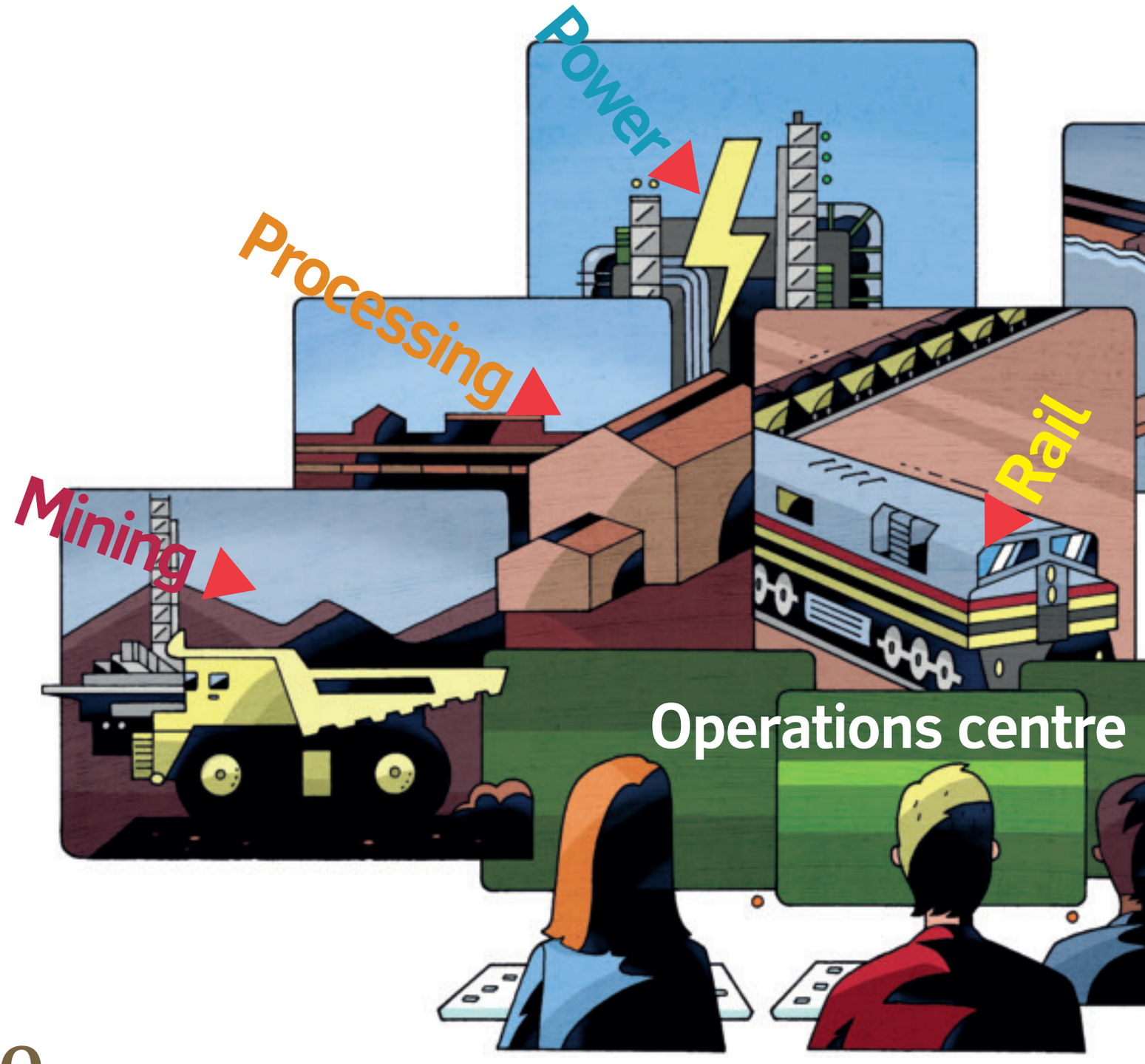
Giant mining machines controlled in harmony from hundreds of kilometres distant are no longer just the stuff of sci-fi. They are moving ever closer, now, reports Julian Cribb.

As investors wrung their hands over sagging global stocks and the US government stepped in to bail out another bank, atop a blood red mountain in Australia's Pilbara ironlands a hundred tonne Terex drill rig, guided via satellite, sank 77 blast holes with pinpoint precision using both hammer and rotary drilling – with no human hand on the controls. It was a world first and it promises to transform mining for all time.

Notwithstanding the world economic downturn, the Rio Tinto automation team is pressing ahead to create the Mine of the Future. The simple reason, says Rio Tinto's head of Innovation John McGagh, is that in challenging times, mine



automation makes better economic sense than ever.

In the vast West Angelas Pit A a "steel ballet" is already in rehearsal. Massive autonomous machines perform their intricate choreography, sensing their environment and one another, moving smoothly to perform tasks ordained in bursts of satellite and wireless data. Operators observe and supervise from mobile cabs that will gradually retreat from the pit to the mine's central office – and thence to Perth, 1,500km away, as the whole, gigantic central nervous system comes alive during the second half of this year.

May marked the public unveiling of this extraordinary feat of advanced technology, one of the world's largest civilian robotics projects, and a no less remarkable statement of confidence in the future of the minerals sector. Where miners traditionally cut back on R&D when times grow tough, Rio Tinto is opting instead to force the pace.

The logic is compelling, says John McGagh: "Every piece in this enormous technical jigsaw puzzle is delivering a measurable payback. For each step, there is a clear value argument: greater efficiency or a lower cost of production. Add them all together and you reap a very large multiplier effect."

The Terex SKSS15 blast hole drill had its proprietary remote control and automation system custom built for Rio Tinto by technology alliance partners including the Rio Tinto Centre for Mine Automation. The rig combines GPS navigation and track encoders to position itself, tilt-meters to jack and level itself within a fifth of a degree, and drilling sensors. "We're drilling most holes within almost half a hole diameter (150mm) of where they should be," says a delighted Charles McHugh, principal mining engineer, Automation. "For a 100 tonne machine, that's not bad."

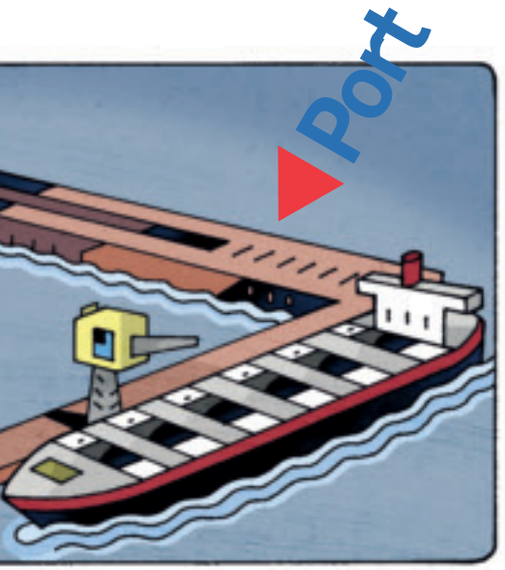
McHugh also exults in the smooth, deliberate purposefulness as the pilotless monster glides from one hole position to the next: "You see it transit very smoothly, ramping up speed, then slowing down as it approaches the next hole location. You see how evenly it levels and maintains pressure." Such smoothness equates with operational celerity: when the 77 hole pattern was drilled autonomously, the feat was accomplished six metres an hour faster than a manned drill, working in similar conditions nearby.

The device is enormously versatile, capable of drilling at speeds between ten and 350 metres an hour in the same hole, of switching from rotary to hammer percussion drilling as required, of stabilizing the hole by collaring, injecting water and back-reaming. It drills to its assigned depth within a tolerance of 10mm. Besides producing ruler-straight rows of blast holes, it can manoeuvre in complex patterns to shape the forthcoming blast so it meshes with the mine development plan.

At the flick of a switch, an operator in the remote observer's cab can move the rig between manual, remote and autonomous operation, choices dictated by the terrain and the complexity of the task. The operator watches the drill's onboard monitoring system as well as the automation computer. In recent months the rig has drilled over 30,000m on remote control and several thousand more in autonomous mode. So far the control cab has occupied positions up to 800m from the drill as the team tests the reliability of the wireless data feed streaming between the two.

As confidence grows, the cab will be taken out of the chain as control moves first to the West Angelas site office, then – in a mighty leap – to the Operations Centre (OC) located beside Perth airport 1,500km away, where the company's future drillers will work in air conditioned comfort. In the coming months the rig will be joined by two more, maybe three, to form a robot drilling fleet.

In parallel development is an automated explosives loading truck that can



The shape of things to come

pick out individual blast holes using GPS, check their depth and condition, download the planned blasting pattern, then blend and inject the correct blasting mixture into each hole in order to achieve a more shaped and precise explosion. The first truck, built in collaboration with a Perth based technology alliance partner, will be delivered to West Angelas in May.

"Rio Tinto Iron Ore drills a million blast holes a year," says John McGagh. The stupendous number brings home the scale of the productivity gains to be won from automation, its significance to the company's future competitive position – and the compelling business reason it is pressing forward so eagerly, despite the current market downturn. Yet both drill rig and blast truck are but small elements in the elaborate, networked intelligence that is taking shape.

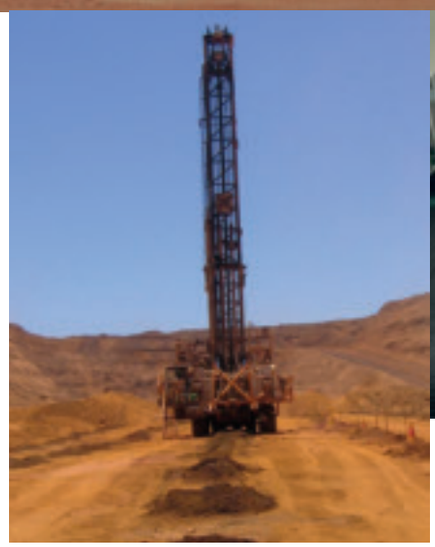
Not far away, a giant Komatsu 930E-4 electric truck, capable of hauling 285 tonnes of ore in a single load, is going through its driverless paces, first in a fleet of five such giants to enter operation at West Angelas this year. The other four are "in school", their electronic brains absorbing the geography of the mine and how to negotiate it smoothly and efficiently while maintaining an alert watchfulness for every other piece of equipment or human being in it.

Within Komatsu's "Frontrunner" system, the trucks are equipped with autonomous navigation equipment, which enables them to pick their way delicately through a complex mining environment at up to 50kph without a driver on board. Perhaps the most eye catching of all the robotic gear that is going in, the 285-tonne trucks are budgeted to shift 31 million tonnes of rock and ore over the coming year or so, an assignment that underscores the real life character of this real life robotic experiment.

The task of loading the driverless Komatsus from the rock pile with shovels and excavators is highly complex and will remain the province of skilled human operators for some time to come – but here too the team sees scope to add more automation to make the work less demanding on man and machine, as well as more efficient.

As the haul trucks deliver ore to the crusher, automation takes a hand again: in late 2008 a West Angelas plant operator sitting in Perth successfully wielded a giant jackhammer in the Pilbara to fragment outsise rocks for crushing, says Andrew Jenkin, general manager, Technology. They not only broke rocks from quarter of a continent away: they did it faster than usual.

Being so far away also proved no obstacle to operators who successfully loaded numerous trains at West Angelas from Perth in another "hands off" demonstration that achieved greater safety, efficiency and precision, Andrew adds. Work is also well advanced in the development of automated ore trains: they have comfortably passed all operational



Robots on the march, guided by satellite. Above, the fleet of automated haul trucks. Right, a blast hole drill – with no one at the controls, and a digitally generated view of the Operations Centre.

tests put to them, although they are unlikely to be introduced before the other key components in the automation package are up and running. Further down the track, many of the tasks involved in managing the ore stockpiles and loading ships at Dampier and Cape Lambert will be progressively automated and control shifted to Perth.

There, beside the airport, a futuristic facility is taking shape, its vast screens, computer power, remote consoles and communications gear evocative of a space launch control room – but, if anything, more up to date. The Operations Centre is the pulsing cortex in the Mine of the Future, the place where billions of nerve signals from individual pieces of equipment, videocams and operators on the ground are collected, analysed and acted on in real time.

The vision that inspired the Centre is credited to Rio Tinto Iron Ore chief executive Sam Walsh and his team, who saw in integrated planning and control and automation the chance to make a quantum leap in the system performance of the Pilbara operations. Up till that point, as robotics guru Professor Hugh Durrant-Whyte has noted, mine automation worldwide had proceeded in piecemeal fits and starts. Lots of robotic equipment had been invented by many companies to achieve small local improvements, but no-one had envisioned the far greater benefits to be won from weaving it all into a single, intelligent and harmonious system.

From the OC, most aspects of mine operations can be seen – and overseen – in real time. Equipment can be monitored as it operates autonomously, or guided hands-on by an operator at the other end of a datalink in Perth. What pilotless vehicles "see" with their onboard videocams and other sensors can also be studied and analysed by the OC team.

The Operations Centre, however, is more than an operational nerve centre. It will also house the entire RTIO integrated planning and scheduling functions, extending from seconds to years into the future. It will supply instant, expert advice and support for operations and maintenance staff working at the mines and it will keep an ever watchful eye over employee health and safety. In summary, its primary focus will be to deliver better, smarter and faster decisions and drive continuous improvement in almost every aspect of the massive operation.

For such a system to work, a "data pipe"– whether wireless, satellite or optic fibre cable – of gargantuan capacity is needed, linking the OC with the various mines, ports and individual pieces of equipment. The output of thousands of closed circuit TV videocams used to scrutinise mining operations alone will gobble up bandwidth by the tera-chunk, not to mention all the other sensors, person to person communication and online videoconferences.

For all their staggering complexity, the OC and the Pilbara Mine of the Future are just the start – a pioneer enterprise, a trailblazer, says John McGagh. In time the automated systems they hammer out can be expected to percolate into coal, bauxite, metals and other Rio Tinto enterprises. "Although it may seem early days, this is now a serious option for the company," he says. "We will have the real life operational experience and the technology, so we can look at adding value across all our current operations. Also, when we look at a new site, we will view its fundamental design with the OC in mind.

"This takes Rio Tinto across a Rubicon. With the experience and the confidence we are now accumulating the mining world will look quite different in future: a 'rock factory' rather than a mine. But this is not science for its own sake, this is an example of science being applied to smart business decisions. Every step will be driven by hard headed financial appraisal and a desire to add value for our shareholders."

Says Sydney University robotics authority Hugh Durrant-Whyte: "It is possible to envisage the use of robotics to mine much more selectively and with lower environmental impact than is currently possible. It is also possible to envisage the use of advanced robotics coupled with other technologies to mine at much greater depths and with much greater selectivity. In turn these will open up enormous opportunities for resource companies and for the development of a new robotics industry."

Julian Cribb is adjunct professor of science communications at the University of Technology, Sydney, and was previously science editor of "The Australian".

Best MATE? A technology that is being adapted in house to help with communication between Perth and mine site is MATE (miner assist technical equipment). Once fully developed, this cluster of hardware, reminiscent of an elite combat soldier's battlefield communications gear, may be worn by Rio Tinto miners to keep them safe and in the picture at all times. It includes a headset and microphone, camera and video display, microcomputer and wireless link.