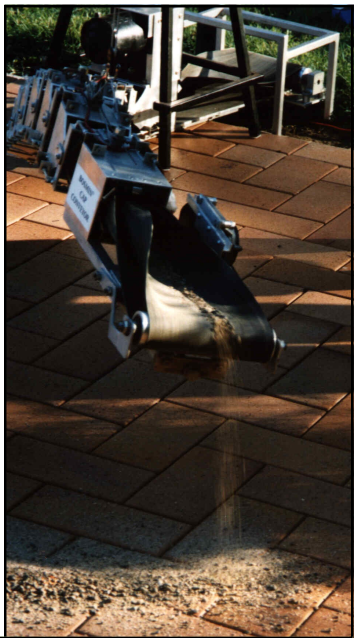
BOSMIN®
COAXIAL PIPE CONVEYORS

THE FUTURE IN FLEXIBLE CONVEYORS

This document explains the operating principles behind the proposed BOSMIN® CoAxial Pipe method of hauling and how the CAP translates into a more flexible transport system.

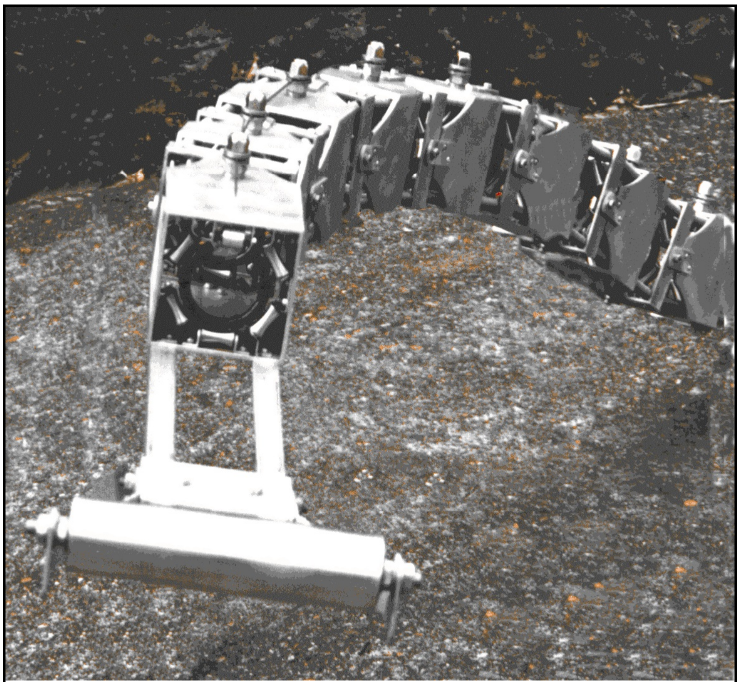


Scale model of a CoAxial Pipe transporter showing dynamic stacking.

CAP - What is it?

The **BOSMIN®** CoAxial Pipe (**CAP**) system for bulk material transporting is most suited to removing sized material from a loading unit, and can lower the operating costs relative to truck or common conveyor haulage.

It involves progressively wrapping a flat belt into a pipe formation to enable material to be delivered along a curved pathway. The return belt is also wrapped into a pipe shape, but is positioned outside the delivery pipe. The two belts are separated by an internal idler set with a belt running on either side of the idler. Both belts open flat at the delivery and loading points, like a conventional conveyor. This design allows the **CAP** to move through two dimensions - while it is operating. Wheel mounting the unit enables it to move in three dimensions.

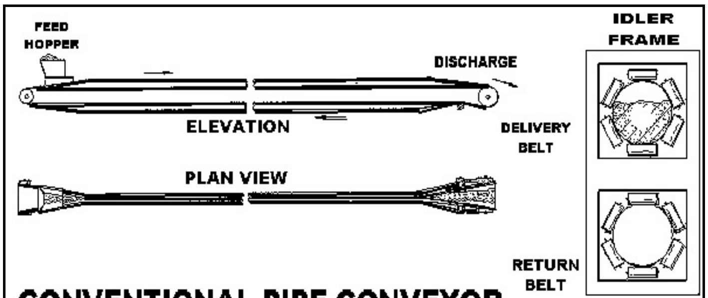

CAP STRUCTURE WITHOUT THE BELT

The process has emerged from desk studies as the most cost-effective way of hauling material from an open cut, but the **BOSMIN® CAP** also has good potential to reduce cost at underground mines and has further industrial applications.

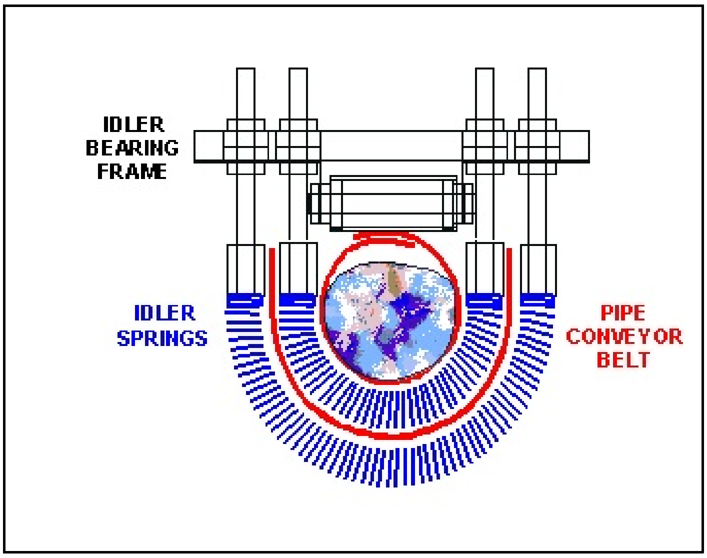
How does the CAP differ from other PIPE CONVEYORS?

Pipe Conveyors (PC) differ from the BOSMIN® CAP in several ways;

- The PC idler frame is a rectangular shape and mounts twelve idlers in each conveyor frame. The **CAP** idler frame is square and mounts one external idlers and one internal idler spring. The **CAP** frame is therefore lighter and more compact.
- The **CAP** idler frame supports the empty belt against the loaded belt. This prevents the empty belt collapsing and allows the conveyor to negotiate a much tighter curve. Recommended curves for PC steel cord and fabric belts are 1000:1 and 300:1 (curve radius:pipe diameter) while **CAP** belts are expected to negotiate curves down to 25:1.
- **CAP** idlers have a helical spring profile while the PC idlers are cylindrical. The spring surface provides greater contact area with the pipe and allows for a less rigid belt. This assists with tight conveyor cornering.



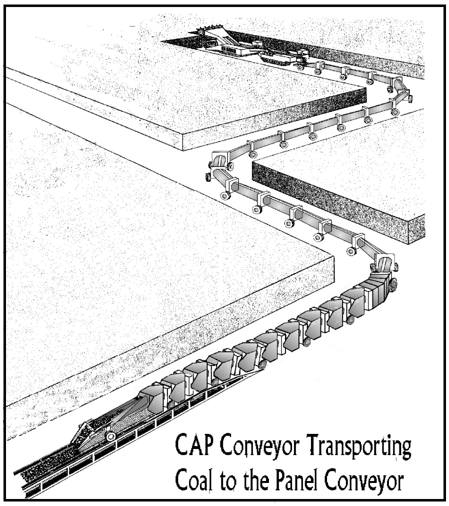
CONVENTIONAL PIPE CONVEYOR



- The delivery side of the **CAP** is in contact with the return side, through the action of the internal idler set. It provides drive in both belt directions along every idler frame set. This differs from the PC which must supply belt tension around the whole conveyor, before inertial forces can be overcome.
- The PC conveyor calls for a specially designed belt, while the **CAP** is suited to a lighter belt specification, with the main criteria being sufficient belt elasticity to negotiate the curves.
- The softer **CAP** belt does not tend to spring open like the PC belt and does not require special sets of transition idlers. Only regular impact idlers are placed at the loading point.
- PC belts experience very high breaking-in resistance with empty belts initially 1.5 times the calculated full load running resistance. **CAP** belts do not resist pipe formation to this extent and consequently do not suffer from the problem of high breaking-in resistance.
- The PC belt has a transition distance (length:diameter) of between 25:1 and 50:1 for nylon fabric and steel cable belts, respectively. The **CAP** belt transition distance is only 8:1, providing more compact loading and unloading spaces.
- The softer **CAP** belt uses more frequent idler spacing than PC belts. The former supports the belt at 3:1 (idler distance:pipe diameter) while fabric and steel cord PC ratios vary from 4.1:1 to 10:1. However, the **CAP** idler frame is half the size of the PC frame, and has fewer bearings.

The BOSMIN® CAP is all about transport flexibility and productivity.

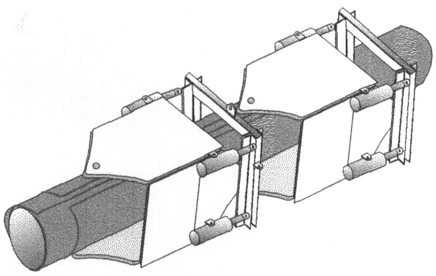
- For many open cut strip operations, a **BOSMIN® CAP** will significantly increase the output of the existing loading equipment by improving the utilisation of the available loaders.
- Using a CoAxial Pipe Conveyor reduces, or eliminates, trucks and can reduce the equipment spreads by mining both waste and ore with only one set of equipment.
- **CAP** hauling conserves natural resources where steep dipping deposits result in lower mining recovery rates.
- **CAP** hauling is also appropriate where limited space is available such as in narrow underground excavations, or along curved roadways.



CAP Conveyor Transporting Coal to the Panel Conveyor

Why is a COAXIAL PIPE CONVEYOR special?

The **BOSMIN® CAP** is an improvement over previous pipe conveyor designs because the return belt is supported internally by the delivery belt. The idler frame is square in shape and forms the spider in a universal joint between adjacent conveyor structures. This arrangement allows the **CAP** to bend in two dimensions, and through tighter curves than other pipe conveyor designs.



Pipe Conveyor Gantries showing Universal Joints

- This principle is put to good effect when conveying material from an open cut, as once the material is sized, it can be removed without using any truck haulage.
- The loading unit can be close coupled to a suitable crusher ensuring the loading unit is highly utilised by not having to wait for trucks to spot.
- This arrangement ensures that all the material leaving the open cut is sized to feed directly into the processing plant. Any secondary blasting is carried out in the open cut, and not at the ROM hopper.

The pipe conveyor design holds the load in a 'sausage' which allows the **CAP** to negotiate steep slopes (tested at +60°), and prevents wind blown dust emanating from the conveyor.

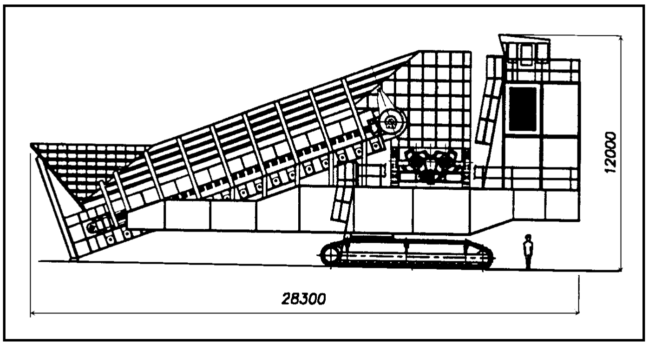
How is the CAP conveyor loaded ?

Ground preparation

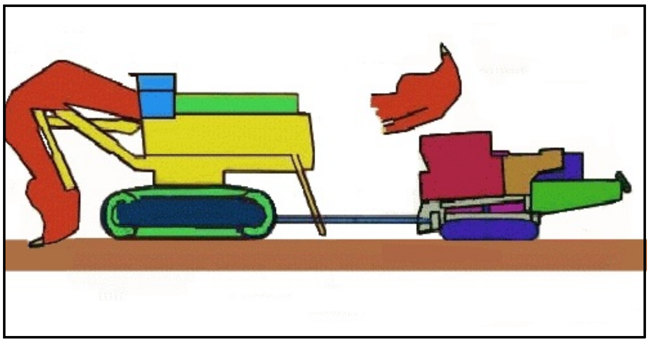
The **CAP** can convey material with maximum particle size up to 33% of the diameter of the pipe when the load cross sectional area does not exceed 75% of the pipe area. Lump sizes up to 66% of the pipe diameter are possible for belts loaded to around half the pipe area. These limitations require that over sized material be either screened or crushed before loading onto the **CAP**. A continuous mining machine may produce suitably sized material.

Loading Units

A **CAP** conveyor may be loaded with sized material, using a feeder to provide constant even flow. With lump materials, this can be achieved by either scalping off the oversize, or crushing it down to undersize dimensions.



Feeder-Crusher after MMD



Shoveller

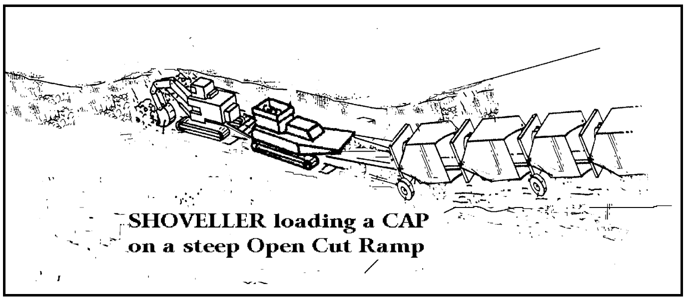
In mining applications, run of mine rock is fed onto an apron feeder using a front end loader, a shovel, or an excavator. The apron feeder conveys material to a scalping screen and the oversize passes into a mobile crusher. Both the scalping screen undersize and the crusher product, feed onto the **CAP**.

The apron feeder and crushing unit can be close coupled to a loading shovel to form a ***shoveller*** unit. This arrangement permits the loading unit to operate continuously while the mobile crusher feeds the **CAP**.

How is the CAP supported ?

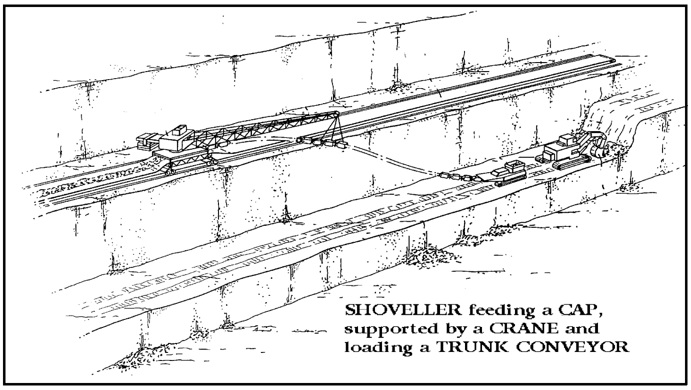
CAP stability considerations

The **CAP** can run on wheels located at the idler frames. This position ensures the wheels track along the circumference of a turning circle providing a good trailing profile. This arrangement is suited to underground applications, or surface mines where the conveyor travels directly up the dip slope.

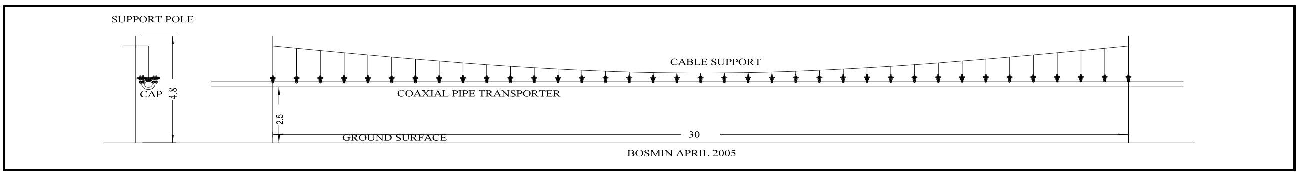


SHOVELLER loading a CAP on a steep Open Cut Ramp

Alternately, the **CAP** may be suspended at the midpoint, from a crane hook. The crane does not need to relocate for small movements of the loading unit, but needs to tram when the angle of suspension exceeds safe limits. Crane tramming can be controlled automatically, or manually from the loading unit. This method of support is suitable when the **CAP** traverses several benches, or when the loader trams laterally while the face advances, and requires a sideways movement of the **CAP**.

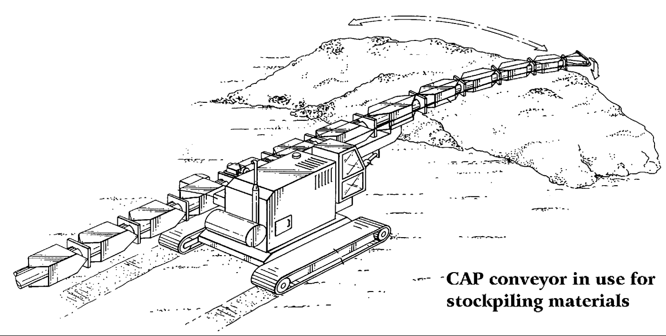


SHOVELLER feeding a CAP, supported by a CRANE and loading a TRUNK CONVEYOR



A **CAP** may be supported from a wire rope. This has application for cross country travel or underground transport along a tunnel opening.

Unloading the CAP.
The **CAP** is suited to substantial automation, and may not require an operator, as the load can simply feed onto a trunk conveyor at a transfer station. However, if the **CAP** is used to load trucks at the top of a slope and feed onto a stockpile between trucks, an operator is required. This operation of the **CAP** provides an alternative to having a truck loading bin, or pausing the conveyor system between trucks.



CAP conveyor in use for stockpiling materials

What are the CAP broad design criteria ?

Idler Size and Belt Speed

A **CAP** idler is designed to limit the speed of bearing rotation to less than 1,000 rpm. However, where tight horizontal curves are required, the belt speed may be limited by the centrifugal forces developed by the load as it negotiates horizontal curves. If centrifugal forces are too high, the **CAP** can rotate excessively in the idler frames, and the belt speed should be reduced accordingly.

The idler speed of rotation is adjusted by forming the helical spring into a spring diameter matching the required belt speed. The spring pitch is adjusted to ensure it meets the British Standard for an infinite spring life.

Indicated belt speed is calculated from:

Belt speed (mps) = 1.56 + 0.01 x **CAP** internal pipe diameter (mm)

Belt Capacities - Small Lumps (m³ per hour).

CAP Diameters		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
Maximum Lump Size		17	33	50	66	83	99	116	132	149	165	182	198	215	231	248	264
Maximum Belt Speeds (mps)	Maximum Idler Diameter (mm)																
2.05	40	11	43	98	174	272	391	533	696	881	1087	1316	1566	1837	2131	2446	2783
2.54	49	13	54	121	216	337	485	661	863	1092	1348	1631	1941	2278	2642	3033	3451
3.03	57	16	64	145	257	402	579	788	1030	1303	1609	1947	2317	2719	3153	3620	4118
3.53	65	19	75	168	299	467	673	916	1196	1514	1870	2262	2692	3159	3664	4206	4786
4.02*	74	21	85	192	341	533	767	1044	1363	1726	2130	2578	3068	3600	4175	4793	5453
4.51	82	24	96	215	383	598	861	1172	1530	1937	2391	2893	3443	4041	4686	5380	6121
5.00	90	27	106	239	424	663	955	1299	1697	2148	2652	3209	3819	4482	5198	5967	6789
Large Lump Belt Capacity																	
Maximum Lump Size		33	66	99	132	165	198	231	264	297	330	363	396	429	462	495	528

Maximum Belt Capacity (m³ per hour). is 88% of Small Lump Size Tabulations

Internal Idlers

The first model **CAP** internal idler set consisted of cylindrical polymer rollers mounted on a stiff but flexible axle, (see cover picture.) More recent developments show that a helical spring design is low friction, and very effective in supporting both the inside and outside belts while providing a ready means to add intermediate drive power along the length of the CAP as seen in the second model CAP.


Model 2

Belt Thickness and Width

The belt thickness increases with **CAP** size, and is 3.3% of the pipe diameter. The belt needs to be sufficiently wide to provide sufficient overlap for the internal pipe.

This is given by: Belt Width = 1.13 × π × **CAP** internal pipe diameter (mm) and 10% wider if the CAP slope angle exceeds 30°

External Idlers

The external idlers are helical springs of similar specification to the internal idler, but suitably longer.

CAP alignment

For a dynamically moving **CAP**, idler frames are connected to the **CAP** intermediate structures, as shown on page 3. These are box sections and join the idler frames, at two opposing fulcrum points, to from a universal joint. The universal joints may be given "stiffness" by including self centring actuators across the hinge joints. This design has the effect of evenly spreading any curve the **CAP** negotiates over a range of idler frames.

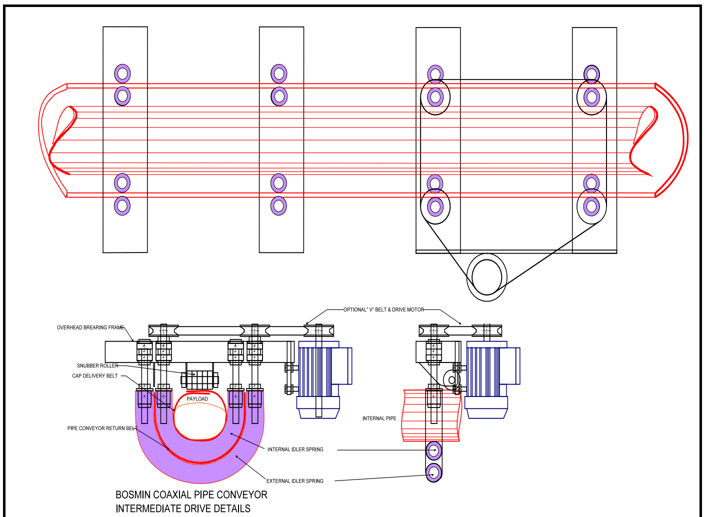
Drive Power Requirements

The **CAP** installed drive power requirements can be approximated from:

kW = 205 × Ln(**L**) - 1078 + (**tgh** ÷ 3600)

Where **L** is for conveyor lengths greater than 250m, **t** is tonnes-per-hour conveyed, **g** is 9.81, and **h** is the transfer height difference. Power for CAPs less than 250m are based on specific bearing friction characteristics.

The drive power may be applied to the belt through driven head and tail pulleys, using pinch rollers as required. Preferably, the power is supplied by driving the idler spigot shafts as illustrated. This arrangement provides for an intermediate drive system and allows for th CAP to be extended over an indefinite length.



CAP IDLER FRAME

What are the Costs ?

The **CAP** system may not require any operating labour, depending on the method of suspension and unloading process. A loader driver can also control the **CAP** operation. This results in very favourable running costs compared to truck haulage. Maintenance costs are confined to periodic belt and idler replacements together with bearing maintenance at the various joining points. The frequency of these services depends on the application, but is expected to be low. Energy costs depend on the transport elevating requirements together with friction losses. The balanced haulage inherent in a belt conveyor provides a substantial energy saving when compared to the trucking alternative.

How does a CAP affect ore reserves?

By reducing the cost of transporting mined materials, it is possible to move the economic limits for mining further down dip or into more marginal areas of reserve, thereby increase mineable reserves. The **CAP** will transport material up steep slopes, making it an ideal tool for mining steep dips, or conveying out of open cut or underground excavations.

BOSMIN® CAP - How does it work?

Equipment maintenance

The shoveller, **CAP**, and trunk conveyor must operate concurrently. The mechanical availability (MA) for the system is therefore the product of each unit's availability. However, all the units are expected to have high MA, when correctly matched to the prevailing mining conditions. In hard rock applications, a standby crusher unit may be justified so that wearing crusher parts are replaced offline. Under these circumstances, a system MA above 90% is anticipated.

Belt Cleaning

The **CAP** runs with the clean side always against the internal idlers. To prevent excessive wearing to these idlers the underside of the belt must be protected at the loading and unloading points. This is achieved by enclosing the gap between the two belts, providing a belt plough, or a blower system to ensure there is positive air flow out of this space. The outer belt surface is cleaned at the discharge point with a conventional belt scraper and by action with the helical spring idlers. These idlers may be powered thereby providing a "live" cleaning action to the belt.

Belt Changes

When a steeply sloping belt is changed or the structure maintained, the belt should be run in reverse or cleaned by passing a "pig" through the pipe to remove the "fixed charge" of material present in the pipe. This is only present in conveyors sloping greater than 35°.

Pit Access

While the **CAP** eliminates truck haul ramps from an open cut, there is still a need to provide pit service access via a less expensive roadway. In an underground situation eliminating trucks can impact ventilation and road size.

What are the key CAP environmental factors?

The **BOSMIN® CAP** system of hauling offers benefits ahead of traditional open cut mining methods. The key factors include:

- *Less power and diesel fuel used in mining.*
  The **CAP** uses much less energy than truck hauling methods. There is an operating cost benefit, and there is a significant environmental benefit in that using fewer kilowatts, results in smaller generating impacts. Much of the diesel truck fuel used for open cut mining can be replaced with locally generated electric power.
- *Low noise emissions.*
  The **CAP** is a significantly less noisy operation than the haul truck alternative. The operating machinery is electrically powered, and only emits a low hum while operating. Large overburden trucks can be a source of noise impact which is avoidable where truck and shovel mining is replaced by the **BOSMIN® CAP** and Shoveller system.
- *Low dust emissions.*
  BOSMIN® CAP greatly reduces dust release when compared to haul trucks and some open conveyors. The load travels in an enclosed 'pipe' isolating the opportunity for dust generation to the loading and delivery points. This reduces the cost associated with haul road dust suppression.

Is the BOSMIN CAP a wise use of human resources?

Introducing new mining equipment can result in severe HR problems due to the need for very specialised skills or for people prepared to work in unfamiliar surroundings. The **CAP** requires few or no operators and a limited number of customary conveyor maintenance personnel. This minimises potential HR difficulties.

Who is responsible for developing new mining machines?

Long term equipment owners (industrialists, contractors or mine operators) benefit most by initiating development of new equipment designs. They own the machine for the longest time and have the best opportunity to depreciate the development cost over an acceptable period. Equipment owners also benefit most by the introduction of more efficient machines through reduced owning and operating costs. Original Equipment Manufacturers (OEMs) can help build reliable machines that meet an operator's specific materials handling needs.

Where to from here ?

1. A desk study quantifies the site specific benefits of using a **BOSMIN® CAP** haulage system. Significant benefits must be defined before making the effort required to build new mining equipment. **BOSMIN®** engineers can assist with evaluating pit layouts and help in quantifying the benefits.
2. Determine the strategic advantages of developing a cheaper transporting method.
3. Design and build a prototype unit and conduct field trials to evaluate productivity sensitive factors.
4. Select equipment suppliers for CoAxial Pipe components.
5. Assemble and install CAP components.

Adding it all together.

The **BOSMIN® CAP** is a new energy efficient equipment design to ensure mining stays competitive. The loader is highly utilised, and the transport system is counter balanced, providing energy efficient elevation of the mined materials. Trucks and haul ramps are eliminated or reduced from metalliferous mines, and tramming cars from underground mines. In deep mines the bottom line is machine efficiency and the **CAP** offers another tool in achieving that aim as well as delivering significant environmental plusses.

References

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