Trials, Tribulations and Triumphs of UAV Surveying at St. Ives Gold Mine

Rick Steven | Survey Superintendent

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Forward Looking Statements

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In particular, the forward looking statements in this document include among others those relating to the Damang Exploration Target Statement; the Far Southeast Exploration Target Statement; commodity prices; demand for gold and other metals and minerals; interest rate expectations; exploration and production costs; levels of expected production; Gold Fields’ growth pipeline; levels and expected benefits of current and planned capital expenditures; future reserve, resource and other mineralisation levels; and the extent of cost efficiencies and savings to be achieved. Such forward looking statements involve known and unknown risks, uncertainties and other important factors that could cause the actual results, performance or achievements of the company to be materially different from the future results, performance or achievements expressed or implied by such forward looking statements. Such risks, uncertainties and other important factors include among others: economic, business and political conditions in South Africa, Ghana, Australia, Peru and elsewhere; the ability to achieve anticipated efficiencies and other cost savings in connection with past and future acquisitions, exploration and development activities; decreases in the market price of gold and/or copper; hazards associated with underground and surface gold mining; labour disruptions; availability terms and deployment of capital or credit; changes in government regulations, particularly taxation and environmental regulations; and new legislation affecting mining and mineral rights; changes in exchange rates; currency devaluations; the availability and cost of raw and finished materials; the cost of energy and water; inflation and other macro-economic factors, industrial action, temporary stoppages of mines for safety and unplanned maintenance reasons; and the impact of the AIDS and other occupational health risks experienced by Gold Fields’ employees.

These forward looking statements speak only as of the date of this document. Gold Fields undertakes no obligation to update publicly or release any revisions to these forward looking statements to reflect events or circumstances after the date of this document or to reflect the occurrence of unanticipated events.
Gold Fields

ST. IVES GOLD MINE

- Located 650kms east of Perth and 100kms south of Kalgoorlie
- Site covers 127,556 hectares of granted tenements
- More than just a single mine
  - 49 Open Pits to date
  - 15 UG mines to date
  - Junction Area ~2.1 Moz
  - Argo - Athena - Hamlet ~3.7 Moz
  - Greater Revenge Area ~3.4 Moz
  - Victory Area ~3.7 Moz
  - Invincible Potential +1 Moz
- Mineral Resources 29.1 Mt @ 3.35 g/t for 3.14 Moz
- Mineral Reserves 17.6 Mt @ 2.72 g/t for 1.54 Moz
St. Ives Gold Mine

A BRIEF HISTORY

- 1897: Gold first discovered at Red Hill
- 1930’s: Mining ceased
- 1966: WMC discovered Nickel
- 1970’s: Explored for gold
- 1980: Victory Gold Mine discovered
- 1988: First dedicated gold plant built
- 2001: Gold Fields acquired St Ives from WMC
- 2004: New Lefroy Mill commissioned
- 2006/2007: Athena and Hamlet discovered
- 2005: Neptune discovered
- 2012: Invincible discovered
Gold Fields

ST. IVES GOLD MINE
Rick Steven

WESTERN AUSTRALIAN AUTHORIZED MINE SURVEYOR #1072

- Western Australian Grade 1 Authorised Mine Surveyor
- Surveying/Mining - 30 years.
- Gold, copper, lead, zinc and nickel underground and open pit mines.
- 1996 - WA Grade 1 MSA
- 2004 – NSW Reg. Mine Surveyor
- Private Pilots License - VFR
Trimble UX5
SALT LAKE AT ST. IVES GOLD MINE
UNMANNED AERIAL SYSTEMS 101

UNMANNED AERIAL VEHICLE VS. UNMANNED AERIAL SYSTEM

- The UAS is the complete solution, including the camera(s), route planning software, GPS and so on. Its survey and mapping applications across the site will directly add benefit to many onsite departments including Engineering, Processing, Geology, Safety/Health and Environment.

- A UAV is, as the name suggests, an Unmanned Aerial Vehicle, either fixed wing or rotating (helicopter) which carries a camera, and following a predetermined flight path takes a series of overlapping photographs of an object area.
Trials

Trial (v): test (something, especially a new product) to assess its suitability or performance.
Step 1

TRAINING AND GOVT. LEGISLATION

- CASA
- The legalities of use of the system
- Overkill of bureaucracy and licensing
- Easing of instruction due to the RPAS Certified Course
- Manufacturer training
- Are we pilots now?
Lesson 1

THE GREAT DRONE UNKNOWN

- Where did/does it fit in the air according to CASA
- Original requirement was Private Pilots License – Visual Flight Rules (PPL VFR)
- Now Remotely Piloted Aircraft Systems (RPAS) certification
Testing

QUESTIONS, QUESTIONS, QUESTIONS....

- How will the data impact our processes? Will it become the primary source of survey data? How will the customer react to all the extra information?

- The first question that was raised was “How long is this new process going to set back the time line in getting usable data onto the server for people to use?”
Live ROM Test

THE CRITERIA THAT WAS TESTED INCLUDED

1. Time taken to conduct the survey
2. Time taken to calculate the volume
3. Level of confidence in the quality of the results
4. Variance of volume calculations from different methodology
5. Safety factor
ROM Stockpile Test

STOCKPILE FINGER - SURVEYED AND COMPARED
## ROM Stockpile Test

### STOCKPILE FINGER - SURVEYED AND COMPARED

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Tribulations

Tribulation (n): an experience that tests one's endurance, patience, or faith.
Expectations, hurdles and obstacles

ENCOUNTERING THE UNKNOWN

- How will it handle a lake environment and extreme weather conditions?
- What to use as landing and take-off areas?
- Will it be a distraction to mining personnel?
- In the planning for the use of the Trimble UX5, two factors loomed large in our collective minds......two factors that we had rarely encountered with any of the other functional processes on site – SPEED and HEIGHT!
Expectations, hurdles and obstacles

SPEED AND HEIGHT

- The Trimble UX5, once airborne and on its flight path, travels at a Ground Speed of 83-91kph, and when it comes in to land, the displayed Ground Speed is 68-73kph. So even with the fully laden Trimble UX5 weighing in at only 2kg, significant force is generated.

- And it’s when that force is coupled with a flying at height of 120m that, regardless of how well everything is going with the survey, there still remains the element of an X-factor!
St. Ives – The Site

SALT LAKES, TEMPERATURE AND WIND
Adjustments made to the camera trigger

SIMPLIFYING TO ACHIEVE GREATER QUALITY

Light Sensor camera trigger. Due to extreme light conditions (caused by salt lake reflection) up to 6% of photos not taken.

USB hard wire photo switch. Since swapping to this trigger (approx. 22 months) the photo loss is 0 photos in total.
Learning to fly.......  

THE OBJECT IS TO STAY IN THE AIR

- Over 440+ flights completed to date
- Not every flight has gone according to plan
- We have trialled, learnt and improved
- Worked with the agents (HLGS) and manufacturer (Trimble) to improve the performance
The Wedge Tail Eagle

NATURAL ENEMY OF THE UAV

- Wingspan between 182 and 232 cm (6 ft 0 in and 7 ft 7 in)
- Weighs between 3 and 5.77 kg (6.6 and 12.7 lb)
- Length varies between 81 and 106 cm (32 and 42 in)
- Each pair occupies a home range, which may extend from as little as 9 km² (3.5 sq mi) to more than 100 km² (39 sq mi).
Anti-Eagle Camouflage
St. Ives – The Site

SOFTWARE LIMITATIONS
St. Ives – The Site

CLIENT EXPECTATIONS

“Don’t worry, the expectations are the same as ever….only completely different”

- Unlimited data flowing directly from the UX5 to their computers as flights occurred and would become real time information
- The Quality vs. Quantity of Data debate = GOLDEN SOLUTION.
Triumphs

Triumph (n): Joy or satisfaction resulting from a success or victory
Universal Acceptance

THE TRIMBLE UX5 HAS NOW BECOME THE PRIMARY SURVEY TOOL

Data quality, both in accuracy and precision, the amount of data capture and refining the process has allowed broad usage of the flight surveys by all departments.

They include but are not limited to:
- Weekly open pit surveys
- Weekly ROM and MOP surveys
- EOM surveys
- Detail survey of non-mining excavated areas
- Incident investigation/Environmental monitoring
- Detailed planning of project work
Quality of Surveyed Data
Quality of Surveyed Data
Utilization of Data

Primary end users of the aerial imaging data.

Form the basis for decisions made about the rolling 13 week forecast all the way to the Six Quarterly (6Q) Schedule.

Planning team have photo/contour data that gives the best representation of the pit surface available.

Integration of data (volumetric/positional) into the planning cycle.
Quality of Surveyed Data
Utilization of Data

OPERATIONS CENTRE PLANS

- Drill and Blast plans
- Dig Flitch plans
- Scheduling plans
- De-watering plans

- Miscellaneous plans
- Day Works plans
- Area No- Access plans
- Emergency plans

Up to date real time photos in these plans provides true and accurate information and adds an element of realism to the plan. Furthermore the ability to use a photo allows the user to have a wider view of the area and any possible points of note or interactions that may have to be considered.
Data to Information
Quality of Surveyed Data
Looking Forward

GREATER UTILIZATION OF THE FLIGHT DATA

- St. Ives Gold Mine is about to embark on a project using Trimble Connected Mine 3D Mining Physicals and Tracking Software Package. Allows the user to don 3D glasses and view the point cloud data in space and visualise the working of the mine. Uses the spatial production data collected in the current Equipment Tracking Software and is used in conjunction with fly over data to provide a visual representation of the mine in 3D with equipment playback.
Conclusion

THE DIGITISED WORLD - METADATA

- An Unmanned Aerial System provides the ability to easily and accurately capture all of a site’s excavation and dump areas and gain all the benefits of detailed imagery and computer modelling.

- Data is just numbers, until someone takes the time to look at it, analyse it and turn it into information.

- Having flown over 440 flights and 580 mission areas flown, with the first flight on July 4th 2014, St. Ives Gold Mine, in embracing the UAS, has not only pushed the boundary but redefined it.

- The Drone’s Eye View is the next step forward in data capture.