Upgrade of the Sishen to Saldanha Iron Ore Line

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Summary: This paper highlights the challenges of upgrading the Sishen Saldanha Iron Ore Line in South Africa from 29mtpa (million tons per annum) in year 2006 / 2007 to a contracted capacity of 60mtpa by mid-2011, with a potential of over 100mtpa over the medium term future. This is being undertaken by the parastatal corporation Transnet Ltd who own and operate the ports, freight railways and fuel transport pipelines within South Africa.

INTRODUCTION

Constructed in 1977, the Sishen to Saldanha heavy haul export ore line was designed as a single track line with 19 passing loops, although only the even numbered loops were constructed initially. The line connected the iron ore mines in the Sishen area of the Northern Cape in South Africa to the port of Saldanha, which is located on Saldanha Bay, in the Western Cape, some 150 km north of Cape Town. The line is approximately 860km long and runs through some extremely remote, arid and inhospitable country.

Over the years, the tonnage carried on the line has increased gradually from 18mtpa on opening to just under 30mtpa in 2007. This increase was achieved by continuously improving operational efficiencies together with a progressive increase in rolling stock; but, without major improvements to the rail infrastructure, other than installing the odd numbered loops of the original design which had not been constructed on opening.

Eventually, there was a demand from the industry to increase the capacity of the line above that which the existing infrastructure could handle. In response, Transnet, as the national freight rail logistics owner, embarked on a project to improve and update the existing infrastructure to cater for these and forecast future demands.

PROJECT DESCRIPTION

Corridor Approach

Oreline is run as an integrated corridor from mine to ship. Trains are loaded at the mines in the Northern Cape where the major mining houses are developing new mines and increasing throughput from existing mines. There is also significant demand from other parties who are currently do not have contracted capacity on Oreline. The current phase of the project will raise the tonnage in stages to 41mtpa, 47mtpa and 60mtpa respectively by improvements to the existing infrastructure on rail, at the mines and in the port. This is being achieved on the railway by increasing the lengths of the existing passing loops to accommodate 342 wagon trains that are around 3.85 km long with traction power from ten locomotives currently in a mixed diesel and electric consist. These are made up of one 9E electric and two Class 34 diesels followed by a rake of 114 wagons. This is repeated twice with a diesel at the end of the train. Hence three electric locomotives and 7 diesels power the long distributed power trains. Eventually, subject to sufficient power from the utility company, there will be five new 15E type electric locomotives powering each train.

Implementation Strategy

Phase 1A was instigated to increase the capacity of the corridor to 41mtpa by lengthening the even numbered existing loops to cater for trains of 342 wagons made up of three rakes of 114 wagons.

Phase 1B increased the tonnage to 47mtpa by similarly lengthening the existing odd numbered loops. However, Loop 7 could not be economically extended and a new loop, 7a was provided.

In the 3rd quarter of 2008, Transnet approved an expan-
sion of the Oreline termed Phase 1C. This expansion is an upgrade of the existing infrastructure to provide a rail capacity of 60Mtpa and an export capacity of 58Mtpa. This phase of the Oreline corridor is due for completion in mid-2011. This comprises operational improvements to the loading and unloading times together with other operational efficiencies; a duplicate line to the tipplers and yard improvements; power upgrade; and other efficiencies. This Phase also includes a new green field spur line of 32km from the existing line to the Sishen South mine at Postmasberg to a connection towards the north of the existing line.

Further expansions to the Oreline corridor are planned in line with the expansions to the iron ore mines owned by Kumba, Assmang and others. These expansions termed Phase 2A and 2B provide rail infrastructure to achieve 80Mtpa for phase 2A and 110Mtpa for phase 2B respectively. Each phase makes provision for an additional marine berth with associated bulk handling equipment and the port and rail sub-systems are then configured to align with this capacity. An alternative to the phased approach of implementing phase 2A followed by phase 2B would be to implement the project as phase 2A and Phase 2B into a single expansion project which would result in noticeable economies.

Port Operations

The expansion of the port is driven by the TNPA Port Master Plan. As a result, the additional berths are located in line with the port master plan for Saldanha, on the south eastern side of the causeway.

Simulations of the port operations allow for 17 different iron ore material grades. Stacking and reclaiming operations are semi-automated. An average berth occupancy of 70% is assumed and a maximum net reclaim rate of 6500 tph is used for simulation purposes.

Mine Upgrades

Extensive upgrading work has been done at the mines in the form of new load-out stations, balloon loops, sidings and other modifications to reduce the turnaround time of the locomotives and wagons; a critical factor in terms of system efficiency.

DESIGN PARAMETERS

Railway Overview

The typical cross section of the line comprises a single track 1067mm gauge railway with a 4m wide access road adjacent to it. Periodically, gated level crossings allow farm animals to cross the railway. Passing loops are situated at intervals of around 90km to allow loaded and unloaded trains to cross. Typically the unloaded trains stop in the loops to allow loaded trains to pass unimpeded. Maintenance sidings have been included in the loops for storage of materials and rail plant.

Although the main line has a typical OHTE catenary arrangement, it is unique insofar as it is electrified at 50kV AC. The existing loops are served by a trolley wire contact system without a catenary wire which limits turnout speed into the loops. 1:20 turnouts have been installed with a view to increasing the turnout speeds to 60kph from the existing 30kph although the trolley wire system in the loops may limit this to 50kph initially.

Detailed designs are in accordance with Transnet standard specification for 30 tonne axle loads. Oreline is unique insofar as the rest of the network is of 26t axle load or less and 25kv AC and 3kv DC electrification which limits interchangeability of electric traction with Oreline.

Power Upgrade

Eskom, the state electricity company, supplies feeder stations along the line with power supplied from a 400Kv grid for the south of the line and a 275 Kv grid in the north. Transformers reduce this to the traction power supply of 50kV AC.

A feeder line is being installed along the entire system, in part, to utilize the dead capacity in the current system. Plans exist for five new feeder stations and an SVC which would reduce the sections from their current 80km length to around 40km. Unfortunately, Eskom the state power supplier is unable to guarantee when their in-feed infrastructure will be in place and consequently a mixed fleet of electric and diesel will need to be used in the interim, and possibly the longer term, rather than the all electric fleet initially envisaged.

Postmasburg Link

As a part of Kumba’s Sishen South mine development, at Postmasburg, a new greenfield line is being constructed to connect the existing line to the new mine and potentially other suppliers in the area. The Postmasburg Link Line will involve the development of a single track railway line. The track structure will be designed for the line standard 30 tonne axle load. In order to ensure a homogeneous operating environment, the line will be built to the same specification as the main Sishen Saldanha Export Line.

Signalling

A new Siemens SiMMIS S electronic interlocking system is currently being implemented to progressively replace
the existing relay based interlocking systems.

**Geometric Design**

Oreline geometry standards were derived from world best practice at the time of construction. Maintenance standards have been refined over the years of operation and result in exceptionally good wheel rail interface characteristics and long rail life. Some of the original rails are only now being replaced.

Geometric design or the railway is in accordance with accepted industry standards as well as Transnet implemented standards such as those contained in the Transnet Freight Rail. Manual for Track Maintenance (2000) which provides for a more onerous regime on Oreline than the rest of the Transnet Freight Rail network. The ruling gradient is 1:250 for facing loaded trains and 1:100 for facing empty trains. A vertical radius of 62500m is used for vertical curves on the running line. The minimum radius of horizontal curves is 1000m. Transition curves of 60m in length are applied for curves sharper than 300m and 80m for curves greater than 300m is applied.

The maximum allowable cant for the 1067 gauge is fixed at 90mm. Cant variation is carried out by gradually raising the outer rail from 0 to the applied cant value. With a maximum application value not exceeding 25mm/m. A cubic parabola is used to attain the cant variation although to simplify calculations a spiral transition curve is used which in the case of transitions between a straight and a circular curve has the equation \( Y = \frac{X^3}{6RL} \).

Geometric design is validated against a 342 wagon train. Therefore, where possible, the main line design aims to accommodate a complete train on one grade or on two or more consecutive grades of the same sign.

**OPERATIONS**

**Rolling Stock**

Currently Oreline runs with a mixture of diesel and electric locomotives, it is currently intended that the line becomes powered completely by electric traction utilizing a new fleet of 15E type locomotives being constructed in tranches by Union Carriage in South Africa. Under Phase 1A and 1B, 44 new electric locos are required. This will be followed by 18 new locomotives for Phase 1C, and potentially 32 and 26 in Phases 2A and 2B respectively. 1696 additional ore wagons are required for 2A and 1860 for the 95mtpa option. To minimize rail wear, Scheffel self-steering bogeys are utilized on the ore wagons.

**Timetable**

Phase 2A capacity based on a 72 slot timetable; 11 intermediate loops and 50 trains per week

Phase 2B capacity is based on a combination of 70 slots in the north and 120 slots per week in the south; all 20 intermediate loops installed; 59 trains per week for 95mtpa and 68 trains per week 110mtpa.

**Maintenance**

On going maintenance is carried out throughout the year; however, in August or September each year the line shuts for 10 days to allow major activities like ballast cleaning, sleeper replacement and the installation of new sets to be undertaken. The logistics surrounding this are enormous due to the remoteness of much of the line and the fact that it can effectively only be accessed at its ends. The provision of the new maintenance sidings along the route will help to alleviate these problems and facilitate ongoing maintenance.

**PHASE 2 EXPANSIONS**

**Development of Throughput Options**

The study objectives require that a balanced throughput option be developed for Oreline corridor. In order to select the optimum throughput option an integrated simulation model was developed to simulate the movement of ore from the mines in the Northern Cape to the point of export in the port of Saldanha. In order to perform the simulations several processes had to be followed. Options for the configuration of the port were developed in conjunction with ITE Consulting who specialise in the modeling and analysis of material handling systems. They have been involved in the port activities since 2005.

The simulation models were used to test each option in terms of loading and unloading activities at the port and the associated rail services timetables. The simulation of rail timetables was prepared by LTS who are specialists in planning rail services. In total, over 600 unique simulation runs were performed on over 35 port terminal configurations.

In preparation for the simulation studies, all operating parameters needed to be revisited and agreed to ensure that they remained realistic and against international benchmarks. From a rail perspective, the rail capacity needed to take into account the fact that capacity is dependent on journey time including allowances for loading and unloading at the mine and port respectively.
As far as the rail sub system is concerned, the main line is the capacity constraint in the system and was therefore analysed to determine the sensitivity to train delays as well as train cycle times with differing loop configurations. These results were then used to develop the timetables and running times in the integrated rail model from the mines at Sishen to the tipplers on the port of Saldanha as an interrelated system. A total of four options for the loop configurations were modeled in this manner.

The results were that under phase 2A, 11 intermediate passing loops should be provided for a sustainable rail capacity of 80mtpa. This recommendation is based on the trade off between the cost of infrastructure against the stability of the timetable and the subsequent difference in the demand for train sets. The results also confirmed that 80mtpa is a logical breakpoint in that if additional capacity is required above this figure then an additional 9 loops need to be installed.

The rail capacity with the additional 9 loops as envisaged under phase 2B and running on a 120 slot timetable is 110mtpa. Though it can be demonstrated that the anticipated rail capacity is 110mtpa, the rolling stock quantities have been limited to a rail capacity of 95mtpa which could be achieved by a service providing 58 trains of 342 wagons per week operating on a 120 slot timetable and with all intermediate loops installed.

KEY RISKS AND CHALLENGES

Risk Evaluations

The project has been subjected to two types of risk evaluations. The first is an evaluation of the implementation risks as contained in the risk registers used for the assessment of contingency allocations. The second group of risks are Client risks which if not suitably mitigated will result in a significant constraint or barrier to achieving the intended project outcomes. The main ones are the potential lack of a business case, particularly in the current market where export prices for iron ore have dropped considerably. Discussions are being held with industry to reach agreement on tariff structure and timing for completion of the phases. A suitable funding mechanism also needs to be found.

Power Supply Issues

A lack of electrical power from the statutory provider Eskom is a critical issue. Historically, a lack of development of power stations in South Africa has resulted in a situation where insufficient traction power may be available for tonnages in excess of 47mtpa. This may result in a need to run a mixed fleet of diesels in the short and possibly longer term.

Local Interests

Vociferous lobbying from 'Interested and Affected Parties' opposed to development in the port had also complicated the environmental approval process.

Environmental Approvals

Though the process of obtaining environmental approvals is well advanced, the process of gaining approvals is proving problematic. Currently, environmental approvals for 93mtpa are being sought for historical reasons and it is thought that this will coincide with the potential future aspirational demand from Industry.

The single most critical issue for the timely implementation of the line is the gaining of environmental and other statutory approvals. This is extremely problematic in the current South African political environment and some parts of the process are without statutory timeframes, which places timelines at large with respect to project delivery.

Longer than anticipated durations to resolve appeals to the environmental Record of Decisions (RoDs) is impacting on schedules as there is no statutory time limit in South Africa for these appeals to be ruled upon, which places the programme at large and is a significant risk to the project. The current planning assumes a six month delay for this process. A further fear is that the current environmental applications are in terms of the 1997 regulations. Since then, the regulations have changed and there is a real risk that with any revised plan to implement Phase 2 that there will be a requirement to obtain authorization in terms of the 2006 regulations. This would require that much of the work done to date would need to be re-performed, especially the interaction with the communities which could set the project schedule back by up to 24 months.

For rail, the scoping report for the environmental impact assessment has been accepted by the Department of Environmental Affairs and Tourism (DEAT). The next phase of the process is to commence with the detailed Environmental Impact Assessment. It is anticipated that the key issue of this assessment will be as a result of increased rail traffic and the associated increase in noise levels. It is again expected that an appeal will be lodged for this application and hence the planning is adjusted for this expectation.

Additionally, the new rail layouts and operating plans need to be submitted to the Rail Safety Regulator for approval prior to the commencement of construction.
Conclusions And Recommendations

Although a part of the Transnet Freight Rail network, with the exception of a small number of general freight slots, the Oreline operates primarily as a dedicated single purpose line. There are indications of Industries commitment to significant iron ore growth on the line and subject to the robustness of the business case a mechanism needs to be developed, in conjunction with industry, for the delivery of the capacity improvements. Compared to some of Transnet’s other heavy haul lines which also carry large quantities of general freight and container traffic, the Oreline lends itself to a capital works delivery mechanism that includes a significant level of participation from industry. Additionally, cognisance needs to be taken of the challenges of delivering major infrastructure projects in the current regulatory environment in South Africa as this significantly impacts on the time and cost of such projects.