mozal Project procedures on three separate occasions during project implementation, no findings or corrective actions were issued at either design office or the construction site.

Further a large number of vendors performed work for the project, resulting in numerous audits and surveillances to ensure satisfactory performance and consistent quality.
The procurement group was responsible for quality control and suppliers' works. A global network of expeditors and inspectors ensured that material and equipment were delivered on time and within specification.

Quality maintenance of the engineering work both internal and external, was achieved through the systematic review and checking of CAD drawings and specifications in accordance with the project procedures. Approximately 8 000 internal technical documents and 40 000 external vendor documents were processed by the project document control section.

Project time management

All project schedule dates were generally met or bettered with respect to the target of 31 months for first metal baseline. This success can be attributed to the multi-level approach to project scheduling for project time management. Schedules were linked vertically through WBS code of account referencing. Schedule levels consisted of a master level, a co-ordination level and a detail level.

In order to create management float and ensure the 31-month target was met, the project team and MPT developed a 27 month first metal schedule into the project implementation plan (PIP). The result was that the actual first metal date was achieved three weeks ahead of the enhanced 27-month schedule. This occurred despite three major threats to project schedule which required recovery schedules and some schedule compression. These included unfavourable geotechnical conditions not detected in the initial feasibility study; the worst storm in 50 years, which hit Mozambique in February 2000, and the relocation of harbour facilities.

Progress and performance management was measured on several key parameters throughout the project using the PM+ system. These included engineering, procurement, construction, pre-commissioning and package close-out. Actual progress was generally compared with baseline on a weekly or monthly basis. Corrective action was initiated as required, in collaboration with MPT.

Project cost management

Savings against the budget of this project are in excess of $ 100 million. This was thanks to strict adherence to the project cost management system implemented with the PM+ Cost Control Module. The process followed included, amongst others, a commitment package definition, validation of packaging, a package dictionary and budget allocation. Further, upon award, commitment entries for each purchase order line item and contract pay item were made in PM+ with WBS reference. The final forecast cost of each package was also reviewed each month as part of the project cost trend review. A project ledger was maintained for each package and an owner procurement committee of representatives of each shareholder monitored the complete procurement process.

Project risk management

The key objective with this project was to ensure that the project was delivered on time and within budget by reducing the probability of a risk event occurring or minimising the impact of a risk event.

The primary role for SLE in the overall project risk management process was at EPCM level. However, this effort overlapped with Mozal operations, Mozal Finance and Administration, Mozal Legal and Mozal Mozambique Affairs. In order to co-ordinate this effort and realise the risk management objectives, a risk steering committee was formed that included representatives from each of the role player. The SLE project team played a pivotal role in this process.

The risk management plan required area management, functional managers, construction management and pre-commissioning management to take ownership of the process. The were given line management responsibility to ensure that risk management was successfully implemented

Team development and human resources management

Developing and motivating an effective team with a multi-national project of this magnitude, posed a real challenge. A key factor in the success of the project was the seamless integration of SNC-Lavalin and EMS resources into a coherent, effective and proactive team. The world-wide experience of SNC-Lavalin in major project and smelter design and construction was integrated to the proven project management skills of EMS and its experience in the implementation of major projects within the Southern African Development Community (SADC).

The SLE project team and MPT management teams initiated several alignment workshops at various phases of the project in order to ensure the swift and seamless transition from one phase to another. This was particularly important given the fast track nature of the project.
Promotion from within, to positions of increasing responsibility, was encouraged. Key positions were recruited from within the SLE wider organisation to strengthen the collective skills and knowledge base of the core organisation. Communications were vital in keeping employees motivated and encouraged a project team ethic. Regular projects status updates were made to the project team in this process. Further, induction sessions were organised giving new staff member a clear understanding of their role in a winning team.

Procurement management

Poor scope definition severely compromises a fast-track project in which the preferred contract type is lump sum. An enormous effort was therefore made to fully define the scope. The procurement management was separated into purchasing, contracts, expediting, inspection, material control and logistics. Area management, in conjunction with the procurement group, used the package scopes and schedules to prioritise and prepare supply and delivery only orders, supply and install contracts and turnkey contracts. In total there were 295 packages. Wherever possible these packages were awarded on a lump sum fixed price basis in order to confer risk onto the package supplier or contractor.

Communications management

At project outset a high-level protocol for communications between all stakeholders was established as part of the Project Implementation Plan (PIP). In particular, the absolute need to respect links of communication was stressed at all organisation levels in all project procedures. The fast-track nature of the project required accurate and frequent communication to all participants.

Distribution of information was achieved through a dedicated website (www.mozal.com), the publication of Mozal News and a variety of brochures and documents, public environmental meetings, a visitors centre, a series of roadshows, industrial theatre presentations and a comprehensive close-out report.

Integration management

To ensure effective integration management an integrated PIP for execution was developed as part of Phase 1. The PIP was derived from SLE methodology development during the execution of numerous smelters worldwide and, in particular, the existing Hillside smelter in Richards Bay. In addition, the PIP incorporated numerous studies conducted with respect to undertaking a major construction project in Mozambique eg into labour relations and training, customs and logistics, government interfaces and local contractor and suppliers capability.

The Line of Balance technique was used extensively for all repetitive multi-trade areas of construction. This was used in order to optimise durations and interface between successive work operations.

Project plan execution

Integrated scope management was maintained throughout project execution by careful work packaging reflecting the phase of work progress. Detailed package dictionaries were prepared to ensure that the complete project scope was allocated. Project execution was tracked through package progress during the engineering, procurement and early construction phases.

The computer software used was the proprietary SLE Project Management System PM+. It was used to manage all project data and provide user access to summary, exception and data views. LANs were established in the Johannesburg design office and at the site office. These were integrated into a project WAN to provide on-line, constant access to all project management data and technical documents.

The basis for overall change control was established in the first instance by a good working relationship between SLE, MPT and MOT. This was reinforced by an agreement on a protocol for communications and responsible authorities for presentation and approval of project changes.

Even QE II paid tribute!

The Mozal Project was not only highly praised for its commitment to its surrounding communities, but also became a symbol of the development possibilities of the SADC region.

The project played host to numerous politicians and dignitaries, including 14 SADC presidents, Queen Elizabeth II of the United Kingdom, Nelson Mandela and Graca

Machel. It also received ambassadors and delegations from various countries including Norway, Canada, the United States and Australia.

Community projects included donating packing wood to a local convent for their woodworking programme, donating the bridge across the Matola River and the secondary site access road to the government, rebuilding one of the main arterial routes into Maputo following the floods and the erection of an informal market on the outskirts of the smelter for local vendors.

Furthermore the project management was committed to a continuous improvement in achieving the highest standards of Occupational Health and Safety performance during the construction of the smelter. A health programme was also launched at its inception focusing on occupational injuries, malaria prevention and HIV/Aids awareness.
Other special issues that received attention during the project included government liaison, fast customs clearance and a high standard of environmental management.

The Mozal Smelter project will now go through to the next round of the international Project of the Year Award organised by the Project Management Institute (PMI) USA. ProjectPro wishes them well and will keep you informed of their progress.

This article was first published in ProjectPro E-Zine May 2001 Back to the top

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