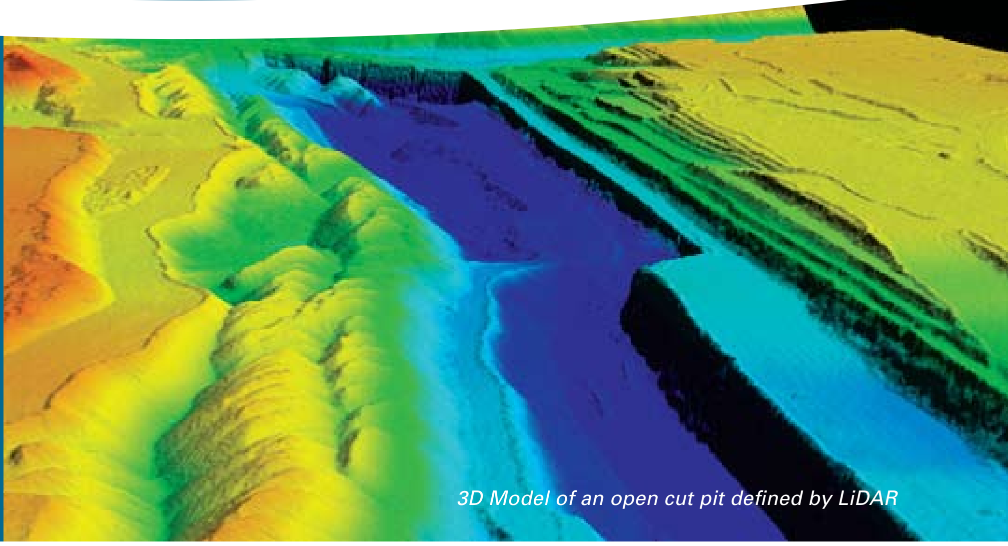
SCANNING THE HORIZONS
A Newsletter on Leading Edge Spatial Technologies

Mining and Engineering Special Issue


3D Model of an open cut pit defined by LiDAR

LiDAR in Mining

Jamie Hansen

Aerial surveying and mapping technologies have been used for 40 years to assist mining companies through all phases of a mine's life, including exploration, resource evaluation, feasibility, mine design, development, operations and site rehabilitation.

For much of this 40 year period, the most appropriate 'fit for purpose' aerial survey methodology for mining has been based around aerial photography and photogrammetry. The success and popularity of this method is dependent on the skill, experience, knowledge and delivery speed of the aerial survey company, ground support from mine site survey staff and some reasonably good weather.

The spatial data acquired from this methodology includes digital terrain models, feature coded mine vector mapping, ortho-rectified geo-referenced imagery, topographic mapping, contours and pictorial imagery.

The spatial data delivered is designed to support a diverse range of mining activities, such as:

- Exploration and resource evaluation
- Design and construction of mine plant and infrastructure
- Determination of ore body, pit and void volumes for mine planning
- Periodic determination of pit, bench, pre-strip and spoil surface volumes for auditing payments to earthworks contractors
- Periodic determination of stockpile volumes for inventory and accounting purposes
- Environmental planning, monitoring and reporting for the mining operation and the neighbouring region

LiDAR in Mining *continued*

Jamie Hansen

In addition to aerial photography and photogrammetry, for the last ten years AAMHatch has also been successfully deploying LiDAR as another 'fit for purpose' broad acre aerial survey methodology for the acquisition and supply of spatial data required for mining projects at pre-feasibility through to the design and construct stage.

More recently however, LiDAR is proving to be a suitable and valuable tool to not only support mining operations, but also to supplement the yield of mine survey staff in providing planning engineers with critical pit data that was previously impossible to acquire in useful timeframes.

Provided clients are comfortable with a point cloud product, the benefits offered by LiDAR make it possible to overcome some of the limitations of aerial photography, such as:

- LiDAR data can be acquired under heavy cloud or at night, dramatically increasing the window of aerial survey capture time – particularly advantageous during the wet season!
- Unlike aerial photogrammetry, LiDAR surveys do not require ground control targets, allowing mine surveyors to concentrate on other important operational activities
- The project critical path to delivery of data can be much shorter and simpler, relying more on CPU time than on man hours

LiDAR surveys are particularly well suited to time-critical applications, in terms of capture window and delivery time. For example:

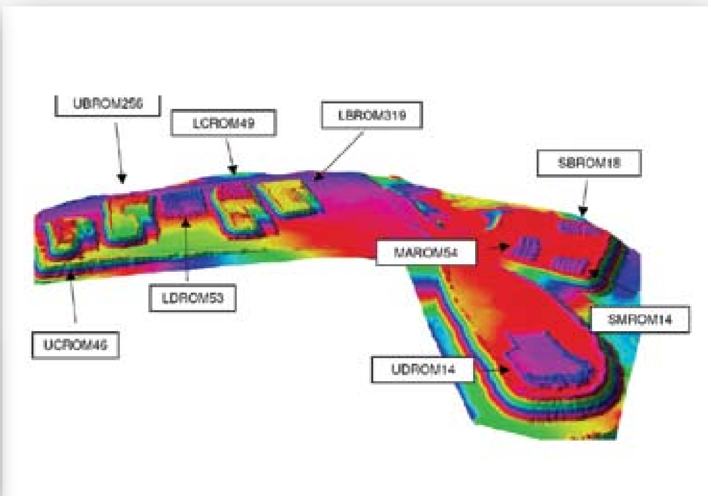
- Stockpile surveys that are required on the last day of the month, to coincide with the financial reporting period
- Specific surveys where the capture window is either very limited or time critical such as pre or post blast, start or end of contract, ship or train loading, empty or new stockpile pads and blending yards

In quantitative terms, a LiDAR survey of a mine pit:

- Can be arranged at 24 hours notice
- Can acquire survey data points at half metre spacing
- Can be at 0.1m accuracy
- Can cover up to 2000ha in one hour
- Can be delivered 48 hours after survey

The mining community over recent years has developed the need for more and faster spatial data. Mine surveyors and engineers have embraced the convenience of terrestrial laser scanning and have developed their ability to work with the subsequent 'clouds' of point data. This experience with terrestrial LiDAR data is a useful introduction to airborne LiDAR. To meet the mining industry need for more and faster spatial data AAMHatch offers a complete range of mining related airborne LiDAR data acquisition, processing and consulting services.

Aerial photograph of product stockpiles



LiDAR survey of product stockpiles for determining volumes

Mine Mapping

Mike Adams

For over 40 years, the most common aerial survey methodology for mining has been based around aerial photography and photogrammetry. In this time there have been many changes, such as:

- Fully digital metric survey cameras have largely replaced film cameras
- Camera position and attitude are now measured on-board
- Time from image capture to delivery is faster but much more CPU intensive
- The same imagery available simultaneously for multi-users in many locations
- More uses for aerial survey data and imagery on mine sites
- Greater diversity of aerial survey products
- High resolution satellite imagery as a viable alternative imagery source

The success and popularity of this method with AAMHatch mining customers is dependent on many things but none are quite as fundamental as having a permanent and metric photographic record of the whole mine site captured in almost the same instant. This is especially useful when a range of imagery products are required for a variety of interested users on the client mine site.

One particular open-cut mine site in Australia is photographed every month by AAMHatch. The 3350ha site is covered by 85 frames of photography. The primary deliverable is to supply, within three days, an update of the pit model to enable mine site survey staff to calculate end of month volumes. However, the supplied updated mine mapping and imagery also provides for many other uses including:

- Engineering and mine planning
- Earthwork contractor monitoring
- Stockpile volumes
- Spoil dump design and monitoring
- Tailings Dam monitoring and void volumes
- Spoil rehabilitation monitoring and reporting
- Asset management
- Environmental monitoring and reporting

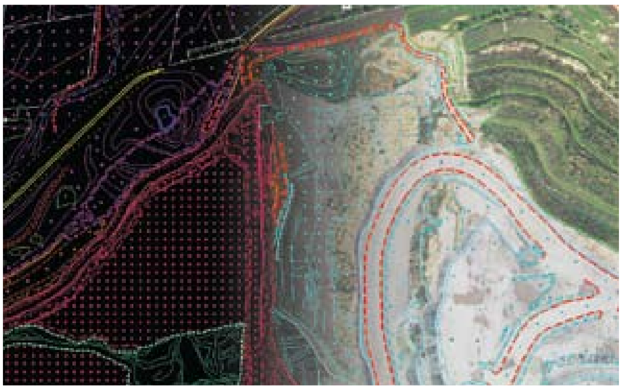
Each of these uses requires mine mapping data that has different characteristics that is best achieved by customising the data capture. This customising relates to feature identification and the density of the data captured.

The result is efficient data sets that, in many ways, are designed to replicate the style of data captured by the site surveyors. Some examples are as follows:

- Areas of active extraction related to contract mining such as pre-strip, pit and ore body surfaces require correct feature coding and greater density of data capture to enable accurate volume calculations
- Areas of waste dumping need to be correctly feature coded but require less data for volume calculations
- Areas of spoil undergoing rehabilitation need separate feature coding and a well defined accurate final surface
- Road infrastructure requires accurate feature coding, especially where heavy vehicles are to be separated from light vehicle traffic
- It is especially critical to correctly identify and code features related to water, site drainage and containment of runoff
- Areas of natural surface are coded separately to provide a means of automating the measurement of disturbed areas and mapped accurately to provide a required 'start of contract' surface
- Ortho rectified imagery for environmental monitoring invariably requires better colour and less contrast than imagery for mine engineering and planning

To enable the delivery of fit for purpose mine mapping data for the multitude of users at this site, AAMHatch makes maximum use of the best available technology.

In addition to the technology, a vital element of this aerial survey methodology is the knowledge and experience of our spatial science staff. The combination of best available technology, staff knowledge and experience ensures that we deliver complete and fully feature coded data in the very short time frames demanded.



Sample mine mapping with ortho image

Engineering Project: On time, to spec, to budget!

Grey Mackay

AAMHatch was commissioned to perform professional services and deliver a range of datasets to underpin a major and urgent engineering design project.

Project Summary

- 400km long corridor
- 8000 hours - LTI free
- 4000 frames of imagery
- Ground pickup every 100m
- Phased data delivery

Deliverables:

- Topo data < +/- 0.07m vertically
- Orthoimagery 0.05m resolution

This project had over 8000 man hours of work involving aerial survey, ground survey and processing in the office. All work was completed with no lost time injuries.

Four sorties of aerial survey were captured. One of these sorties involved the capture of over 2000 frames of imagery from a large format digital camera.

AAMHatch delivered phased data deliveries with zero rework and all data supplied loaded first time every time. This meant the client had the confidence to meet their own challenges and supply their client with accurate engineering design data in a timely manner.

The safety aspect of field work was enhanced through the use of the GPS 'SPOT' system. All field staff were equipped with this unit ensuring all crews were tracked while in the field. Regular reporting was also achieved with this tool.

The products included topographic data, digital terrain models and orthoimagery. Aerial survey data was field checked and met the project accuracy of better than +/- 0.07m vertically (1 sigma) and in most cases was closer to 0.05m. Orthoimagery was supplied with a pixel resolution of 0.05m.

The aerial survey data along the entire line was verified with a ground pickup every 100m. This ground survey data was used to provide greater accuracy where needed (for example rail tie ins etc) as well as for verification of the supplied aerial data. Due to the numerous bridges along the route, more detailed survey data was captured around these locations.

Is your Infrastructure on the Move? A TLS Case Study on Monitoring

Glenn Morrison

Mining infrastructure has the ability to move over time due to inherent instability in the ground surface caused by seasonal weather variations and post construction settlement. The trouble is some monitoring techniques have deficiencies!

Traditionally the relative movement of structures has been monitored using conventional survey techniques involving the repeat measurements to prisms or targets mounted on the structure from known survey control stations. The subsequent measurements are compared to determine the relative movement over time of the structure. This type of monitoring only provides the surveyor and structural engineer with the localised movement of the structure in the vicinity of the measurement point on the structure and cannot accurately determine the total movement of the structure.

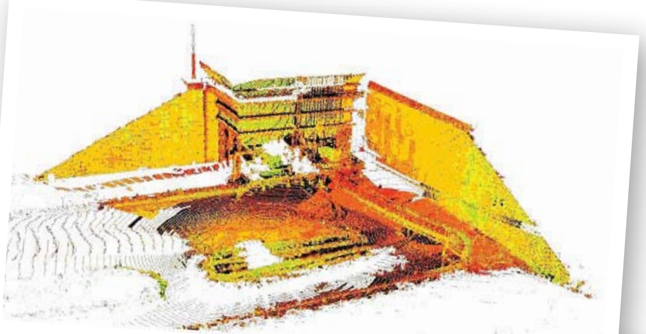
AAMHatch has an advanced technique for monitoring structures using Terrestrial Laser Scanners (TLS) to accurately monitor the relative movement of the whole structure over time. A TLS allows millions of individual measurements to be observed across the surface of the structure instead of the isolated points observed using traditional methods.

As the TLS scan location is referenced to the existing site survey control, subsequent scans of the structure can be compared to either a common reference plane or each another. This method of comparison involves the TLS point cloud surface being 'cleaned' of erroneous data and compared to a vertical plane. Through the use of vertical plane offset colour mapping the surveyor and structural engineer are able to accurately monitor the relative movement of the whole structure over time and determine localised areas of distortion (as depicted in the images below).

Should the level of movement be deemed to be of concern, the monitoring interval can be increased to allow the relative movement over time to be determined and the appropriate structure failure measures to be put into place.

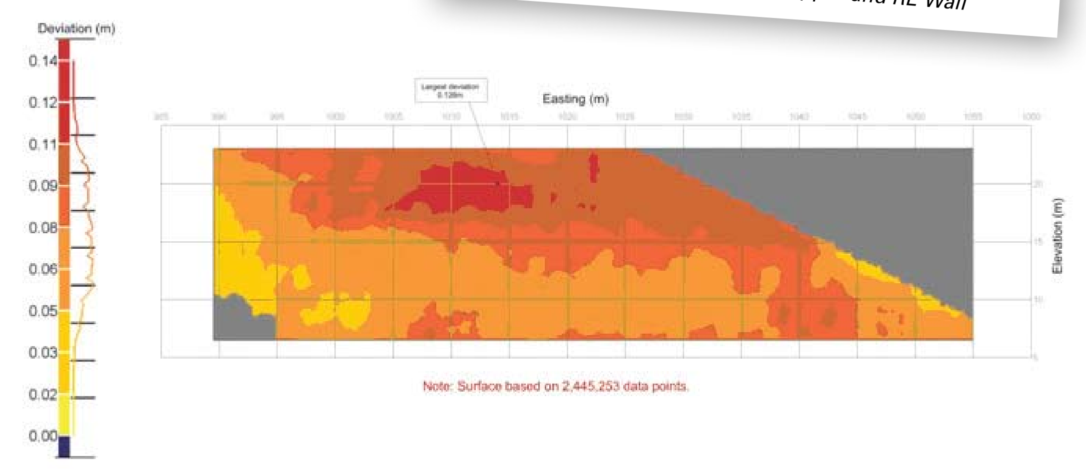
Case Study

These images depict the monitoring process undertaken on a ROM RE Wall. The images show an intensity based laser scan image through to final deliverable in the form of an intensity based plot.



Registered point cloud of a ROM Hopper and RE Wall

This image indicates the amount of deformation to a vertical plane of the cleaned TLS point cloud surface to the vertical plane. The colour variation indicates the amount of deflection from the vertical plane, from minimal movement (yellow) through to maximum movement (red). The graduation in deflection is shown in the legend on the left of the point cloud.



Subsidence Monitoring wins National Award

Scott Ramage

Above image web enabled

At the 6th Annual Asia-Pacific Spatial Excellence Awards, AAMHatch won the Land Titling and Development category for the Gippsland Precision Subsidence Monitoring project which sought to provide scientific evidence to refute or confirm claims of land subsidence along a 100km section of the Victorian coastline.

The APSEA Judges commented that "The project demonstrates the increasing demand for highly accurate measurement within the environmental domain and the levels of accuracy that are able to be achieved. The project involved rigorous and careful design, execution and processing of GPS data that achieved very stringent accuracy specifications required by the client."

The surveys, which achieved 6mm accuracy and were undertaken over a 4 year period, showed no significant subsidence had occurred. The leading edge technologies and techniques used on this project have the potential to be applied to many other land and structure monitoring and measurement tasks, including measurement of ground movement.

LiDAR Applied to Coastal Engineering

David Jonas

LiDAR was recently deployed to a coastal site in Malaysia to provide a rapid, detailed and accurate site plan in preparation for engineering design works.

The vegetation on site (illustrated right) proved no obstacle to the LiDAR penetration, allowing a detailed and accurate terrain definition. The LiDAR Digital Terrain Model (DTM) as shown, clearly defined the subtle drainage patterns along the coastal area, allowing flood modelling and accurate earthworks volumes.

The terrain model and resultant orthophoto were installed into the engineering team's workflow, with on-site instruction and guidance on how to incorporate the intricate details offered by LiDAR into their planning decisions.

This project was a successful demonstrator of the suitability of LiDAR to Asian coastal environments, providing details on coastal zone mapping, vegetation penetration and terrain definition.

Project Deliverables

- DTM accurate to 0.15m
- 0.5m contours
- 0.2m resolution colour orthophotos

The terrain was defined by an Optech 3100EA LiDAR sensor with an average point spacing of less than 1m. Digital aerial imagery shown was captured at the same time as the LiDAR data.

Orthophoto *LiDAR Surface*

As-Built Documentation Tools in Action Underground

Stuart Gordon

AAMHatch has taken its as-built documentation tools underground to digitally document a 1km drift at a colliery south of Sydney. One of AAMHatch's specialist industrial survey teams was commissioned to capture high-density, accurate point data using the latest Terrestrial Laser Scanning (TLS) technology and high-resolution spherical video imaging for visualisation purposes.

The team quickly captured 38 scans spaced every 30m down the 1:3.4 grade drift, which is used to transport materials, equipment and water down to the working faces of the underground coal mine, as well as bringing product to the surface. The drift is a cold, windy and dark place but this is no problem for a laser imaging device which emits its own light source and can scan under almost any lighting condition. Approximately 400 million 3D points were captured and now accurately represent the infrastructure inside the drift, including top of rail, conveyor and supports, pipes and internal surfaces.

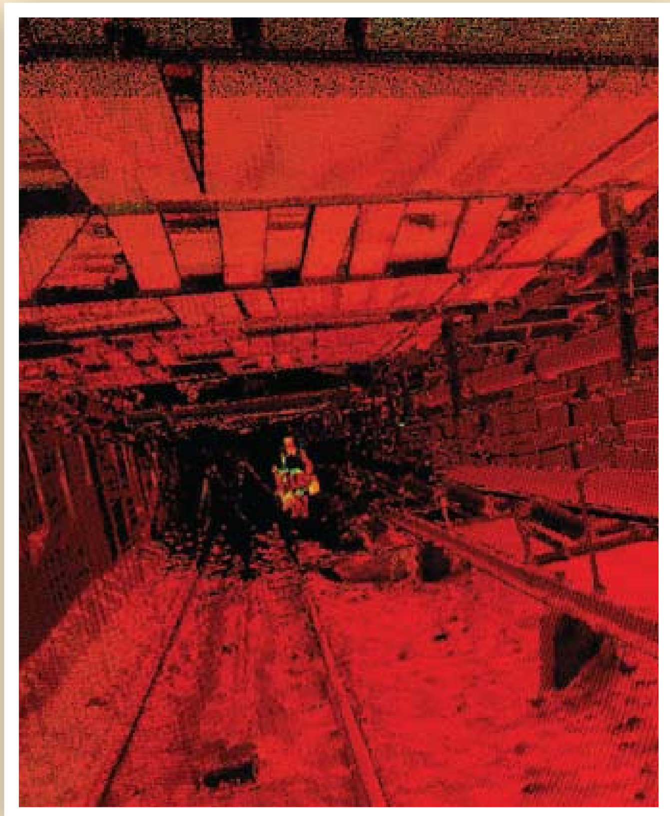
As part of the AAMHatch as-built documentation system, a modelling team extracted some of these salient features from the point data and converted them to CAD entities for more efficient analyses inside engineering software.

As part of the capture process, a SiteSeeV spherical video camera along with some special lights was also used to capture 360° imagery of the entire length of the drift. This means that engineers working on the drift, which is typically pitch black and an unfriendly environment, can traverse to any part of the route and make inspections from the safety and comfort of their desktop. This information can extend to safety staff to give inductions to new staff and contractors without needing to travel up and down the drift.

More information on TLS can be found at our website:
www.aamhatch.com/tls

Information and demos about the spherical video can be viewed at:
www.aamhatch.com/360

Above: A screen capture of the spherical video as the camera enters the drift opening



Above: A single scan looking down the drift, clearly showing the conveyor and footings, piping, rail and all surfaces

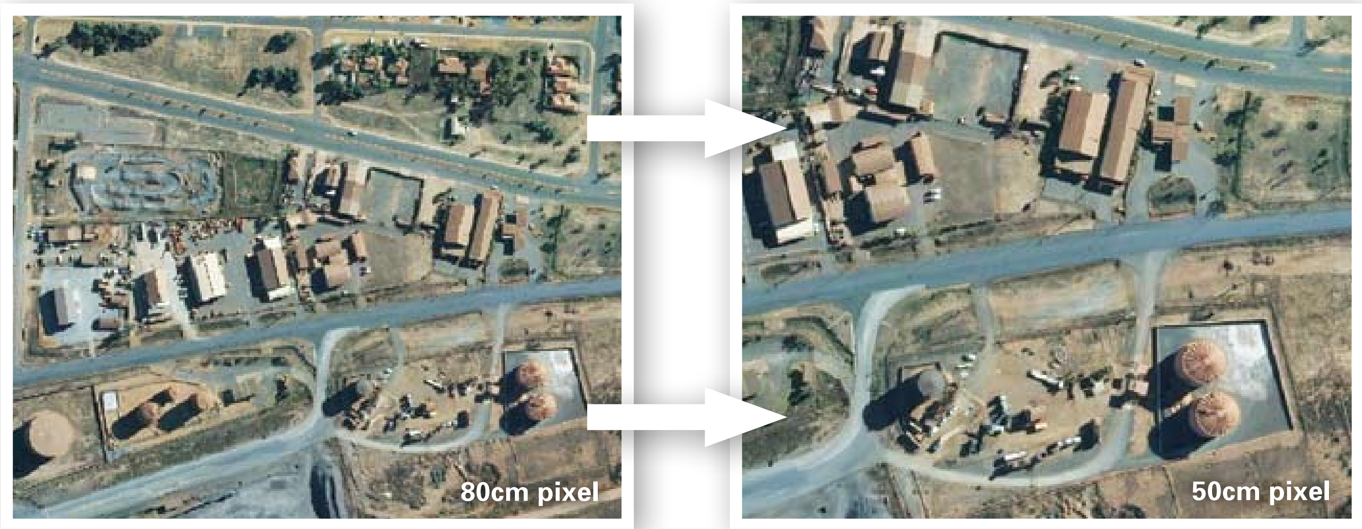
50cm GeoEye-1 Imagery

Lisa Dykes

Get ready, 50cm GeoEye-1 satellite imagery is here. Launched last year, this satellite imagery is commercially available now. This new satellite is the world's highest resolution, commercial Earth-imaging satellite, providing multispectral data. It is anticipated that the most popular product will be the GeoEye-1 colour imagery with a 50cm pixel size.

The GeoEye-1 satellite began commercial operations on the 6 February. With GeoEye-1 and IKONOS satellites both in operation, new tasking and faster capture will be possible in 2009.

The GeoEye-1 satellite, in combination with the existing IKONOS satellite, will continue to complement our aerial imagery and LiDAR surveys when providing accurate snapshots of ground operations for both mining and engineering applications. Regular high resolution satellite image captures over mine sites provide a cost effective method of monitoring change on a monthly or quarterly basis.



Data 'Off the Shelf'

Alex Cowdery

AAMHatch has released a number of datasets which are available 'off the shelf' and will be invaluable particularly to our mining and engineering customers:

- **Hunter Valley (~2500sqkm)**
  – 50cm and 1m resolution
- **Port Hedland**
  – 25cm resolution
- **Pilbara**
  – 1m resolution

AAMHatch has acquired and processed a range of data sets including LiDAR terrain data, colour orthophotos, Pictometry® imagery and 3D city models. These datasets are available almost immediately, perfect for those urgent requirements.

For more information visit **www.aamhatch.com/data** or contact **data@aamhatch.com**