



# SMALL IS BEAUTIFUL

Is mining about to go micro? By Dennis Franklin

For many years, the business of mining has been a story of more mechanisation, bigger and bigger mines, and bigger and bigger equipment. Advances in the technology of moving large amounts of material in open cut mines has driven the development of the larger than life machinery; but will it be like that forever?

I don't think so, because I believe a whole new set of technology developments will mean that the transport of mass materials will be done by smaller and smaller machines, each operating autonomously, making their own decisions, and at a much lower total cost than a fleet of large haul trucks.

## ISSUE

So why are large haul trucks about to see the end of their run? They are really expensive to buy and maintain. At about \$5 million for a Caterpillar 797, and a significant ongoing cost for maintenance and operating inputs, there may be a case for doing things differently. Add in the costs of all of the people and other systems that are needed to enable the management of truck fleets, such as roadways and critical parts, and the cost keeps piling up. What if there was a better way of doing things?

## WHY WE ARE HOOKED ON BIG TRUCKS

For the moment, we use large equipment because the economies of scale have tended to support their development. The industry has been in this evolutionary paradigm for many years because bigger trucks means fewer drivers, less trucks needed per kilometre/tonne of ore moved, and the development of more efficient large engines means the fuel component is less cost per km/t. I'm sure there are also many other efficiencies that work well for large trucks over small ones. But why has the 'going small' option not been considered before?

In most cases, new ways of doing business are strongly resisted on a few fronts. Firstly, people are pretty conservative and won't take the time to consider alternatives to the way things have "always been done".

Secondly, there is a cost associated with change that might mean that large amounts of invested capital will need to be abandoned, and despite the best efforts of economists worldwide to convince people that invested capital should not be considered for future investment decisions, it usually is. In this instance, there is a lot of existing infrastructure associated with supporting haul trucks, and few will want to write it off.

Perhaps the biggest issue is the risk involved in taking on a new idea - what if it doesn't work - can I bet the company on this?

## SMALL IS THE NEW BLACK

Let us imagine for a moment, replacing your \$5 million Caterpillar truck with 400, Ford F150 pickup trucks - that's how many you'd need to match the carrying capacity. At \$20k each, that would cost you \$8 million, but you'd be able to make up the Km/t figure by doing more trips because the F150 is much faster. The biggest issue though is that you'd need a lot more drivers (1200 versus 3 or 4 per truck) so the economics don't work. Unless, that is, you can remove the need for drivers completely.

If you could have smaller vehicles operating independently and automatically you might be able to make an economic case for this scenario. Of course you'd need to implement all of the technologies to operate a large number of autonomous vehicles. I'll cover a few such technologies here and provide some idea of where that technology is today and where it might be heading.

## ADVANCED ANALYTICS

The use of analytical algorithms that assist with making many low level decisions is quite advanced in many industries. Because the mining industry is not as technologically mature as others, there is plenty of opportunity to learn from how the aerospace industry uses these advanced analytical techniques to remove the need for human intervention in many processes. Aircraft can now land themselves on autopilot, a specific and highly complex event that needs microsecond by microsecond adjustment of aircraft and engine power in three dimensions, responding to highly dynamic changes in the surrounding environment in real time. All of this can happen with a plane load of hundreds of people. As a specific task, they don't come much more complicated, and this level of knowledge is in use today in commercial airliners. Why not apply these technologies and techniques in the mining industry?

## SMART SENSORS

Many of the individual, microsecond decisions can actually be undertaken away from the smart core algorithm by smart sensors operating at the periphery of a complex computer algorithm. For very well understood and constrained processes a smart sensor might 'decide' to provide data to a central algorithm only when the process deviates from a pre-established norm. For example, a smart thermometer might only



## ROBOT DRAGONFLY

Robotics, artificial intelligence, automation, and remote management are all technologies in which the rates of innovation are astounding. 'New Scientist' reports on a robotic dragonfly that could guide Mars rovers - giving the fly's eye view in a task analogous to helicopters being used as force projection assets of naval warships.

In the near future, further miniturisation of the electronics, and better smarts will mean that this kind of technology can be used to continually update the topography of an open cut mine, with swarms of such robots preceding ultra large automated vehicles, helping automated shovels load automated trucks. Perhaps they will even be able to replace the truck fleet, with millions of tiny robot flies moving enormous tonnages of ore without the need for roads, ramps etc. Just the saving in the profile of the open cut pit would change the economics of mining.

Underground mines could benefit too, with robot miners like the fly moving in to survey the mine after blasting - testing the air, rockface stability, everything.

report fluctuations in engine temperature outside of a particular range, or if the temperature changes much faster than expected. This takes pressure off the central processing ability of the system.

### MACHINE INTELLIGENCE

Both advanced analytical capabilities and smart sensors lead the way to 'machine intelligence'; the ability of a machine to have some level of understanding of the environment around it and of its role within that environment. At the moment, small mobile machines are being designed with levels of intelligence approximating insects. Indeed, some of these machines are incorporating insect neurons within the machine's IT architecture. These machines learn!

### AUTOMATION

Komatsu and Caterpillar have already produced haul trucks that can be operated remotely, and are working on autonomous operation. To help cope with communications lag times, the Mars Rovers have limited levels of autonomy to allow them to move around on the service of Mars with minimal intervention by people.

### ROBOTICS

Another technology that is critical to automating machinery is robotics. Robotics incorporates all of the other technologies discussed here, but also concerns the form and function of the machines. Robotic science is very highly advanced and very sophisticated. Some of the recent advances look to nature to inspire the development of robots, and it is here that I believe the mining industry can look for the future of the mining process.

### SMALL ROBOTS

Predicting the future uptake of technologies is a difficult thing to do. Not many people would have predicted the internet or its impact, even as recently as 15 years ago. So, let's suspend our disbelief for a while and see where this might go.

Imagine small earthmovers - not Ford's - but small 'microbots'. As an example consider the dragonfly robot. This small robot can see, fly, and power itself by the sun. What would you be able to do if you could have a million of these machines each moving a small amount of crushed ore? While this is perhaps far fetched, it is worth considering as a possibility just as an exercise in reviewing the economics of the small.

If you could engineer it so that the bot knew where to pick up a load and where to drop it off, travel in as straight a line as possible to get it there, and rest in the sun to recharge itself when it needed to, little else is

needed. The prototype of the bot already exists, the swarm intelligence algorithms already control robots in the laboratory, and the sensor and control systems exist to control such a system; so what are we waiting for?

### WHAT IS THE ADVANTAGE

The economic viability of this idea has not yet been modelled, but as with all technologies, the costs reduce over time, and with take-up. A single mine using flying microbots would probably be enough to reach those long run efficiencies in terms of manufacture of the robots, and continuing advances in solar power technology mean that the path to sufficient power resources for this idea is quite predictable.

For me the biggest single effect lies in the ability to change the dynamics of pit morphology. By not having to step the pit back to get to deeper parts of the orebody, the options for continuing mine operations to depth are very different.

### CONCLUSIONS

There is no doubt that flying dragonfly robots will not replace haul trucks in the next five years or maybe ever. Even though most of the technologies are in place, or being researched now, there is still a while before they'll be bought together to this one task. But there is one thing that technology futurists well understand. The pace of technological innovation is relentless, is accelerating, and most people underestimate what can be done, and when.

### REFERENCES

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[http://en.wikipedia.org/wiki/Caterpillar\\_797B](http://en.wikipedia.org/wiki/Caterpillar_797B)

A New Scientist video recently turned up on Jack Uldrich's 'Jump the Curve' blog. Have a look at it to see some of the future of robots. New Scientist also has a blog specifically about robotics.  
[http://www.jumpthecurve.net/index.php/recent\\_posts/our\\_robotic\\_future/#When:15:43:00Z](http://www.jumpthecurve.net/index.php/recent_posts/our_robotic_future/#When:15:43:00Z)