High Angle Conveyor Offers Mine Haulage Savings

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Synopsis:
Costs of truck haulage from mine pits are high and spiralling with inflation, increasing haul distances and depths. A high angle conveying system is an economic and energy saving alternative, with the capability of achieving very high, steep angle lifts and capacities up to 10 000 t.p.h. Standard locally available components and conventional belts are used.
This paper describes a typical open pit mine's requirements, concentrating on haulage alternatives. Definitive costs for high angle conveyorised systems are compared with truck haulage. These costs have been developed from existing current operations.
Mine operators should find this useful in looking for means of improving productivity and reducing costs per ton.

INTRODUCTION

Trucks, traditionally, have long been a favourite tool in surface mines for hauling material from the pits. The increasing strain of an inflationary economy has caused mine operators to look at alternatives to the longstanding workhorses (trucks) in material haulage.
The intent of any major modification of the time-honoured material handling by trucks is to achieve the goal of a marked reduction in haulage costs; sufficient not only to recoup the capital investment, but to make the final product more competitive in today's world market. In-pit crushing and belt conveyor systems are one prominent alternative that has gained popularity. More than fifty major conveyorized surface mines are in successful operation around the world. Major savings in capital and operating costs are realised when conveyorized systems are properly applied with other proven mining technologies.
By combining the flexibility of trucks with the low cost of conveyors, an alternative is offered by the application of movable crushing plants followed by belt conveyor systems in conjunction with steep angle conveyors for the main haul out of the pit.
Truck haulage can be restricted to travel between the working face and the pit crusher. This means that trucking is limited to level haulage on individual shovel benches and to very little inclined haulage. It is on the inclines where a truck's efficiency is so low.
A high angle conveyor can be defined as any conveyor that transports material along a slope exceeding the dynamic stability angle of the transported material.
The application of conveyors in this mine study recognises the cost savings in material haulage that a high angle conveyor has in a total system.

High Angle Conveyor Principles

There are two basic designs which have been developed to a stage of commercial practicability - the sandwich belt system and the pocket belt system.
In this study we are considering the high angle conveyor or HAC as developed by the Continental Conveyor & Equipment Co. in the U.S.A. This is a sandwich belt design which employs two ordinary rubber belts on top of each other sandwiching the material between them.
The geometry and design features of the HAC provide sufficient friction at material/belt and material/material interfaces to prevent the material sliding back. Careful selection of radii, belt tensions and pressing forces are required. The bottom belt is carried on troughing idlers and the top, or cover belt, is softly pressed onto the conveyed material by fully equalised pressing rolls.

Material is loaded onto the tail end of the bottom belt in the conventional manner and sandwiching commences at the start of the concave radius leading into the inclined position. In this radius the top belt is supported on inverted troughing idlers and the bottom belt supports the material by virtue of its radial tension component. Ample belt edge distance assures a scaled material package during operation and lump sizes up to the trough depth or slightly more present no problems. All components are standard and proven for conveyor applications.

Economic Feasibility

The viability of the high angle conveyor system application lies in the degree of economic advantage it offers over the conventional truck system it is to replace.

For economic comparison both the high angle conveyor system and the truck haul system are developed for the same mining sequence, pit configuration and production schedule.

Intangible benefits that exist in favour of the conveyorized system are difficult, if not impossible to document, are not included. Logical considerations indicate that these benefits exist. Different cycle times occur between two apparently identical trucks and each driver has different abilities, erratic arrivals and departures at the loading and dumping points and decreases in shovel and truck efficiency. These inefficiencies at such times and shift changes are particularly detectable.

Mine Design

In this study the mine is a hypothetical composite featuring existing conditions in different mines in the United States and represents an average size. The ultimate mine pit configuration measures approximately 1900 metres x 1450 metres. The ultimate depth of the pit floor from the highest pit crest is 550 metres and the average depth to pit floor is 400 metres. The benches have an average slope of 58 degrees and average width of 8 metres. The haul roads inside the pit area are on 8 percent grade and 36 metres wide.

The mine is at a depth of approximately 175 metres. This is reaching the limit of acceptable truck haulage costs. The costs are found to increase at a dramatic rate as the depth of the pit increases. Vertical lifts in excess of 150 metres create traffic and maintenance problems; efficiency drops rapidly and costs rise.

Some 375 million tons of ore reserves were calculated to be excavated from this pit in 22 years. A daily ore and waste mining production of 130 000 tons is desired with a stripping ratio of 1,8 tons of waste to 1 ton of ore (83 500 tons of waste and 46 500 tons of ore).

This mine is assumed to work 365 days per year, 3 eight hour shifts per day. Equipment mechanical availability is approximate at 82 percent, and personnel time efficiency is at 83 percent for an overall utilisation of 68 percent, or 16,3 hours per day.

Equipment Selection

From the work schedule and daily production requirements, the following assumptions were made to determine the number and sizes of the equipment.

I. All Truck Systems:

The waste system has three routes. One route located 45 metres from the rim, the second route located 30 metres below the first route and the third route located 30 metres below the second route. The waste dump is approximately 1 280 metres from pit perimeter. A total of twelve trucks of 170 ton capacity is required. Five, four and three trucks, respectively, for the three routes. Trucks from the two top waste benches use the same ramp and the trucks from the bottom bench use the one exit ramp. Their trip cycle times were calculated as 19, 24 and 31 minutes.

The ore system has two routes, resulting in the use of twelve trucks of 170 ton capacity. Six trucks, respectively, for each unit. These trucks operate from 185 metre and 200 metre levels. The primary crushing station is located 1960 metres from pit perimeter. The trip times are 34 minutes and 35 minutes.

The five shovels required, three for waste and two for ore, are of the 16 metre cubed type.

The all truck system is comprised of the following major equipment:

a. Waste system components
   3 - 16 metre cubed shovels
   12- 170 ton trucks
b. Ore system components
   2 - 16 metre cubed shovels
   12- 170 ton trucks
   1 - crusher station

The all truck haulage system is represented by Figure 1.

II. <u>Conveyorized System:</u>

The waste and ore removal and discharge areas are the same as the all truck system.

The waste system has three routings which requires seven trucks of 170 ton capacity. The trip cycle times are approximately 16, 4,5 and 5.0 minutes. The routings of the trucks at bench locations at 45 metre and 75 metre elevation below the rim have the trucks dumping into the same mobile crusher station and the route at 105 metre elevation below the rim dump into a second mobile crusher station. The truck requirements are 2 for the first working bench, 3 for the second working bench and 2 for the third working bench.

The ore system has two routings resulting in trip times of 14 minutes and 12 minutes. The truck requirement is four trucks.

The conveyorized system is comprised of the following major equipment:

a. Waste system components (initial)
   3 - 16 metre cubed shovels
   7 - 170 ton trucks
   2 - Mobile crushing stations with apron feeder - 2 000 mm wide x 25 metres, 3 500 tph, maximum capacity. Gyratory crusher 54 x 74, Crusher discharge conveyor, 2 400 mm wide x 30 metres.
   8 - In-pit conveyors - 1200 mm wide to transport waste to high angle conveyor, 3 250 tph capacity.
   2 - High angle conveyors, 2 000 mm belt width, 6 500 tph capacity, one with 60 metre lift and one with 50 metre lift.
   1 - Overland conveyor, 1500 mm wide x 1280 metres to handle 6 500 tph.
   1 - Shiftable conveyor with stacker, 1500 mm wide x 2 000 metres.
b. Ore System components (initial)

   2 - 16 metre cubed shovels
   4 - 170 ton trucks
   1 - Mobile crushing station (same as waste system)
   2 - In-pit conveyor, 1200 mm wide to transport ore to high angle conveyor, 3 250 tph capacity.
   2 - High angle conveyors, 1500 mm belt width 3 250 tph capacity, one with 90 metre lift and one with 75 metre lift.
   1 - Overland conveyor, 1200 mm wide x 1 960 metres, 3 250 tph capacity.

Additional equipment includes two self-propelled crawler transporters of 300 ton capacity. These are used in relocating the mobile crushing stations.

The belt conveyors are sized and powered to permit temporary surges without overloading system components. The ore system average flow sheet rate is 2 853 tph and the belt units are designed for 3 250 tph (+ 14%). The waste system average flow sheet rate is 2 562 tph for each of the two systems and the belt units are designed for 3 250 tph (+ 22,5%).

The conveyorized system is represented by Figure 2.

Operating Costs

The base costs used for estimating operating costs are:

- Diesel fuel = $1.00 gallon
- Electricity = $0,0325/Kwh.
- Operator's wages = Prevailing wages including all fringe benefits.

The costs of the trucks, graders, dozers, etc. are divided in categories covering specific items. The following example is for the 170 ton trucks. The other equipment was figured in a similar manner.

Truck Estimated Operation Cost - All Truck System

1) Fuel Cost	$56,50/hour
2) Tyre replacement cost (200 hr life of tyres)	15,82
3) Tyre repair	1,70
4) Oil, grease, filters etc.	1,00
	$75,02/hour

Truck Estimated Operation Cost - Truck/Conveyor System

Truck Estimated Operation Cost - All Truck System

1) Fuel Cost	$33,90/hour
2) Tyre replacement cost (200 hr life of tyres)	15,82
3) Tyre repair	1,72
4) Oil, grease, filters etc.	1,00
	$52,42/hour

Note: The hourly fuel costs are based on simulated conditions.

For the electrical costs, the crushing plants and conveyor system will operate 5 950 hours each year (68% on 16,3 hour/ day) loaded and 2 810 hours empty. The Kwh for the system is:

Ore system :	25 533 000 Kwh
Waste system :	42 947 000 Kwh

For extending the high angle conveyor deeper into the pit during years 6, 12 and 18, the following additional electrical power will be required: 7 199 000 Kwh each frame.

In compiling the operating costs, a comparison of the total travel and lifts of the two systems were determined. The run of the truck/conveyor system decreased by approximately 89%. To put this in perspective, the following is the tabulation of the estimated runs and lifts:

System	Haulage Distance	Lift
All truck	5850 Km/day	113,9 Km/day
Truck/conveyor	2575 Km/day	14,1 Km/day

Table 1-1 shows the all truck haulage capital asset schedule. Year one is the beginning of the mine plan when truck/conveyor system begins its comparison with all truck system.
Table 1-2 shows the truck/conveyor haulage capital asset schedule. Some existing trucks (approx. 9) being used for the present mining plan would be reserved for retirement and spare parts.
Table 1-3 indicates the capital costs over the life of the mine for both systems.
Table 1-4 lists the personnel requirements for the two systems.
Table 1-5 illustrates the operational costs for the two systems.
Table 1-6 shows the total costs over the life of the mine at 0% inflation rate.
Advantages and Disadvantages

A. Truck system:
    1. System is flexible, a single truck fleet can serve several production areas.
    2. It is a proven system.
    3. There is efficient loading. Trucks can be spotted at the most efficient location for the loader.
    4. It is a non-permanent system.
    5. It is very sensitive to inflation.
    6. Truck costs increase exporentially with increase in lift height.
    7. Truck haulage is dependant on skilled maintenance labour.
    8. Trucks are less efficient energy users than conveyors.
    9. Truck fuel is subject to sharp price increases and shortages that could result in rationing or being put on allocation.
    10. Ore losses are encountered on initial start-up due to long truck ramps.
    11. Trucks generally have a lower productivity than conveyors.
B. Conveyorized Systems:
    1. Flexibility of mine planning is reduced.
    2. Initial capital cost of the conveyor system is high.
    3. Conveyors cannot be lengthened or shortened as easily as truck haulage.
    4. Conveyors must be either straight or have a very large radius of curvature in the plan view.
    5. By using a high angle conveyor a much shorter total haul length is encountered.
    6. Conveyors almost always provide lower operating and maintenance costs, and are more efficient energy users than trucks.
    7. They provide comparable operating availability.
    8. Frequently conveyor/high angle conveyor gives a comparable operating flexibility to a truck system, depending on mine plan.
    9. They are less sensitive to inflationary pressure and to fuel shortages.
    10. They are much less labour intensive.
    11. Conveyors are environmentally preferable, because it is much quieter and has fewer particulate emissions.
    12. Lower unit costs may extend the economic pit life.
    13. Operation is less sensitive to inclement weather.
    14. Truck cycle times are shortened.
    15. Conveyor components are readily available and are often locally produced.

SUMMARY
This study has determined that a truck-conveyor-high angle conveyor system is economically viable in the open pit mine.
Technically, the high angle conveyor and the attending conveyor system have been developed from proven, state-of-the-art design standards in the areas of belt conveyance of loose, bulk materials.
The new concept of high angle conveyors can be incorporated with minor modification to the pit configuration. From an economic standpoint, the high angle conveyor is a cost saving method of

transporting material out of the pit. This cost saving is greatly enhanced when mines are deep with high lifts and long transport distances.
Maximum economic stripping ratios may increase because of lower mining costs, expanding pit perimeters and deepening pit bottoms.
As an addendum and for comparison, a similar study to the above is attached for reader's interest. This study is based on realistic, current South African conditions and was undertaken to evaluate a specific situation.
Every haulage system is extremely site specific. With proper interfacing with mine planning, a conveyor high angle conveyor/haulage system can provide many years of economical and reliable operation for the owner.
It should be noted, of course, that high angle conveying has many other applications both in underground mines and surface plants. The constraints imposed by inclination considerations need no longer inhibit the use of conveyors. When overall savings in land, excavation, services, controls etc. are added to those savings more directly measurable, the potential for improving returns on investment is very attractive.

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TABLE 1-1
ESTIMATED CAPITAL ASSETS SCHEDULE
DIRECT HANDLING - ALL TRUCKS
($1,000)

	170 Ton Truck	Truck Dozer	Motor Grader	Wheel Dozer	Water Wagon
Unit Price	900	291,6	273,9	200,4	531,9
Life/Years	6	3	3	3	3
Years					
-2					
-1	6300	291,6	273,9	200,4	531,9
1	9000	291,6	273,9	200,4	531,9
2					
3	2700	291,6	273,9	200,4	531,9
4		291,6	273,9	200,4	531,9
5	1800				
6	8100	291,6	273,9	200,4	531,9
7	900	291,6	273,9	200,4	531,9
8	5400				
9		291,6	273,9	200,4	531,9

10		291,6	273,9	200,4	531,9
11	1800				
12	7200	291,6	273,9	200,4	531,9
13	900	291,6	273,9	200,4	531,9
14	5400				
15		291,6	273,9	200,4	531,9
16	2700	291,6	273,9	200,4	531,9
17	1800				
18	7200	291,6	273,9	200,4	531,9
19	1800	291,6	273,9	200,4	531,9
20	4500				
21	5400	291,6	273,9	200,4	531,9
22		291,6	273,9	200,4	531,9
Totals	72900	4665,6	4382,4	3206,4	8510,4

TABLE 1-2
ESTIMATED CAPITAL ASSETS SCHEDULE
INDIRECT HAULING - TRUCK/CONVEYOR/HIGH ANGLE
($1,000)

	170 Ton Truck	Truck Dozer	Motor Grader	Wheel Dozer	Water Wagon
Unit Price	900	291,6	273,9	200,4	531,9
Life/Years	6	3	3	3	3
Years					
-2					
-1	6300	291,6	273,9	200,4	531,9
1	9000	291,6	273,9	200,4	531,9
2					
3					
4		291,6	273,9	200,4	531,9
5					
6	8100				
7		291,6	273,9	200,4	531,9
8					
9					
10		291,6	273,9	200,4	531,9
11					
12	8100				
13		291,6	273,9	200,4	531,9
14					
15					
16		291,6	273,9	200,4	531,9
17					
18	8100	291,6	273,9	200,4	531,9

19		291,6	273,9	200,4	531,9
20					
21					
22		291,6	273,9	200,4	531,9
Totals	39600	2332,8	2191,2	1603,2	4255,2

TABLE 1-3
EQUIPMENT
CAPITAL COSTS OVER LIFE OF MINE
($1,000)

	All Truck System		Truck/Conveyor System	
Item	Qty	Cost	Qty	Cost
170 ton truck	81	72900	44	39600
Track dozer	16	4666	8	2333
Motor grader	16	4382	8	2191
Wheel dozer	16	3206	8	1603
Water wagon	16	8510	8	4255
Mobile crushers	-		3	6300
Conveyors	-		10	19800
High angle conveyors	-		4	6200
Spreader	-		1	4250
Transporters - Crawler	-		2	1200
Relocate crushers	-		-	9500
Relocate waste shiftable conveyor	-		-	600
Electrical distribution	-		-	1975
Total		93664		99807

NOTE:

Equipment that would be used for either all truck or truck/conveyor not included in above, such as: shovels and their support vehicles, maintenance truck, fuel and lube truck, shop, tyre truck, welding truck, storage tanks for diesel and gasoline, pick-up trucks, mobil radio units etc.

TABLE 1-4
LIST OF PERSONNEL AND ANNUAL TOTAL PAYROLL

(Note: Supervisory personnel same for both systems. Support personnel that is common for both systems not included)

Personnel	All Truck		Combination	
	No.	Annual Cost	No.	Annual Cost
Truck driver	72	2 265 840	33	1 030 510
Track dozer operator	6	188 820	3	94 410
Grader operator	6	188 820	3	94 410
Wheel dozer operator	6	188 820	3	94 410
Water wagon operator	6	188 820	3	94 410
Truck mechanic	12	377 640	6	188 820
Truck mechanic helper	4	85 028	3	63 771
Dozer mechanic	6	188 820	3	94 410

Dozer mechanic helper	3	63 771	3	63 771
Grader/Water Wagon mech.	4	125 880	3	94 410
Grader/Water Wagon mech. helper	3	63 771	3	63 771
Labour pool*	33	956 142	24	695 376
Conveyor mechanics**	-		34	794 376
Total (Avg. per year for Mine Life)	161	4 882 172	124	3 474 855
Total Avg. Mine Life (22 years)		107 407 784		76 446 810

* Weighted average of all classifications. Men required for vacation time, absenteeism and odd shifts on seven-day work schedule.
** Weighted average of all classifications

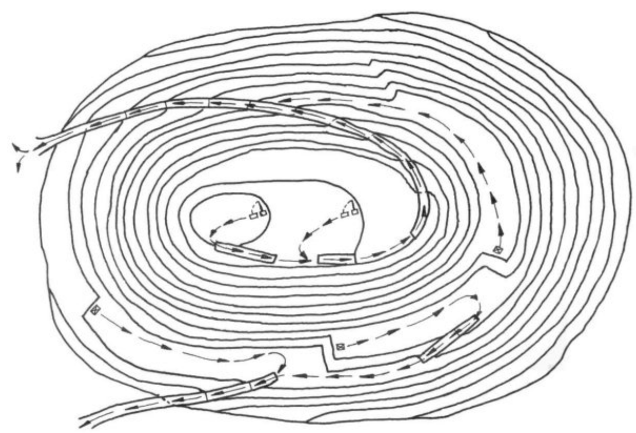
TABLE 1-5
OPERATING COSTS (TYRES, FUEL LUBE, ETC.)
($1 000)

	All Trucks		Truck/Conveyor	
Item	Qty	Amount	Qty	Amount
170 trucks	24	10 730,8	11	3 436,7
Track dozer	2	783,2	1	391,6
Motor grader	2	715,3	1	265,9
Wheel Dozer	2	624,8	1	312,4
Water wagon	2	894,2	1	379,8
Electrical power (base system)	-		1	2 225,6
Sub Total per year		13 748,3		7 012,0
Sub Total life of mine		302 462,6		154 264,0
Additional electrical power (Years 6,12 & 18)				702,0
Total Operation Costs		302 462,6		154 966,0

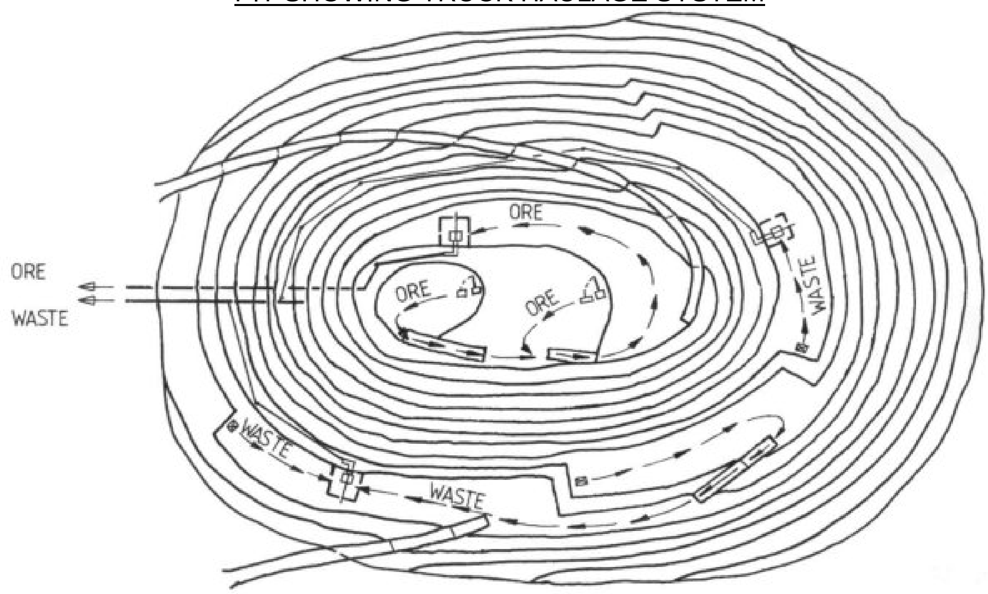
Based on operating 16,3 hours per day for hauling materials and 7,7 hours per day of idle time.

TABLE 1-6
TOTAL COST OVER 22 YEAR MINE LIFE
(0% ANNUAL INFLATION)
($1 000)

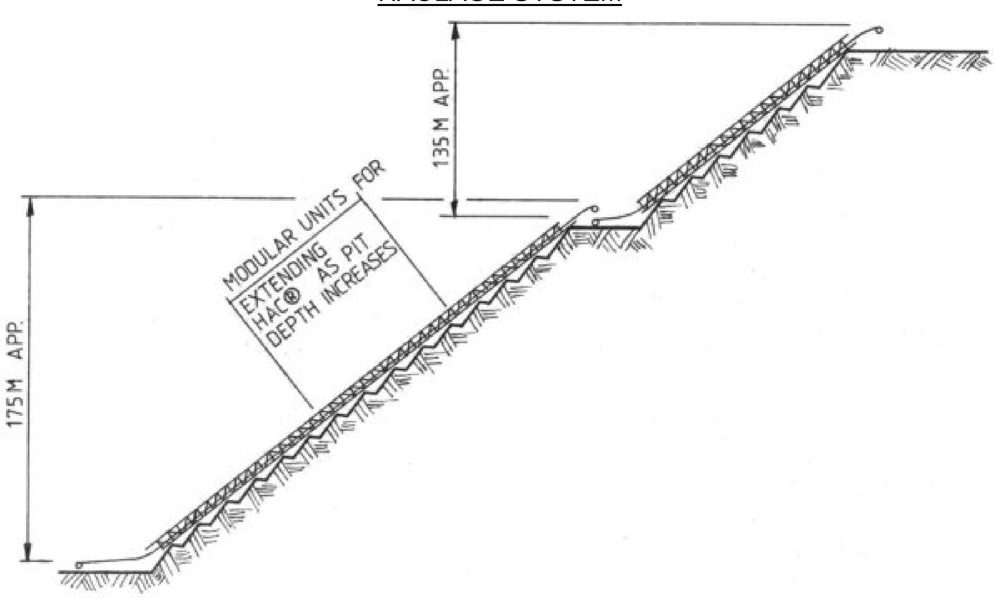
	All Truck	Truck/Conveyor
Capital Costs	93 664,0	99 807,0
Labour Costs	107 407,8	76 446,8
Operationg Costs	302 462,6	154 966,0
	503 534,4	331 219,8
Average cost per ton (375 million tons)	1,3428/ton	0,8833/ton



PIT SHOWING TRUCK HAULAGE SYSTEM



SAME PIT SHOWING IN-PIT CRUSHER - CONVEYOR HAULAGE SYSTEM



TYPICAL ARRANGEMENT OF MODULAR
HIGH ANGLE CONVEYORS
Spencer(Melksham) S.A. (Pty)Ltd.
ADDENDUM
COMPARATIVE COSTS OF CONVENTIONAL
VERSUS
HIGH ANGLE CONVEYING
IN A SOUTH AFRICAN OPEN PIT MINE

Introduction

This is a summary of a study which evaluates the difference in Initial and Maintenance costs (over a 15 year period) of two alternative systems for conveying material out of an open pit mine. It compares only the conveyors needed to lift material from pit bottom to it's lip.

SYSTEM 1

CONVENTIONAL conveyors, each of capacity 5 000 tph, Single flight length, 1 000 metres, lift 80 metres. 3 flights with total length of 3 000 metres for overall lift of 240 metres. Angle of lift 4,3 degrees.

SYSTEM 2

HIGH ANGLE conveyor, capacity 5 000 tph, Single flight length 391 metres, lift 240 metres, Angle of lift 53 degrees.

The conclusion reached is that the High Angle Conveyor is the most economical alternative. The cost per tonne of ore transported is 4 cents versus 6 cents for conventional conveyors. Truck haulage could, by comparison, cost 41 cents per tonne or more.

In this study certain design parameters are based on the requirements of the specific application. For example, the conventional conveyors would be routed along the existing truck haulage road thus obviating the need for extensive new earthworks and difficult access.

To avoid contentious debate on intangible benefits and for the sake of simplification, certain costs have not been included in either case. This approach has been followed when it was felt that the benefit so derived was clearly in favour of the conventional system. These items include:

Site preparation
Earthworks
Civils
Electrical Power and Controls
Lighting
Weather protection

A. CAPITAL COSTS

Capital costs were established by estimating each system in detail to an accuracy of +-10%
These costs are summarised on Table A.

The High Angle Conveyor does not require a seperate drive house as the drives are positioned in the head end structure.

	Capacity TPH	No. of flights	Total Lift	Total kW Inst.	Full Load kW	50% Load kW	No. Load kW	Head sect. Cost	Lin.M. Costs	Tail & TU Sect Cost	Drive Hse Costs	Total Installed Cost
								R000s	R000s	R000s	R000s	R000s
Conventional Conveyors												
3 off each	5000	3	240m	6030	4797	2745	399	4825	5898	578	928	12229
1000m long 80m lift 1800mm wide 3,0m/sec		@ 4,3°										
High Angle												

Conveyor												
1 off	5000	1	240m	4800	4292	2404	520	3549	3833	1134	-	8516
391m long 240m lift 2100mm wide 3,48m/sec		@ 53°										

TABLE A : BASIC PARAMETERS AND CAPITAL COST SUMMARY

B. MAINTENANCE COSTS

To establish a base for maintenance costs, the following must be assumed:

1. A single flight of 1000 metres of a conventional conveyor shall be assessed for maintenance on 1 shift on the 7th day of a 6 day working week. Therefore, the conventional conveyor systems shall have 3 maintenance crews for 1 shift on the 7th day of a 6 day working week.
2. Each belt of the High Angle Conveyor shall be assessed for maintenance for 1 shift on the 7th day of a 6 day working week. Therefore the High Angle Conveyor shall have two maintenance crews for 1 shift on the 7th day of a 6 day working week.
3. Running hours shall be 6 days a week, 24 hours per day, 309 days per year, making 7416 hours per year.
4. Each conveyor belt maintenance shift shall be serviced by one maintenance crew consisting of:

1 fitter	)each R95 per 8 hour shift,
1 boilermaker	)plus 12% escalation per year
1 electrician	)for inflation.
6 labourers	each R26 per 8 hour shift plus 12% escalation per year for inflation.

5. Each artisan and 2 labourers shall have separate transport facilities (bakkie). R10 per hour plus 12% escalation a year for inflation.
6. There shall be a standard charge per maintenance shift for consumables. This charge shall be increased by 20% per year to allow for escalation and increased usage.
7. Idler replacement shall be based on the following unit usage and subject to 12% per year escalation.

1st	10%
2nd year	5%
3rd year	7½%
4th year	7½%
Thereafter	10%

8. The following will be replaced at their time periods and are also subject to 12% per year increase in cost for escalation.

Belt scraper blades	: 1 set per scraper per year.
Skirt Rubber	: Complete replacement

	every 6 months
Chute Liners	: 1 set per chute per year
Wire ropes	: 1 set every 5 years
Sheaves	: Complete bearing replacement every five years
Pulleys or bearings	: We shall allow 5% of the initial cost of these items to be reserved annually at 12% escalation.

9. <u>Belting:</u>

We shall allow for complete renewal in 5 years. Therefore 100/5 reserved annually at 12% escalation for belting.

Table B.1 summarises maintenance costs over a 15 year period. It should be noted that the figures given allow for annual escalation of 12%.
Tables B.2, B.3 and B.4 analyse the maintenance costs in detail. Table B2 covers one conventional conveyor. Tables B3 and B4 cover the HAC bottom and top belts respectively.

<u>INDICATION OF COSTS SUMMARY</u>
<u>MAINTENANCE COSTS OVER 15 YEARS</u>
R x 1000

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th year
Conventional Conveyors 3 off	878	941	1079	1210	1386	1243	1393	1563	1753	1966	1810	2031	2280	2560	2875
High Angle Conveyor 1 off	403	424	500	561	648	616	691	776	870	977	962	1080	1213	1363	1531

<u>TABLE B.1 : MAINTENANCE COSTS SUMMARY</u>
<u>MAINTENANCE COSTS PER SYSTEM</u>

Type: Conventional Overland	TPH: 5 000	No. of Belts: 1	Width of Belt: 1800	Pulley Centres: 1000 m

	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	
int- ce v er															

er- er tri- ers															
1 441	22491	25178	28200	31584	35374	39619	44373	49698	55662	62341	69822	78201	87585	98095	1
ort: h es 240	12240	13708	15353	17196	19259	21571	24159	27058	30305	33942	38015	42577	47686	53409	5
m- R60 :	2880	3456	4147	4976	5971	7166	8599	10319	12383	14860	17832	21398	25678	30814	3
- e- : nly, l : 77	25547	14306	24035	26919	40199	45023	50426	56477	63255	70845	79347	88868	99533	111477	1
er es l : x 2 00	1900	2128	2383	2669	2989	3347	2749	4199	4703	5267	5899	6607	7400	8288	
t er: l s x 2 0	830	929	1041	1166	1306	1462	1638	1834	2055	2301	2577	2887	3233	3621	
e s: l s 0	8000	8960	10035	11239	12588	14098	15790	17685	19807	22184	24846	27823	31167	34907	3
e s: l t 0	200	224	250	280	314	352	394	442	495	554	621	695	779	872	
es: l t x8 00	1200	1344	1505	1685	1888	2144	2368	2652	2971	3327	3727	4174	4675	5236	
&															

gs: l t	6458	7232	8100	9073	10161	11381	12746	14276	15989	17908	20057	22464	25160	28179	3
g: 348 yr 255 yr 386 yr	210969	236285	264640	296397	331964	268051	300217	336243	376592	421783	340577	381446	427220	478486	5
l ear	292715	313750	359689	403184	462013	414214	464459	520883	584217	655312	603320	677145	760116	853384	9

TABLE B.2
MAINTENANCE COSTS PER SYSTEM

Type: Bottom Belt Hac TPH: 5 000 No. of Belts: 1 of 2 Pulley Centres: 391 m 240 m Lift

	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	
int- ce v er er- er c- n ur-															
1 : 1	22491	25178	23200	31584	35374	39619	44373	49698	55662	62341	69822	78201	87585	98095	1
ort: h es 240	12240	13708	15353	17196	19259	21571	24159	27058	30305	33942	38015	42577	47686	53409	5
m- R60 :	2880	3456	4147	4976	5971	7166	8599	10319	12383	14860	17832	21398	25678	30814	3
- e- :: s , l : 04	18530	10377	17433	19525	29157	32656	35575	40964	45880	51386	57552	64458	72193	80857	9
er es l 950 00	1900	2128	2383	2669	2989	3347	2749	4199	4703	5267	5899	6607	7400	8288	

t er: .l s 5 = 0	830	929	1041	1166	1306	1462	1638	1834	2055	2301	2577	2887	3233	3621	
e s: .l s 0	8000	8961	10035	11239	12588	14098	15790	17685	19807	22184	24846	27828	31167	34907	3
e s: .l t 0	200	224	250	280	314	352	394	442	495	554	621	695	779	872	
es: .l t x8 00	1200	1344	1505	1685	1888	2144	2368	2652	2971	3327	3727	4174	4675	5236	
r & gs: .l t	38390	42996	48156	53935	60407	67656	75775	84868	95052	106458	119233	133541	149566	167514	1
g: 96 yr 37 yr 23 yr	119779	134152	150251	168281	188474	152187	170450	190904	213812	239470	193364	216568	242556	271663	3
l ear	226440	243453	278754	312536	357727	342258	383870	430623	483125	542390	533488	598934	672518	755276	8

TABLE B.3

MAINTENANCE COSTS PER SYSTEM

Type: Top Belt Hac TPH: 5 000 No. of Belts: 2 of 2 Width of Belt: 2200 Pulley Centres: 391 m

240 m Lift

	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	
int- ce v er er- er c- n ur-															

1 t 1	22491	25178	28200	31584	35374	39619	44373	49698	55662	62341	69822	78201	87585	98095	1
ort: h es 240	12240	13708	15353	17196	19259	21571	24159	27058	30305	33942	38015	42577	47686	53409	5
m- R60 t	2880	3456	4147	4976	5971	7166	8599	10319	12383	14860	17832	21398	25678	30814	3
- e- t: s , l t 93	30129	16872	28345	31747	47409	53098	59469	66606	74593	83550	93577	104806	117383	131468	1
er es l t 0 00	1900	2128	2383	2669	2989	3347	2749	4199	4703	5267	5899	6607	7400	8288	
t er: l s 5 = 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
e s: l s 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
e s: l t 0	200	224	250	280	314	352	394	442	495	554	621	695	779	872	
es: l t x8 00	1200	1344	1505	1685	1888	2144	2368	2652	2971	3327	3727	4174	4675	5236	
& gs: l t	14336	16056	17983	20141	22557	25264	28296	31692	35495	39754	44525	49868	55852	62555	7

g: 92 yr 40 yr 92 yr	90758	101648	122995	137754	154285	121488	136066	152394	170681	191163	154358	172881	193627	153695	2
l ear	176134	180614	221161	248032	290046	274049	307473	345050	387288	434758	428376	481207	540665	607599	6

TABLE B.4

C. OPERATING COSTS PER TONNE

	Conventional Conveyors	High Angle Conveyor
1. Actual operating hours: 6 days at 24 hours per day, 309 days a year =	7 416 hrs per year	7 416 hrs per year
2. Conveyors 1st year maintenance costs = Per hour =	R878 145 R118,41	R402 574 R54,28
3. Full load power consumption @ R0,037 per kW/hr	4 797 kW R177,49	4 292 kW R158,80
4. Total operating and running costs for 1 hour = Cost per tonne @ 5000 tph =	R295,90 R0,06	R213,08 R0,04

D. OFF HIGHWAY HAULAGE VEHICLES

For order of magnitude comparison purposes, a brief look at haulage truck alternative is given. Assume plus/minus 160 tonne capacity Diesel Electric Drive Trucks are used and that these are fitted with trolley assists to utilise external electric power for haulage on the incline section of the loaded trip.

The electrical rating of each truck is plus/minus 1193 kW and when using electrical assist the diesel consumption of the idling diesel engine at 21 km/hour on a 8% grade is 8 litres.

There are many costs in truck haulage that must be considered and to be accurate a proper analysis is necessary. Discussion with users has indicated that normal daily maintenance and running costs are in the area of R0,41 to R0,46 per tonne hauled on the incline section of their route. It should be stressed however that no claim is made that these figures are any more than indicative.
To road haul 5000 tph of ore in the case examined, an actual operating fleet of 15 trucks is required. This does not include any standby vehicles.
The purchase price for each 160 tonne capacity truck is R2 million each.
The comparison of capital and maintenance costs with conveyors. leads one to suspect that conveying up the inclined section of an open pit mine warrants careful consideration.