Peter McCarthy, Chairman of AMC Consultants stresses the importance of equipment choice to mine planning. “While underground equipment should be selected to suit the mine, it is equally true that the mine should be designed to suit the equipment. It is impossible to begin mine planning and scheduling without a good idea of the type and size of equipment [to be used].” Design of the stopes and underground infrastructure (including ventilation passages) “must be based on an assumed type and fleet of equipment.”

“Stoping equipment should be appropriately sized for the characteristics of the orebody and the stope dimensions. Development openings should be sized to suit the stope dimensions and the stoping equipment capabilities and requirements. Development equipment should then be sized to mine the required size of stope development. Separate development fleets for access and stope development may be required.” Large development equipment that is inappropriate in the stopes can cause “inefficiencies in stope design, poor geotechnical conditions or excessive overbreak and dilution.”

Equipment access dimensions must be identified and managed. “In a shaft mine, for example, the machine size may be limited by the dimensions of shaft compartments and the component sizes in which the machine can be broken down for transport.”

New machines can “allow a new way of working. For example, replacement of rear-wheel drive trucks with four-wheel drive trucks would allow ramps to be steepened. This could reduce overall costs, and it is this larger context which must be analysed. Machines should be compared in terms of capital cost, operating cost, specifications, performance, availability, service and parts backup and service life.”

“Jumbo drills must be capable of reaching the limits of the largest excavation required, usually determined for the production drills and the trucks. LHDs must be able to reach and fully load the trucks in three to five passes. Sometimes a workaround will enable incompatible units to be used. For example, a ‘step’ in the floor may enable small LHDs to load large trucks.”

When equipment is obtained from a single manufacturer then those engineers should be able to say how well-matched the machines are. “If they come from different manufacturers then some research may be needed, including detailed study of the specifications and calls to other mines using the units together.”

“The manufacturers range from large, international firms with worldwide representation to small manufacturers, generally serving a local market or a specialised niche. In general, the international firms offer robust, reliable and well-proven equipment at the upper end of the price range. Equipment is usually priced in Euros or US dollars, which may appear prohibitive when converted to a local currency.”

“Small, regional manufacturers can offer attractive pricing and may offer a viable alternative to the ‘name’ brands. Because their level of research and development is limited and because they are building to a price, machines from such manufacturers generally have lower availability and may have reduced performance. These factors should be assessed carefully in deciding whether the lower capital cost outweighs the higher operating costs, including the impact of servicing and breakdown delays on the mining system as a whole.”

“Other manufacturers offer specialist equipment that is not available from the major suppliers.” Products from international niche manufacturers include narrow-vein mining machines from Aramine in France or Dux and Maclean in Canada, rockbolters from those same Canadians, backfill slinger trucks from Paus in Germany and so on.

“The most important factor in choosing between otherwise similar machines is the level of backup support provided in your region by the manufacturer. Appropriate questions include:

■ What training will the manufacturer offer to your operators and maintenance personnel?
Does the manufacturer have service facilities with trained personnel within an hour or two by road of your mine? If not, is it willing to establish such facilities on the basis of your order?

Will the manufacturer stock a comprehensive range of spare parts in-country for the specific model that you are buying? What is the likely delivery time?

Will the manufacturer provide spare parts in your mine store on a consignment basis, so that you pay only when they are used?

Which major components are not stocked in-country? How long would it take to obtain them if needed and what would be the cost of urgent air freight?

Will the manufacturer offer maintenance and consumables on a fixed cost per hour or per metre basis, establishing its own maintenance workforce on site?

What is the reputation of the manufacturer for service and spares backup in your region?

“Once these questions have been addressed, it may be advantageous to source the key fleet items, such as trucks, LHDs and jumbo drills, from a common supplier. It is also attractive to minimise the number of different models of equipment on the mine site, even if from the same manufacturer, to minimise duplication of stores inventories.”

In conclusion, McCarthy turns his attention to appropriate technology. “Any new machine should incorporate a level of technology that can be understood and supported by the operators and maintenance team. While it may be appealing to engineers to acquire the latest technology, the potential performance will not be delivered if the machine spends much of its time waiting for repairs. At the crudest level, there are mines which operate compressed-air rockdrills and do not have the workshop facilities or the skills to maintain hydraulic rockdrills. Similarly many mines do not have the electronics capability to maintain the latest fully computerised jumbo drills and prefer to buy the versions with manual controls.

“In general, the longer the supply lines to the mine and the less educated the workforce, the more robust and less innovative should be the technology. It is also difficult to mix different technologies within the one operation.

“Innovative new machines, even from the most reputable manufacturers, may present operational problems. It often takes two or three years of operation to resolve design problems in trucks, loaders and jumbo drills, with trucks giving the greatest problems. Usually the machine gets a bad name in the industry and a revised model with a new code name is released once the problems are resolved. The problems are not predictable and could be as simple as shearing of wheel studs on a high-powered truck.

“The promised performance of a new model may be appealing, and some mine has to be the first to try it. If you are considering such a machine it is usually possible to negotiate a performance guarantee with the supplier. This should take the form of an operating availability guarantee, possibly with a minimum performance expressed as t-km/h, m³/h drilled or similar. Financial compensation applies if the machine does not deliver the guaranteed performance. It is usual for the manufacturer and supply agent to be very interested in the success of a new product and they may provide high standards of operator training and assume responsibility for maintenance for an extended period.”

**Loading technology**

The latest addition to Atlas Copco’s range of Scooptram underground loaders – the ST7 – has been given top marks undergoing field tests at the Lovisa lead and zinc mine in central Sweden for almost a year – and Atlas Copco reports, “has passed all of its trials by a wide margin, confirming major advances in performance, productivity, serviceability and comfort.”

Mine Manager Jan-Erik Björklund reports that the Scooptram ST7 has resulted in a dramatic productivity increase in loading operations as well as improvements in the working environment. “The ST7 is just great,” he says. “It’s been going for more than 2,000 hours and we have seen a productivity increase of almost 100%, going from two loads per shift to nearly four. In addition, we previously had four loaders in operation and now we only need one – the Scooptram ST7. Only a few modifications have been required during the test period and our operators are very happy with it. They think it is more comfortable to drive and easy to service – so we think it’s a good investment for us.”

The Scooptram ST7 has a tampering capacity of 6.8 t, articulated steering and an oscillating rear axle. It is powered by a clean burning, Cummins Tier 3 engine and benefits from traction control to increase loading performance and improve tyre life. A load-sensing hydraulic system increases traction and improves fuel economy.

Key safety features include spring-applied, hydraulically released (SAHR) brakes, automatic brake testing with diagnostics and logging and an oil-free cabin environment. Safety is further enhanced by three emergency machine stop buttons and a system that applies the brakes, blocks steering, and prevents bucket movement when the cabin door is open.

The ISO and ROPS/FOPS approved cabin features the Atlas Copco foot box that provides increased leg room, ergonomic control placements, a simple and intuitive control panel display and air-suspended seat. The cabin is placed on rubber mounts, reducing vibrations while a ‘soft-stop’ feature reduces vibrations from the steering and boom components.

For serviceability, there is easy access to service points, filters and valve blocks and the Atlas Copco Rig Control System displays service information via the in-cabin monitor, relaying information from the air, hydraulic and transmission filter sensors. Added to this, there is a patented automatic lubrication system.

**Sandvik LT514E**
complete with integral fault detection.

A low-profile version – the Scooptram ST7LP – is also available. This unit, which has a canopy height of just 1,390 mm, has the same engine specifications and hauling capacity.

The latest Sandvik addition to its fresh, upgraded LHD portfolio is an electric-powered 14-t tramming capacity electric unit that blends higher productivity, lower operating costs at reduced environmental impact with all the strengths of diesel machines. It exhibits very low emissions (IM, July 2009, pp6-12).

Like all Sandvik loaders, the LTS14E incorporates key features of the recently launched diesel LHDs, such as upgraded cab design and Vehicle Control and Management System (VCM). The electronic control system incorporates a state of the art user interface with enhanced diagnostics and a platform for Sandvik’s Automine technology, plus an upgraded electric system that are designed to interface optimally with the electronic control system.

The specialty upgraded electric and hydraulic systems and improved tramming capacity deliver greater productivity, reliability and performance. Offering extended operating range with up to 400 m of cable, they are ideal for use in all applications where the hauling distance is short and operations are repetitive.

Easy to service and maintain, eLHDs also offer reduced downtime by improved diagnostics and trouble-shooting with the VCM system. Additionally, new manuals and up-to-date training materials make them perfectly suited for all global users with reasonable operational and management practices as required for electric fleet.

The electric motor’s peak torque results in faster bucket filling and better acceleration. The machine features buckets ranging from 4.6 m³ to 7.0 m³, three-phase, squirrel-cage 45 kW pump and 132 kW drive motors with Dana 5000 series gearbox and Posi Stop axels. Sandvik eLHDs have an attractive list of features, including better visibility with horizontal cable reel, better fire safety as there is no need for flammable diesel fuel, no hot engine parts and no exhaust fumes.

“Building on our innovative solutions Sandvik eLHDs further increase the ability of underground mines ranging from mass mining to more conventional mining methods to develop a safer and more productive workplace not forgetting the opportunity to reduce environmental impact. Over 400 electric machines delivered are succesful proof of the concept, ” said Olli Koivisto, Product Line Manager of Sandvik Underground Mining.

The use of Sandvik eLHDs can reduce compound cost – lower operating cost, lower ventilation cost, lower service costs, lower emission levels and improve performance where a balance of flexibility, productivity and safety is required.

Schopf’s new SFL60FLP flameproof LHD was noted last month in the article on the Bauma exhibition. The company says it is setting “new LHD
standards in South Africa’s underground coal mines. Its 1.38 m height – lower than any competitor’s – takes future decreasing seam thicknesses into consideration, while at the same time offering such superior operational features as a 6 t payload and a 3.2 m³ ejector bucket. “Design features include centre oscillation, Z-linkage and individual cooling circuits for hydraulics, brakes, transmission and engine. Its 21 t operating weight is perfectly matched by the six-cylinder, 127 kW John Deere engine. Boasting an oversized drive train, the loader offers the highest tractive effort in the field making it the ideal tool for heavy haulage and transport tasks, quick cycle times in coal and – especially – waste rock loading and hauling in main and chain road development, the company says.

Armatures and controls are stripped down to an absolute minimum; simple hydraulic systems and electrical circuits with easily accessible, off-the-shelf components reduce the complexity of the unit from a maintenance standpoint. Safety and ergonomics are evident in ample space, automotive-style operator seating, a certified FOPS/ROPS roof, standard failsafe Posistop brakes and all SABS flameproof standards approvals.

Paus says its PFL 8, 12, 18 and 30 LHDs are some of its most popular products and have been successfully operating in mines around the world for many years now. Paus LHDs are offered with payloads from 1.5 to 5.5 t. The company places great emphasis on “excellent operating comfort.”

The cab is equipped with two joysticks: one multifunction joystick for driving direction and gear shifting and another for the boom hydraulics. While the PFL 8 is driven hydrostatically, the PFL 12 – like the PFL 18 and 30 – can also be equipped with a hydrodynamic drive. Depending on the requirements, customers may choose between air-cooled and water-cooled engines complying with Tier 3 exhaust gas emission standards. Safety is of course paramount and all models are fitted with underbody and ram protection. The easily accessible fire extinguishing system can be actuated from several points. Of course, the operator’s position complies with ROPS/FOPS requirements. During downhill trarming in loaded condition, the posi-stop brake ensures safe manoeuvring of the loader.

PFL LHDs offer ease of maintenance; engine components like filters or oil dipstick are easily accessible. The central lubrication system also covers lubrication points that are difficult to access; also, the battery box is retractable. The clearly arranged hydraulic valves and piping can be reached easily, too. A small but important consideration is that screws are countersunk, to ensure that screw heads will not be damaged in tough underground operation. Furthermore, two strong bearings, easy to lubricate and of very sturdy design, form the articulation joint. If necessary, these bearings can be replaced quickly and easily.

Tested at altitude

GHH Fahrzeuge’s latest LHD, the LF-10/11, is now being thoroughly tested at Codelco’s Andina mine in Chile. This unit is equipped with what GHH describes as “the newest, most innovative drive line system for underground loading and haulage.” This unique system is a combination of hydrodynamic and hydrostatic drives. It is called the Efficient Drive Sytem (EDS) and offers significant savings in operating costs and wear. Whenever LHDs attack rock piles, power is required to penetrate deep enough into the pile so that the bucket can be filled to capacity without wheel spin, bucket sticking and without several attempts to penetrate the pile successfully. GHH says the new EDS system solves these problems and provides to operators with “ultimate drive comfort. The noise and vibration level in the cabin is much lower than requested by national regulations in Chile. For the complete speed range no gear switching is necessary and reversing can be done at any speed without using the brake pedal. The speed acceleration and deceleration will be performed by the position of the drive pedal. Change of direction or switching from first to second gear will be done smoothly and without hits.” The company also says the productivity of the LF-10/11 “is more than 10% higher than for general 10 t LHDs.” The EDS system enables maximum propel force and high tractive force at the stall point, even at low rpms.

The LF-10/11 offers a breakout force of 192 kN, which GHH says “is due to EDS the highest breakout force in its class.” This drive line concept delivers “only the necessary power for traction and eliminates nearly completely the slip which occurs in hydrodynamic applications usually, especially when the machine is running at full power and at the stall point. Due to the automatic adaptation of the pump flow rate and the standby operation at the stall point the power consumption is orientated at the traction power.” The key to high penetration with low fuel consumption and less tyre wear lies in the hydraulic system that distributes and controls the flow of hydraulic oil. This is where the power is generated and where power loss can occur. The EDS system enables fast changes from forward to reverse and high acceleration that reduces cycle times significantly. GHH’s special switching logic allows the use of EDS as
a retarder without overloading the drive motors. In general use no friction brake is needed to control machine operation. Due to hydrostatic brake performance of up to 180 kW there is no brake wear and the life is greatly extended.

All relevant machine parameters and operator inputs are collected and linked logically, for optimum control of the drive line. GHH says its specifications for drive line control guarantee optimised operation that is gentle on machine components. There is less oscillation caused by revolving parts like prop shafts, which are eliminated with the EDS. Due to that component life and operator comfort are influenced in a very positive way.

The LF-10/11 with an operating weight of 41,000 kg and a heaped bucket capacity of 4.5-5.5 m³ is designed for rough underground conditions and gets its power from a Cummins QSL9 engine. This engine develops 209 kW, is EPA Tier 3/Com III certified and provides high productivity and reliability with low fuel consumption, few exhaust fumes and low noise. The EDS supports the quiet running of the engine with its optimised rpm control. The much higher efficiency factor of the EDS reduces oil temperature and the aging of the hydraulic oil. The improved efficiency factor and the optimised control of rpms reduces fuel consumption and, as a result, exhaust emissions, which will reduce other costs.

During operation the CANBUS system controls and monitors all systems, informing and guiding the operator, should any abnormality occur. The system and the maintenance display in the cab can prevent small problems from becoming a major service issue. The system features oil temperature, fuel consumption, maintenance intervals etc., all failures are displayed on the LCD. All failures will be stored for troubleshooting assistance and to minimise diagnostic and repair time. The LF-10/11 is equipped with a data logging device and weekly the operational data and machine parameters are sent from Chile to GHH in Germany for analysis. This monitoring helps increase the availability of the machine, allows remote diagnosis by HRI S.A., the local distributor for GHH equipment in Chile, or by GHH Service “and helps to keep the machine in excellent operating condition. Business efficiency and productivity is optimised and the availability of the LF-10/11 in Andina is up to 100%,” GHH reports.

“After approximately 1,000 operating hours during the trial run at Codelco Andina the EDS concept has shown that this new and unique system is superior to any hydrodynamic drive line concept.”

Andina is one of the largest and most modern underground mines in the world. It is located 80 km northeast of Santiago, at 3,700 to 4,200 m above sea level.

Automated backfill haul
Atlas Copco’s Scooptram Automation system has been extensively tested, both in system verification in Atlas Copco’s test mine in Kvarntorp, Sweden and in a field test at Outokumpu’s Kemi mine in Finland. The Auto Tram system was initially designed with normal production in mind; i.e., loading in a stope and dumping in an orepass. In the field tests however, the machine was used in a backfill operation where its flexibility and user friendliness were really put to the test.

In the Kemi mine a standard WLAN network is installed to enable communication via IP-telephones that are used both above and below ground by all personnel in the mine. During the initial installation, the Scooptram Automation system showed one of its major benefits: the use of standard WLAN communication components to provide communication between the machine and the operator station. No hardware modifications were required to enable the machine and the OPS to communicate through the mine’s standard WLAN network. This strength was confirmed by frequent changes of the operating area between different levels and...
areas of the mine. Deploying the machine in a completely different area only required reconfiguring the access points of the new area to single channel operation.

The machine ran more than 1,440 km and 28,500 t of waste rock was backfilled in teleremote and autonomous mode. As part of the trial, the automated system was compared to an on-board manual operator driving exactly the same 2 × 225 m long route with the ST14 Scooptram. This comparison showed that the productivity of the automation system is equal to or slightly higher than the productivity of the manual operator for the evaluated application.

Outokumpu’s estimated maximum capacity of one ST14 Scooptram Automation vehicle was 1,662 t/shift at a distance of 255 m. This compares favourably to Outokumpu’s traditional system with manually operated loader and trucks, where one loader and three trucks have a capacity of 3,621 t/shift at a distance of 220 m.

The RouteManager software was not available at the beginning of the field test, and all Auto Tram routes were generated, validated, and commissioned by Atlas Copco engineers. With RouteManager available however the task of teaching, generating and commissioning routes in a new area was completely handled by the ordinary on-site service personnel with support from LHD operators, proving the efficiency of the automated route administration. A few times the mine’s conventional backfill operation was interrupted because of roof collapses and ground conditions that did not allow manual operation in the unsafe areas. In these situations the automation system proved to be the safest method to maintain the area as well as to complete the task with high productivity.

**New trucks**

Atlas Copco says its new Minetruck MT42 “represents our next generation of underground trucks. This high-speed 42 t articulated truck has been designed to maximise productivity as well as provide increased safety and excellent operator comfort in underground haulage.” The dump system can discharge a full load in just 13 seconds.

It is available now in Scandinavia and Canada and will be launched globally in 2011. The truck is powered by a fuel efficient, low-emission Cummins QSX15 EPA Tier 3/Stage IIIA engine, coupled with proven drivetrain components, delivering high speed on ramps. The transmission has eight forward and two reverse gears and features a self-diagnostic system for rapid troubleshooting.

Operator comfort in the standard ISO ROPS/FOPS certified cabin include an air suspended forward-facing seat, a clear, multifunction display monitor, air conditioning and a trainer’s seat. The operator’s sound exposure is below 80 dB (A) in the cabin. Front axle suspension further contributes to operator comfort, while also allowing greater speeds on mine roadways. Rear facing cameras, one backup camera and one loading camera covering the box, complement the operator’s view from the cabin.

An extensive, 12-month field test at Boliden’s Garpenberg mine in Sweden proved the capabilities of the Minetruck MT42, while also winning praise from the operators. It “has a lot of power and with its four wheel drive it can go anywhere,” said Stefan Olsson, a truck operator with contractor Euromining. Fellow operator, Jan Lehtinen also appreciates its driving qualities. “The MT42 is able to go round corners that other trucks would need to back up again and again to get round. Both backwards and forwards, it takes corners smoothly,” he said.

“Some trucks can lose traction on inclines, especially when they are not carrying a load or in wet conditions. This is no problem for the MT42, you just drive straight on.”

The truck has SAHR brakes, which eliminate the need for a separate parking brake, are low maintenance and provide extended service life. A service bay on the side of the truck allows easy access to filters, valve blocks and service points for daily maintenance and the cabin can be hydraulically tilted to expose the engine bay.

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