As the research program for Deep Exploration Technologies CRC (DET CRC) concludes, eight-years after it was established, I feel extremely proud of the outcomes knowing that we achieved what we set out to do – on-time and on-budget.

DET CRC was created to develop cheaper, faster and safer methods of discovering mineral deposits hidden under deep cover. Specifically, we were tasked with addressing the most significant challenge to the future of the minerals industry – the reduction in mineral resources inventory in Australia due to high production rates and low mineral exploration success.

Through DET CRC, we leveraged the expertise and financial support of Government, industry and researchers in a collaborative environment to deliver on our three key research pillars.

The RoXplorer® Coiled Tubing Drill Rig – the showpiece of DET CRC which was honoured with the CRCA Excellence in Innovation award – was taken from a concept, to a design, to pieces of steel and finally, to a working prototype. I think this will prove to be the biggest development in drilling technology since the advent of reverse circulation drilling 50 years ago. DET CRC’s Board has accepted a commercialisation proposal for the RoXplorer® Coiled Tubing Drill Rig from Imdex.

The two other pillars of our three pillars have also delivered. Lab-at-Rig® is successfully providing assay at the drill site and has been licenced to Imdex. The driller-deployed AutoSonde is successfully measuring natural gamma, magnetic susceptibility, resistivity and IP properties of rocks drilled, requiring negligible extra rig time and without the need to mobilise a separate wireline logging crew. The driller-deployed AutoShuttle is successfully measuring spectral gamma properties. Both have been licenced to Boart Longyear.

Our fourth major success has been the Wireless Sub which records drilling parameters and has also been licenced to Boart Longyear. In all of these areas of ‘real-time sensing’ we note recent parallel industry developments and believe the vision articulated by, and success of DET CRC has already significantly influenced the industry.

I’d like to personally thank the many partners who have supported DET CRC over the last eight years. Given some of the issues that have impacted on the sector during that time, it hasn’t always been easy. I’m thankful for the commitment and belief entrusted to us by our Participants and Affiliates, and believe the outcomes we’ve delivered will help build a stronger, thriving minerals exploration industry well into the future.
BACKGROUND
DET CRC was established in 2010 to address one of the most significant challenges facing the minerals industry and more broadly, the Australian economy.

Mineral resources make-up about 50% of the nation’s exports, and yet 80% of Australia’s mineral production is from mines discovered more than 30 years ago.

There are few, if any, remaining major, new mineral deposits to be found in Australia that are exposed at the surface, meaning mineral exploration is moving from Australia to less well explored countries.

With A$155M of cash and in-kind funding from the Government of Australia and supporters, DET CRC was the world’s best-supported independent research initiative in mineral exploration.

Our vision was clear – to develop transformational technologies for successful mineral exploration through deep, barren cover rocks to be utilised and commercialised by the mineral exploration industry, addressing declining mineral resource inventories and enabling continued improvement in global standards-of-living.

DET CRC was focussed on three key areas of innovation:

**DRILLING**
Improving the cost-effectiveness, safety and environmental impact of drilling.

**LOGGING AND SENSING**
Improving analysis of rocks intersected by drilling.

**TARGETING**
Improving early information on the extent of subsurface ore bodies.
1 RoXplorer® Rig
Design, fabrication and deployment of the RoXplorer® coiled tubing drilling system for mineral exploration.

- The RoXplorer® is a revolutionary drill rig for mineral exploration that utilises a continuous, malleable steel coil, removing the need to add individual drill rods as a drill hole deepens, thereby making drilling faster, cheaper and safer, estimated to be 1/6th cost of diamond drilling and 1/3rd cost of reverse circulation drilling.

- RoXplorer®’s drill bit is driven by a motor within the drill string near the base of the hole as opposed to conventional rotation of the entire drill string by the drill rig at the surface.

- Small lightweight rig, small drill pad, fluid recycling (no sumps), and lower consumables (e.g. fuel) all render coiled tubing more environmentally friendly than conventional drilling methods.

2 RoXplorer® Research
Numerical modelling, laboratory analysis and fieldwork to overcome the key challenges to deploying coiled tubing drilling in mineral exploration.

- Increasing from approximately 30 to 1,000 the number of trips in and out of the borehole that coiled tubing can undertake prior to fatiguing, by utilising new materials, positioning the reel directly above the drill hole and numerous other design features.

- Drilling hard rocks with low weight-on-bit using percussion and high speed rotary (full-face diamond) drilling methods driven by downhole motors and turbines.

- Developing fluid systems that can sufficiently clean dirty water and cuttings-loaded recirculated drilling fluids to drive the downhole motors.

- Developing the CTrol® and CTrolX drilling fluids which control fluid loss from the borehole into the formation being drilled.

3 RoXplorer® Trials
Successful field trials of the RoXplorer® coiled tubing drill rig at our Brukunga Drilling Research & Training Facility (South Australia), Port Augusta (South Australia) and Horsham (Victoria).

- The Port Augusta trial demonstrated that the RoXplorer® system can successfully drill the consolidated Adelaidean cover of the Gawler Craton that overlies the Olympic Dam iron-oxide-copper-gold province.

- The Horsham trial demonstrated that the system can successfully drill unconsolidated Murray Basin cover and underlying prospective basement.

- Both trials achieved rates of close to 100 metres per 12 hour shift. This has provided strong encouragement that the aim of $50/metre coiled tubing drilling can be achieved.

- Recovering a geologically representative sample from
RoXplorer® coiled tubing-drilled holes. Assays of the cuttings from the Port Augusta trial show a remarkable match to assays of diamond drill core from an adjacent hole, including across a one metre zone of low grade copper mineralisation at 400 metres depth.

- Operating in temperatures from <0ºC (Horsham) to ~40ºC (Port Augusta).
- Overcoming potential hole deviation problems and drilling straight and vertical holes in the trials.

4 Wireless Sub
Design, fabrication and deployment of the Wireless Sub and associated software. The Wireless Sub is an instrumented connector (‘sub’) that couples the drill rig to the drill string in conventional diamond drilling. It provides measurements of drilling parameters independent of, and more accurately than, the existing gauges on the drill rig in order to monitor and optimise drilling. Field trials at our Brukunga Drilling Research & Training Facility (South Australia), Oberon (NSW) and on the Eyre Peninsula (South Australia) have demonstrated that the Wireless Sub alone can result in an approximately 10% increase in diamond drilling productivity.

5 AutoSonde
- Design, fabrication and deployment of the AutoSonde for acquisition of total count natural gamma, magnetic susceptibility, resistivity and IP (induced polarisation) data from conventional diamond drilled boreholes. The AutoSonde passes through the inside of the drill rods and protrudes beyond the drill bit. Physical property data is acquired as the driller recovers the drill rods. Extensive field testing has shown results consistent with conventional wireline data but at higher resolution.

6 AutoShuttle
- Design, fabrication and deployment of the AutoShuttle for acquisition of spectral natural gamma data from conventional diamond drilled boreholes. The AutoShuttle sits within the core barrel assembly and continuously acquires data during drilling. Both the AutoSonde and AutoShuttle can be deployed by the driller, removing the need to and expense of mobilising a separate wireline logging crew and risk of losing the hole prior to logging. Both operate autonomously meaning there are no wires connecting the tool to the surface. All data captured are transmitted wirelessly to a handheld device on return to the surface. These technologies will both improve the productivity of conventional diamond drilling and were a stepping stone to developing similar downhole sensing technologies for coiled tubing drilling.

7 Lab-at-Rig®
Design, fabrication and deployment of the Lab-at-Rig® for real-time determination of geochemistry and mineralogy from...
diamond drill cuttings at the drill site. Extensive field testing has demonstrated decimetre (~10 cm) fidelity to core and resolution of horizons. Lab-at-Rig® utilises XRF (X-Ray Fluorescence) to determine geochemistry and XRD (X-Ray Diffraction) to determine mineralogy. A prototype Lab-at-Rig® has also been demonstrated for the coarser and wetter coiled tubing drilling samples.

8 Field Trials
Extensive successful field trials of the Wireless Sub, AutoSonde and Lab-at-Rig® technologies in field drilling programs with Geoscience Australia/Geological Survey of Victoria (Stavely, 2014), Anglo-American (Oberon, 2014) and with the Geological Survey of South Australia (Eyre Peninsula, 2015-2016). The trials advanced the technology readiness level of these technologies by one level, generally from ‘Prototype System’ to ‘Demonstration System’. The latter being a level higher than that to which the DET CRC originally intended to develop its technologies.

9 Software for Geochemistry and Mineralogy
SwiftMin® software developed for automated processing of XRD data. GeoLIBS® software developed for improved processing of LIBS (laser-induced breakdown spectroscopy) spectra including reliable sub-ppm gold detection. Progress on GeoPIXE for XRF spectral deconvolution and on software for coupled XRF/XRD inversion. Software suite will facilitate the rapid analysis of samples by Lab-at-Rig® required to keep pace with rapid coiled tubing drilling.

10 EM and Seismic Geophysics
Key developments in electromagnetic and seismic geophysical methods to complement improvements in drilling and sampling.

- Joint inversion of co-located electromagnetic and seismic data improved the resolution of subsurface geophysical modelling leading to more confident geological interpretation and drill hole targeting, including in specific case studies such as the Kevitsa mine (Finland).

- Successful field acquisition of cost-effective seismic data in mineral exploration, notably at the Hillside copper-gold deposit in South Australia, and imaging of steeply dipping structures, notably by pre-stack diffraction imaging.

- Vertical seismic profile successfully acquired using optic fibre distributed acoustic sensors. Data collected ~5 times faster than conventional methods and of higher quality.

- Database of seismic surveys in mineral exploration.
ADDITIONAL MAJOR ACHIEVEMENTS

Inputs
Increased end-user financial cash support from $20.6M (original Commonwealth Agreement Budget) to $33.7M during the lifetime of DET CRC and increased in-kind support from $61.5M to $93.1M, despite the mining downturn of 2011-2016 and the associated collapse in mineral exploration activity.

Industry-Led
Engagement of 63 Participants, Other Participants and Affiliates with a very strong industry focus as witnessed by the following.

– Head Office embedded in industry.
– ~30% of research funds flowing to industry.
– Engagement with 110 industry-based researchers (~27 cash-funded industry FTE person years and ~78 in-kind FTE person years), comprising approximately one third of DET CRC’s total research FTE.
– Strong engagement of industry in the Science Steering Committee and on project reviews.
– Approximately half of the attendees at each annual conference being from industry.

Communications
A successful communications program with, for example, 43,000 views of 81 videos on DET CRC’s YouTube Channel.

Students
Completion of 36 postgraduate research students to-date (and another 7 theses submitted) and training of 407 driller trainees.

Prospecting Drilling
The RoXplorer® coiled tubing drill rig combined with DET CRC’s other new technologies will open the Gawler Craton, Murray Basin, and indeed the ~70% of Australia where mineral deposits are hidden by barren cover rocks, to ‘prospecting drilling’ which will enable progressive vectoring towards concealed mineral deposits using multiple, cheap holes in a single drilling campaign.

Technology Awards
DET CRC awarded an annual prize for the best technological advance based on the following criteria:

– degree of innovation and technical challenge overcome;
– relevance to DET CRC’s core purpose and vision, and;
– positive impact on sponsor’s view of DET CRC.

The awardees were as follows.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TECHNOLOGY</th>
<th>PROGRAM</th>
<th>PROJECT PARTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>CTrol® and CToI® Drilling Fluids</td>
<td>Program 1</td>
<td>Boart Longyear, Curtin University, CSIRO, Imdex</td>
</tr>
<tr>
<td>2016</td>
<td>RoXplorer®</td>
<td>Program 1</td>
<td>Boart Longyear, Curtin University, CSIRO, Imdex</td>
</tr>
<tr>
<td>2015</td>
<td>Wireless Sub</td>
<td>Program 1</td>
<td>Boart Longyear, CSIRO, Epslog, Globaltech</td>
</tr>
<tr>
<td>2014</td>
<td>Lab-at-Rig® Sample Handling and Sensor System</td>
<td>Program 3</td>
<td>CSIRO, Curtin University, Imdex, Olympus, University of Adelaide</td>
</tr>
</tbody>
</table>

~27 CASH-FUNDED INDUSTRY FTE PERSON YEARS
43K VIEWS ON YOUTUBE
~78 IN-KIND INDUSTRY FTE PERSON YEARS
The RoXplorer® coiled tubing drilling system provides cheaper, faster, safer and more environmentally friendly drilling, estimated to be one sixth of the cost of conventional diamond drilling and one third of the cost of conventional reverse circulation drilling. The RoXplorer® coiled tubing drilling system was the recipient of a CRC Association ‘Excellence in Innovation’ Award in May 2018.

The CRC has delivered an excellent series of outputs through the step change in drilling technology, drill sensing ability and the real-time, or near real-time analytical technologies. It has also trained a new generation of earth scientists and engineers in these novel technologies.

ALAN COLLINS
UNIVERSITY OF ADELAIDE
WEIGHT (without the coiled tubing reel)
12,471 kg

NUMBER OF ELECTRICAL CONNECTIONS
753

LITRES OF DRILLING FLUID IN ROXPLORER®’S 500M COIL
475

HEIGHT
10.60 m

NUMBER OF HYDRAULIC HOSES
241

MAN HOURS TAKEN TO ASSEMBLE
4,481 hrs

MAXIMUM SPEED
5 kph

LITRES OF HYDRAULIC FLUID
759

LINES OF CODE IN ROXPLORER®’S CONTROLLER AND OPERATOR CONSOLE
3,553
ECONOMIC IMPACT
ECONOMIC IMPACT
FINANCE SNAPSHOT

LIFETIME INCOME

DET CRC
LIFETIME INCOME
$61.8M

Olympus $400,000
Vale $2,667,000
BHP Billiton $3,600,000
Barrick Gold $3,600,000
Anglo American $3,600,000
Geological Survey of SA $3,500,000
Grants/Other Income $2,667,000
Newcrest $2,305,000
Affiliates $2,205,000
Gold Fields $2,063,000
Geoscience Australia $1,665,000
Interest $1,341,000
Imdex $1,200,000
Boart Longyear $1,200,000
Curtin University $610,000
CSIRO $250,000
CRC Program $28,000,000
- 22
### Lifetime Expenditure

**Total Lifetime Expenditure:** $61.7M

- **Head Office:** $5,183,000
- **CSIRO:** $12,422,000
- **Boart Longyear:** $11,931,000
- **Curtin University:** $6,518,000
- **Centrally Expended Research Costs:** $5,183,000
- **Education:** $3,819,000
- **University of Adelaide:** $3,704,000
- **Globatech:** $1,638,000
- **Teakie Composites:** $1,049,000
- **Annual Conference:** $785,000
- **UniWA:** $543,000
- **Imdex:** $485,000
- **Commercialisation:** $476,000
- **Olympus:** $365,000
- **UniTas:** $50,000
- **Geoscience Australia:** $265,000
- **Epslog:** $114,000
- **GSSA:** $95,000
- **UniSA:** $192,000
ECONOMIC IMPACT
ECONOMIC BENEFITS
OF DET CRC’S TECHNOLOGY

Coiled Tubing Drilling

The economic benefit of DET CRC’s coiled tubing drilling system can be considered in three ways:

01

Value of savings to drilling costs which can be estimated.

**SAVINGS**

A$140M EACH YEAR BY REPLACING HALF OF AUSTRALIA’S DIAMOND DRILLING

OR

2.5 METRES DRILLED TIMES OR

1.4M METRES ADDITIONAL DRILLING IN AUSTRALIA EACH YEAR.

02

Value of new discoveries resulting from lower drilling costs, which can be estimated, but with significant uncertainty.

**DISCOVERIES**

2.5 EXTRA MODERATE DISCOVERIES EACH YEAR IN AUSTRALIA

OR

VALUE OF DISCOVERIES

US$200M EXTRA IN VALUE EACH YEAR IN AUSTRALIA

US$2BN EXTRA OVER 10 YEARS IN AUSTRALIA

US$16BN EXTRA OVER 10 YEARS GLOBALLY

03

Value of discoveries due to a new approach to mineral exploration, which cannot be estimated.

**SAFETY**

50% OF WORKPLACE INJURIES WILL BE ELIMINATED

AND

CO₂ EMISSIONS AND SURFACE CONTAMINATION RISKS SIGNIFICANTLY REDUCED
These figures do not make any allowance for smarter mineral exploration due to, for example, improved knowledge of the distal footprints of mineral deposits that result from additional coiled tubing drilling. It also doesn’t attempt to place an economic benefit on the AutoSonde and AutoShuttle (for real-time downhole determination of rock properties), or on the Lab-at-Rig® (for real-time top-of-hole determination of geochemistry and mineralogy). The AutoSonde, AutoShuttle and Lab-at-Rig® replace existing technologies at lower cost, but the savings will be smaller than those outlined above and their real value is in the routine collection of more and better quality data to assist smarter mineral exploration, the value of which cannot be reasonably quantified.

The way industry has interacted, and CRC management/researchers have responded to industry priorities was a major highlight compared to historical industry-university research interaction.

TONY BELPERIO
MINOTAUR EXPLORATION

BASED ON A 10% INCREASE IN THE PRODUCTIVITY OF CONVENTIONAL DIAMOND DRILLING

A$38M EACH YEAR
The South Australian Government has been one of DET CRC’s key supporters. Headquartered in Adelaide, DET CRC provided significant benefits to the State during its eight-year lifespan.

<table>
<thead>
<tr>
<th>Benefits to the South Australian Government</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$6M</strong> cash invested by South Australian Government</td>
</tr>
<tr>
<td><strong>200+</strong> South Australian companies collaborated with or supplied services to DET CRC</td>
</tr>
<tr>
<td><strong>$31M</strong> cash expenditure in South Australia</td>
</tr>
<tr>
<td><strong>407</strong> driller trainees at the Brukunga Drilling Research &amp; Training Facility</td>
</tr>
<tr>
<td><strong>265</strong> FTE years of employment in mining services and advanced manufacturing</td>
</tr>
<tr>
<td><strong>20 PhD</strong> students supported with scholarships</td>
</tr>
<tr>
<td><strong>43</strong> completed Honours research projects and 3 completed coursework Masters research projects</td>
</tr>
<tr>
<td><strong>8000</strong> metres drilled in Gawler Craton</td>
</tr>
</tbody>
</table>
80% of South Australia covered by barren rocks and requiring DET CRC’s new technologies for exploration.

20 South Australian based suppliers involved in fabrication of the world’s first coiled tubing drill rig for mineral exploration in South Australia.

5 conferences for national and international delegates with an average of 150 attendees at each, providing significant benefits for numerous local suppliers.

Mineral Systems Drilling Program

$8M cash and in-kind Mineral Systems Drilling Program (MSDP) developed from $2.5M cash contribution from the South Australian Government.

100 South Australian based suppliers supported by MSDP.

The Mineral Systems Drilling Program uncovered new mineralised provinces in the Gawler Craton, uncovered the new technologies required to explore beneath barren cover and built collaboration between junior explorers, METS sector, government and research organisations in South Australia.
COMMERCIALISATION AND UTILISATION

DETCRC UNCOVERING THE FUTURE

29 -
It was never the intention of DET CRC to commercialise via spin-off companies. Mining companies wished IP to be commercialised via licensing agreements with existing METS companies.

DET CRC’s rights and obligations with respect to the above mentioned commercialisation licence agreements and in the associated background IP and royalty agreements will be assigned to MinEx CRC consistent with the approach outlined in the Wind-Up Plan.

Licencing Agreements relating to the AutoSonde, AutoShuttle, Lab-at-Rig®, Wireless Sub and the RoXplorer® coiled tubing drilling system are expected to have the greatest impact on the mineral exploration industry and revenue generation.
 Progress of DET CRC’s key technologies through Technology Readiness Levels

<table>
<thead>
<tr>
<th>THREE PILLARS</th>
<th>ADDITIONAL KEY TECHNOLOGIES &amp; THREE PILLAR DEVELOPMENTS</th>
<th>INCOMPLETE TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Rig</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total y Auto-Sonde</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XRF &amp; XRD Lab-at-Rig®</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full commercial application 9 role of commercialiser (ROC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>First of a kind commercial system 8 role of commercialiser (ROC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstration system (e.g MSDP) 7 2017 2017 2016</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prototype system (e.g Brukunga) 6 2016 2016 2015</td>
<td>2015 2017 2017 2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lab-at-Rig Percuss’n</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LIBS for Lab-at-Rig</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Composite Rods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Rod Handling</td>
</tr>
</tbody>
</table>

Role of commercialiser (ROC)

No further progress

**Progress of DET CRC’s key technologies through Technology Readiness Levels**

**DETCRC UNCOVERING THE FUTURE**
COMMERCIALISATION AND UTILISATION
The Lab-at-Rig®, while not yet a fully commercial product, was a model collaborative research project involving research organisations, industry suppliers and industry end-users.

The Lab-at-Rig® was an 18-month, $1M cash, $2M in-kind ‘Opportunity Fund’ Project to produce a prototype top-of-hole analysis system for diamond drilling. The technology is a world-first, delivering near real-time analysis of geochemistry and mineralogy of the cuttings from diamond drilling, thereby facilitating rapid decision-making in mineral exploration. The project brought together a research team from CSIRO, Imdex and Olympus.

Project management was strongly influenced by the industry partners and was best practice at each stage including work undertaken to scope the project, landscape reviews of existing technologies and to confirm freedom to operate. The outputs of the project, in addition to the demonstrated prototype, included a detailed Opportunity Assessment Report and Technology Transfer Pack suitable for a commercialiser to assess the business opportunity. The technology was offered for commercialisation in October 2014. A commercialisation proposal from Imdex was accepted in January 2015 and a licence agreement was executed in September 2015.

The Lab-at-Rig® was extensively deployed by Imdex on the Geological Survey of South Australia funded Mineral Systems Drilling Program in 2015 and 2016. This provided an invaluable opportunity to build confidence in the technology as well as undertake product development with a ‘friendly’ client.

In 2016 Imdex entered into a ‘Kickstarter Agreement’ with Barrick Gold whereby the two companies (a supplier and an end-user) now have a strategic relationship to further develop and deploy the technology. A pre-commercial trial of Lab-at-Rig® was carried out by Imdex at a Barrick site in Nevada during 2017. This trial fed into a process of value modelling conducted jointly between Imdex and Barrick and has led to a decision to automate the technology. The initial stages of this automation work is now underway.

There is great potential for the technology to be applied to other forms of drilling other than diamond drilling, including Reverse Circulation (RC) drilling and to Coiled Tubing (CT) drilling.
## REGISTERED IP

**DET CRC’s patent portfolio.**

<table>
<thead>
<tr>
<th>TITLE</th>
<th>PROJECT</th>
<th>COUNTRY</th>
<th>APPLICATION NO.</th>
<th>PRIORITY DATE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole Logging Methods and Apparatus</td>
<td>AutoSonde</td>
<td>International</td>
<td>2013904475</td>
<td>19 Nov 2013</td>
<td>Managed by Boart Longyear. Patent applications lodged in numerous countries</td>
</tr>
<tr>
<td>Sampling and Analysis System and Method for use in Exploration Drilling</td>
<td>Lab-at-Rig®</td>
<td>International</td>
<td>2014904646</td>
<td>19 Nov 2014</td>
<td>Managed by Imex: Patent applications lodged in numerous countries</td>
</tr>
<tr>
<td>Drying apparatus and related method</td>
<td>Lab-at-Rig®</td>
<td>International</td>
<td>2014904649</td>
<td>19 Nov 2014</td>
<td>Managed by Imex: Patent applications lodged in numerous countries</td>
</tr>
<tr>
<td>Capture of drilling fluid returns</td>
<td>Lab-at-Rig®</td>
<td>Australia</td>
<td>2015903272</td>
<td>14 Aug 2015</td>
<td>Managed by Imex: Patent applications lodged in numerous countries</td>
</tr>
<tr>
<td>High Speed Downhole Coring System</td>
<td>RoXplorer® CT Rig</td>
<td>Australia</td>
<td>2017101088</td>
<td>10 Aug 2017</td>
<td>Managed by DET CRC: Innovation patent granted</td>
</tr>
<tr>
<td>Mobile Coiled Tubing Apparatus</td>
<td>RoXplorer® CT Rig</td>
<td>International</td>
<td>2017050508</td>
<td>18 Jan 2017</td>
<td>Managed by Imex: PCT application submitted</td>
</tr>
<tr>
<td>Sample Collection System and Parts Thereof</td>
<td>RoXplorer® CT Rig</td>
<td>Australia</td>
<td>2017903541</td>
<td>1 Sep 2017</td>
<td>Managed by Imex: Provisional application submitted</td>
</tr>
<tr>
<td>Rotary Drill Head for Coiled Tubing Drilling Apparatus</td>
<td>RoXplorer® CT Rig</td>
<td>International</td>
<td>2017051098</td>
<td>11 Oct 2017</td>
<td>Managed by Imex: PCT application submitted</td>
</tr>
<tr>
<td>Drilling Fluids and Uses Thereof</td>
<td>RoXplorer® CT Rig</td>
<td>Provisional</td>
<td>2018901763</td>
<td>21 May 2018</td>
<td>Managed by Imex: Provisional application submitted</td>
</tr>
</tbody>
</table>
### DET CRC’s registered design portfolio.

<table>
<thead>
<tr>
<th>TITLE</th>
<th>PROJECT</th>
<th>COUNTRY</th>
<th>APPLICATION NO.</th>
<th>PRIORITY DATE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluids Capture Apparatus 1</td>
<td>Lab-at-Rig®</td>
<td>Australia</td>
<td>201514172</td>
<td>14 Aug 2015</td>
<td>Registered, managed by Imdex</td>
</tr>
<tr>
<td>Fluids Capture Apparatus 2</td>
<td>Lab-at-Rig®</td>
<td>Australia</td>
<td>201514173</td>
<td>14 Aug 2015</td>
<td>Registered, managed by Imdex</td>
</tr>
<tr>
<td>Mobile Coiled Tubing Apparatus</td>
<td>RoXplorer® CT Rig</td>
<td>International</td>
<td>201710287</td>
<td>18 Jan 2017</td>
<td>Registered, various countries, managed by Imdex</td>
</tr>
<tr>
<td>A Cone Member for a Cone Splitter</td>
<td>RoXplorer® CT Rig</td>
<td>Australia</td>
<td>201715232</td>
<td>1 Sep 2017</td>
<td>Registered, managed by Imdex</td>
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</tbody>
</table>

### DET CRC’s trademark portfolio.

<table>
<thead>
<tr>
<th>TITLE</th>
<th>COUNTRY</th>
<th>APPLICATION NO.</th>
<th>CLASSES</th>
<th>FILING DATE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DET CRC Logo</td>
<td>Australia</td>
<td>1410230</td>
<td>37, 42 &amp; 45</td>
<td>22 Feb 2011</td>
<td>Registered, managed by DET CRC</td>
</tr>
<tr>
<td>Lab-at-Rig®</td>
<td>Australia</td>
<td>1581982</td>
<td>7, 9, 37 &amp; 42</td>
<td>23 Sep 2013</td>
<td>Registered, managed by Imdex</td>
</tr>
<tr>
<td>RoXplorer®</td>
<td>Australia</td>
<td>1664080</td>
<td>7, 37</td>
<td>11 Dec 2014</td>
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</tr>
<tr>
<td>GeoLIBS®</td>
<td>Australia</td>
<td>1754508</td>
<td>9 &amp; 42</td>
<td>24 Feb 2016</td>
<td>Registered, managed by DET CRC</td>
</tr>
<tr>
<td>SwiftMin®</td>
<td>Australia</td>
<td>1825962</td>
<td>9 &amp; 42</td>
<td>15 Feb 2017</td>
<td>Pending</td>
</tr>
<tr>
<td>CTrol®</td>
<td>Australia</td>
<td>11827061</td>
<td>1</td>
<td>21 Feb 2017</td>
<td>Registered, managed by Imdex</td>
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</tbody>
</table>
INTERNATIONAL IMPACT AND ENGAGEMENT
# INTERNATIONAL IMPACT AND ENGAGEMENT

During its lifetime, DET CRC had global reach and engagement that included:

<table>
<thead>
<tr>
<th>Country</th>
<th>Collaboration and Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canada</strong></td>
<td>- Annual sponsor updates at Prospectors &amp; Developers Association of Canada</td>
</tr>
<tr>
<td></td>
<td>- Technical input into projects from Barrick Gold and provision of samples to assist Lab-at-Rig® Futures Project</td>
</tr>
<tr>
<td></td>
<td>- Technical input into projects from Vale</td>
</tr>
<tr>
<td></td>
<td>- Worked with First Quantum Minerals on the provision of Kevitsa reflection dataset</td>
</tr>
<tr>
<td></td>
<td>- Sensor design for AutoSonde and AutoShuttle with University Laval</td>
</tr>
<tr>
<td></td>
<td>- Worked with the University of Alberta on hyperspectral characterisation of mineral systems</td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td>- Collaboration with Tenaris Coiled Tubing on the development of the coiled tubing</td>
</tr>
<tr>
<td></td>
<td>- Development of sensor technologies for Lab-at-Rig® with Olympus USA</td>
</tr>
<tr>
<td></td>
<td>- Extended deployment of prototype RoXplorer® by Imex, Barrick Gold and DET CRC</td>
</tr>
<tr>
<td></td>
<td>- Development of sample handling system for Lab-at-Rig® with Honeybee Robotics</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with Tempress Technologies for development of downhole turbines for RoXplorer® coiled tubing rig</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with DataDrill on the development of downhole data capture for CT Rig</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with Power Hydraulics on the development of the reel for CT Rig</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with Tempress Technologies on the development of turbines for the CT Rig</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with Drilex on the development of drilling motors for CT Rig</td>
</tr>
<tr>
<td><strong>United Kingdom</strong></td>
<td>- Collaboration on the development of drilling motors for CT Rig with Toro Downhole Tools</td>
</tr>
<tr>
<td></td>
<td>- Extensive collaboration with Boart Longyear to develop novel bits for coiled tubing drilling</td>
</tr>
<tr>
<td></td>
<td>- Collaboration with Cobra Downhole on the development of drilling motors for the CT Rig</td>
</tr>
<tr>
<td><strong>Belgium</strong></td>
<td>- Design strain gage amplifier/signal conditioner module of the Wireless Sub with Nomics SA</td>
</tr>
</tbody>
</table>

During its lifetime, DET CRC had global reach and engagement that included:

**INTERNATIONAL IMPACT AND ENGAGEMENT**
Switzerland
Collaboration with Wassara on development of hammer technologies for CT Rig

Work on seismic reflection dataset at Neves Corvo with Lundin Mining

Work on Kevitsa reflection dataset with the University of Uppsala

Adelaide Hills
Brukunga Drilling Research & Training Facility

Gawler Craton, South Australia
World-first Minerals Systems Drilling Program

RoXplorer® coiled tubing rig field trial

Stavely, Victoria
RoXplorer® coiled tubing rig field trial and early concept Lab-at-Rig trial

Adelaide, Australia
DET CRC headquarters

Pilbara, Western Australia
Field trials of the AutoSonde

Oberon, NSW
Trials of the Wireless Sub, Autosonde and Lab-at-Rig

New Zealand
Collaboration with Flexidrill on trials of downhole tooling

South Africa
Samples from Anglo-American from Kumba iron ore mine analysed by XRD and LIBS techniques

Technical input into projects from Anglo-American and provision of samples to assist Lab-at-Rig® Futures Project

Ukraine
Provision of scintillation crystals for AutoSonde and AutoShuttle from Institute of Single Crystals

Finland
Use of joint inversion of co-located electromagnetic and seismic data in Kevital mine

Italy
Collaboration on the development of a water pump for the CT Rig with Interpump Group

Sweden

Australia
DET CRC headquarters

Pilbara, Western Australia
Field trials of the AutoSonde

Adelaide, Australia
DET CRC headquarters
SME ENGAGEMENT
DET CRC’s key engagement activity with SMEs was the Affiliate program. There were three groups of Affiliates (known as Colleges). Junior mining or exploration companies (defined as those with market capitalisation of less than $1BN, all of which are SMEs as defined by <200 employees) constituted one college. METS (Mining, Equipment, Technology and Services) suppliers constituted the second college and geological surveys (who are Commonwealth and State government agencies) constituted the third college. Each college was entitled to a vote on the Science Steering Committee equal with that of each of the Essential Participants. Each Affiliate paid a $10,000 membership fee each year.

Affiliates engaged with DET CRC through:

- Accessing the network of mining companies, supplier companies, geological surveys and research organisations participating in the CRC
- Understanding the R&D priorities of the major mining company and geological survey sponsors
- Utilising the Brukunga Drilling Research & Training Facility
- Utilising research outcomes
- Being an active Project Party and receiving funding for research
- Of DET CRC’s 47 Affiliates over its lifetime, 33 were SMEs.

### AFFILIATE JUNIOR EXPLORER SME’S

- ABM Resources
- Blackthorn Resources
- Carpentaria Exploration
- Heathgate
- Investigator Resources
- Kingston Resources
- Minotaur Exploration
- Nautilus Minerals
- Monax Exploration
- Paladin
- Rex Minerals

### AFFILIATE SUPPLIER SME’S

- Australian Drilling Industry Association (ADIA)
- Australian Training Alliance (ATA)
- CSA Global
- Century Engineering
- Corporaal Enterprises
- Diarotech
- Downhole Surveys
- Diamant
- Drillco Tools
- Epslog
- Flexidrill
- GeoMole
- Globaltech Downunder
- Hardcore Diamond Products
- HiSeis
- ioGlobal
- JKTech
- Leapfrog
- SAGE Automation
- Teakle Composites
- Training Prospects
- Wassara
Key SME outcomes
HiSeis, an Affiliate Supplier SME, licenced three technologies from DET CRC related to seismic exploration techniques and is developing these technologies into commercial products and services.

Another Affiliate Supplier SME, Globaltech was a key research party in the Wireless Sub and AutoSonde/AutoShuttle projects. Globaltech received in excess of $1M research funding from DET CRC. In the course of DET CRC, Participant Supplier Boart Longyear developed a strategic relationship with Globaltech and took a significant shareholding in the company.

Teakle Composites has expertise in composite materials which was utilised for the development of composite fibre drill rods and coiled tubing. Teakle Composites received in excess of $1M research funding from DET CRC and as a direct result was able to build its capacity by obtaining specialised equipment such as a pultrusion winding machine and by taking on additional personnel. New steel coiled tubing products were in the end selected for the RoXplorer® rig, but composites remain an exciting area for future research.

Wassara, an Affiliate Supplier SME, has developed specialised water-driven downhole drilling hammers and an underground coiled tubing system to drill blast holes in Swedish iron ore mines. DET CRC utilised the Wassara water hammer system in our greenfields, exploration-focused RoXplorer® coiled tubing drilling system. There was also extensive collaboration between DET CRC and Wassara regarding water-driven downhole hammers and the application of coiled tubing drilling to mineral exploration and mining.

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New Zealand-based Affiliate Supplier SME, FlexiDrill tested its high frequency drilling motors at the Brukunga Drilling Research & Training Facility. Affiliate SME Suppliers, the Australian Training Alliance (ATA) and Training Prospects offered a practical element to their VET courses by utilising the Brukunga Drilling Research & Training Facility, including access to Boart Longyear’s drilling rig and drilling crew. Over 400 trainees utilised the Brukunga Drilling Research & Training Facility during the lifetime of DET CRC.

The biggest news in decades in the mineral exploration industry arrived quietly last month with the unveiling of the RoXplorer drill rig.

DAVID UPTON JOURNALIST
DET CRC allocated $3.8M to Education and Training, principally via $75,000 to the host university per PhD student and $50,000 per Masters by Research student enrolled with DET CRC support. A $3,000 bonus was awarded to PhD students on completion and a $2,000 bonus to Masters by Research students.

DET CRC had the goal of completing 40 postgraduate research students, a goal that will be achieved. To-date the status of DET CRC’s postgraduate research students is:

- **59** POSTGRADUATE RESEARCH STUDENT COMMENCEMENTS
  - 53 PHDS + 6 MASTERS
- **40** POSTGRADUATE RESEARCH STUDENT COMPLETIONS
  - 37 PHDS + 3 MASTERS
- **2** POSTGRADUATE RESEARCH THESIS UNDER EXAMINATION
  - 2 PHDS + 0 MASTERS

**Dr Masood Mostofi** (Project 1.2 PhD student)

Dr Masood Mostofi attained a Bachelor and Master of Drilling Engineering from the Petroleum University of Technology of Iran, and also holds a Master of Petroleum Engineering from Curtin University. After working in two research centres in Iran, Masood undertook a PhD at Curtin University from 2011-2014 in DET CRC Project 1.2. Masood’s project investigated the drilling response of impregnated diamond bits through modelling and experimental investigation. The results of this research were used in the second phase of DET CRC for development of interpretation software for drilling action of impregnated diamond bits. Masood received a top-up scholarship from MRIWA at 2015, and the quality of Masood’s research was highlighted when he received a Dean’s Commendation for his Doctoral Thesis in 2014. Masood is now a Lecturer at the Curtin University WA School of Mines where he teaches undergraduate and postgraduate students in drilling engineering fundamentals. Since completing his postgraduate studies, Masood has stayed strongly connected with DET CRC and has become a key researcher within DET CRC Project 1.1 investigating borehole stability, borehole erosion and particle tracking in the coil tubing drilling system. Masood played an integral role in the DET CRC RoXplorer® field trials at Port Augusta and Horsham through his research into drilling fluid properties and fluid management system associated with the coiled tubing drill rig. Masood has supervised eight DET CRC postgraduate students, three of whom have qualified for their postgraduate degree.

“It has been a great opportunity for me to be part of DET CRC, and I am very happy that I can continue my work and research in this community.” Dr Masood Mostofi
Commencements and completions by University and School/Department at June 2018

- **Petroleum Engineering**
  - Curtin University
  - Commencements: 18
  - Completions: 9

- **Civil, Environmental & Mining Engineering**
  - University of Adelaide
  - Commencements: 7
  - Completions: 7

- **Exploration Geophysics**
  - Curtin University
  - Commencements: 17
  - Completions: 11

- **Earth Sciences**
  - University of Adelaide
  - Commencements: 13
  - Completions: 10

- **Civil, Environmental & Mining Engineering**
  - University of WA
  - Commencements: 4
  - Completions: 3
Annual Student Prize winners
An Annual Student Prize was awarded for the best one-minute presentation and poster at the Annual Conference. The winning student accompanied the DET CRC team to the world’s biggest mineral exploration-related conference, the PDAC Convention (Prospectors & Developers Association of Canada) in Toronto with all their expenses being met by DET CRC. The winners have been as follows.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>STUDENT</th>
<th>PROGRAM</th>
<th>DEGREE</th>
<th>UNIVERSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Stephanie McLennan</td>
<td>3</td>
<td>Earth Sciences</td>
<td>University of Adelaide</td>
</tr>
<tr>
<td>2012</td>
<td>Amir Mokaramian</td>
<td>1</td>
<td>Petroleum Engineering</td>
<td>Curtin University</td>
</tr>
<tr>
<td>2013</td>
<td>Sebastian Schnaidt</td>
<td>2</td>
<td>Earth Sciences</td>
<td>University of Adelaide</td>
</tr>
<tr>
<td>2014</td>
<td>Mohammad Hossain</td>
<td>3</td>
<td>Exploration Geophysics</td>
<td>Curtin University</td>
</tr>
<tr>
<td>2015</td>
<td>Stuart Addinell</td>
<td>1</td>
<td>Petroleum Engineering</td>
<td>Curtin University</td>
</tr>
<tr>
<td>2016</td>
<td>Eline Baudet</td>
<td>3</td>
<td>Earth Sciences</td>
<td>University of Adelaide</td>
</tr>
<tr>
<td>2017</td>
<td>Hongyang Zhang</td>
<td>1</td>
<td>Petroleum Engineering</td>
<td>Curtin University</td>
</tr>
</tbody>
</table>
Honours students have undertaken the research component of their degrees on DET CRC-related research projects.

Driller trainees accessed the Brukunga Drilling Research and Training Facility in 28 courses largely at the Certificate II Level.

Masters by Coursework students have undertaken the research component of their degrees on DET CRC-related research projects.

Postgraduate research students have had industry co-supervisors.

Drillers, driller assistants and field technicians trained in the use of DET CRC’s new technologies.

Note data correct as of May 2018.
PARTICIPANTS AND COLLABORATIONS
Participants

There was a total of 63 Participants, Other Participants and Affiliates engaged by DET CRC, with very strong industry collaboration achieved through:

- Head office embedded in industry
- Approximately 30% of research funds flowed to industry
- Engagement with 110 industry-based researchers (approximately 27 cash-funded industry FTE person years and approximately 78 in-kind FTE person years), which corresponded to about one third of DET CRC’s staffing both in terms of individuals and FTE years.
- Strong engagement of industry in the Science Steering Committee and on project reviews
- Approximately half of annual conference attendees from industry.

**Det CRC had 16 Participants and Other Participants over its lifetime**

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglo American</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Barrick Gold</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>BHP</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Boart Longyear</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Geological Survey of South Australia</td>
<td>Participant</td>
<td>2010-2014</td>
</tr>
<tr>
<td>Gold Fields</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Imdex</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Newcrest Mining</td>
<td>Participant</td>
<td>2010-2015</td>
</tr>
<tr>
<td>Vale</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Curtin University</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>University of Adelaide</td>
<td>Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>University of South Australia</td>
<td>Participant</td>
<td>2017-2018</td>
</tr>
<tr>
<td>Geoscience Australia</td>
<td>Other Participant</td>
<td>2011-2018</td>
</tr>
<tr>
<td>Olympus</td>
<td>Other Participant</td>
<td>2013-2018</td>
</tr>
<tr>
<td>University of Western Australia</td>
<td>Other Participant</td>
<td>2011-2018</td>
</tr>
</tbody>
</table>
DET CRC, with its end-user driven collaboration of METS companies, miners, government (geological surveys) and research institutions, helped meet the aims of METS Ignited Sector Competitiveness Plan.

Relevant Publications by Participants
There have been 236 formal publications by Participants during the lifetime of DET CRC. Much of DET CRC’s work remains unpublished due to its commercial-in-confidence nature and DET CRC’s Centric Project Management Systems contains 1,153 documents.

In addition to uncovering new technologies, DET CRC helped uncover new relationships both within Australia’s METS sector and between Australia’s METS Sector and research organisations. These relationships will outlive DET CRC and are part of a significant ‘soft’ legacy that adds to the ‘hard’ legacy of the new technologies that DET CRC has developed.

Australia’s Mining Equipment Technology and Services (METS) Sector contributes over $90 billion in gross annual revenue to the country’s prosperity. It exports over $15 billion of products and services to every corner of the globe and invests $4 billion in R&D.
PARTICIPANTS AND COLLABORATIONS
The AutoSonde and AutoShuttle are downhole sensing technologies that add value to conventional diamond drilling. They permit key information on the physical properties of the rocks that a borehole has intersected to be determined by the drilling crew in the routine course of drilling. Previously such data required a separate wireline logging crew to be mobilised to often remote drill sites, costing significant time and expense, and with the risk that the borehole may collapse prior to vital information being obtained.

The AutoSonde and AutoShuttle:
- Were developed collaboratively by scientists and engineers from Curtin University and Perth-based METS SME Globaltech.
- Have been licenced by Boart Longyear, one of the world’s biggest drilling companies.

In the course of the project:
- Boart Longyear acquired a significant shareholding in Globaltech.
- Globaltech moved its offices to co-locate with Boart Longyear’s Forrestfield Facility in Perth.
- Globaltech negotiated the manufacturing rights for TRUPROBE, Boart Longyear’s commercial version of the AutoSonde, creating new high technology, METS sector employment in Australia.
- Boart Longyear sponsored a Chair in Geophysical Instrumentation at Curtin University held by the leader of DET CRC’s AutoSonde and AutoShuttle project, Professor Anton Kepic.
PARTICIPANTS AND COLLABORATIONS
The Lab-at-Rig® analyses rock cuttings from drilling, determining both their geochemistry (i.e. assay) and mineralogy. Its near real-time assay can preclude months of delays and enable instant decisions on extending or terminating holes, or drilling new holes, without demobilising and remobilising drill rigs and their crews to remote areas.

**The Lab-at-Rig®:**
- Did not exist in DET CRC’s original research roadmap and developed as research evolved due to interactions between researchers from CSIRO, Olympus and the participant mining companies.
- Commenced as an Opportunity Fund project to deliver a prototype system which was developed collaboratively by scientists and engineers from CSIRO, Imdex and Olympus and in the end constituted one of DET CRC’s key projects.
- Was licenced by Imdex, a Perth-based METS company specialising in drilling fluids, downhole instrumentation, geoscience technologies and data analytics and after licensing underwent extensive pre-commercial field trialling at Participant, Barrick Gold’s site in Nevada.

**In the course of the project:**
- Olympus elevated their membership from Affiliate to Other Participant, which delivered extra cash and in-kind resources to the project.
- Imdex acquired then Affiliate ioGlobal which produces industry-leading software for analysis of geochemical data and cloud-based data management systems.
- Imdex recruited then Project Leader for the Lab-at-Rig® project, James Cleverley, from CSIRO.
- Imdex developed a commercial relationship with Olympus for the rental and use of portable XRF analysers as part of their real-time geochemical analysis solutions.
- Australian-based Imdex’s development and support of Lab-at-Rig® will help to grow METS sector employment and exports.
PARTICIPANTS AND COLLABORATIONS
DET CRC originally planned to develop technologies to the level of demonstrating prototypes at the Brukunga Drilling Research & Training Facility prior to offering them for commercialisation. While invaluable, the Brukunga Drilling Research & Training Facility only provides one particular set of subsurface (geological) conditions within which drilling and sensing technologies can be tested. Furthermore, activities there are not subject to the time pressures of operational drilling where there is a strong focus on maximising the number of metres drilled per day. Hence, in order to advance technologies further towards commercial products, field drilling and technology testing programs such as the Stavely Drilling Program and Mineral Systems Drilling Program were undertaken.

One of DET CRC’s major activities in 2014-2015 was the Stavely Drilling Program. Geoscience Australia and the Geological Survey of Victoria wished to undertake drilling in the relatively poorly geologically known Stavely Province of western Victoria in order to improve knowledge of the mineral potential of the area. DET CRC collaborated with Geoscience Australia and the Geological Survey of Victoria in order that the drilling project was also used to trial DET CRC’s new technologies. Boart Longyear undertook the drilling and assisted with the deployment of DET CRC’s technologies.

Fourteen holes were drilled in the program with in excess of 1km of sonic drilling and in excess of 1km diamond drilling. The University of Melbourne contributed additional funding to deepen one of the holes in the program in order to undertake palaeoclimatic studies. By ‘piggy-backing’ on the existing drilling project, the University of Melbourne was able to avoid mobilisation and site remediation charges and Geoscience Australia received additional core from the deepened hole at no extra cost to them.

The key technologies deployed by DET CRC were its Lab-at-Rig® and AutoSonde. Lab-at-Rig® routinely provided geochemical and mineralogical data to Geoscience Australia and the Geological Survey of Victoria that was also uploaded to the REFLEX Hub (Imdex’s cloud-based data storage/analytics system). The availability of near real-time geochemical and mineralogical data was greatly valued by the geologists from Geoscience Australia and Geological Survey of Victoria and enhanced their analysis of the core recovered. The majority of holes were also logged by the AutoSonde, providing a log of the natural gamma radiation of rocks intersected by the holes.

The program was successful and contributed to the more rapid development and field-testing of DET CRC’s new technologies. Prolonged field-testing was invaluable for modifying and ruggedizing the technologies for field operation and the research teams learnt invaluable lessons on the operation of the technologies. It was also an excellent example of inter-organisational cooperation involving Boart Longyear, CSIRO, Curtin University, DET CRC, Geological Survey of Victoria, Geoscience Australia, Globaltech, Imdex, Olympus and University of Melbourne.
PARTICIPANTS AND COLLABORATIONS
Mineral Systems Drilling Program Collaboration (South Australia)

The Geological Survey of South Australia supported the MSDP in order to elucidate regional signatures of mineral systems under cover in the Gawler Craton (northern Eyre Peninsula). The Geological Survey of South Australia wished to work in collaboration with the mineral exploration industry and invited the industry to propose locations for a co-funded drilling program. The proposals selected by the Geological Survey were submitted by Kingston Resources and Minotaur Exploration and focused on the southern Gawler Craton. The Geological Survey was also supportive of helping develop DET CRC’s new mineral exploration technologies, because such technologies are required for more successful exploration of areas of deep, barren cover such as the Gawler Craton.

The MSDP was funded by $3.5M cash ($2.5M from the Geological Survey of South Australia’s PACE Frontiers programme, $400K from Minotaur Exploration, $250K from Kingston Resources and $345K from DET CRC). There was a further $4.1M in-kind contribution from those parties. Fourteen holes were drilled in a continuous program from August 2015 to April 2016 to a total of 7,868 m. The MSDP also utilised in excess of 100 South Australian-based suppliers from providing water-trucking services to road-grading to catering 3,225 meals served at remote field camps.

The MSDP involved almost all of DET CRC’s projects. As well as thoroughly testing individual technologies, it was the first time that several of DET CRC’s technologies were integrated and operating at the same time in a drilling operation. It provided invaluable field trialling for a suite of technologies, specifically:

- Wireless Sub (2,197 m of drill hole logged)
- AutoSonde with gamma and magnetic susceptibility sensors (4,876 m logged by gamma sensor and 728 m logged by magnetic susceptibility sensor)
- AutoShuttle with gamma (88 m logged)
- Lab-at-Rig® (5,809m sampled for geochemistry by XRF and 2,747 m sampled for mineralogy by XRD)
- Fluid Management System (2,800 m sampled)
- Seismic methods (surface reflection seismic lines and borehole-based vertical seismic profiles acquired)

The MSDP also made drilling results remotely available in real-time. The Real-Time Drill Site Project, which was funded by a $350K grant from the South Australian Government’s MIPO (Mining Industry Participation Office), provided a platform on which to show live data from the Wireless Sub, AutoSonde and Lab-at-Rig®. A demonstration of the Real-Time Drill Site Project took place on 14 April 2016 with Participants in Australia and internationally simultaneously viewing real-time and near real-time results from the remote MSDP drill site in South Australia.
PARTICIPANTS AND COLLABORATIONS

- Researchers from Curtin University and Globaltech Corporation collaborated with BHP in order to conduct field trials of a reverse circulation (RC) drilling version of the AutoSonde at BHP Area-C iron ore deposit in the Pilbara. Learnings from the trial were invaluable for the research team and BHP gained an increased understanding of the technology prior to its commercialisation.

- Researchers from Imdex, CSIRO and Olympus collaborated with Anglo American to conduct Lab-at-Rig® field trials at Anglo’s Bushranger exploration project (Oberon, New South Wales). Researchers from CSIRO, Globaltech and Boart Longyear collaborated with Anglo American to conduct Wireless Sub trials at the same project. The deployments were organised at the request of Anglo American and served as a model for collaboration, assisting end-users to understand the role that our emerging technologies may play in their business, and assisting researchers to optimise their technologies for real world conditions.

- The assembly of the RoXplorer® coiled tubing drill rig involved personnel from Century Engineering, Boart Longyear, OmniLogix and DET CRC.

- The field testing of the RoXplorer®, throughout the first half of 2017, was a significant collaborative effort involving a team of drillers, driller assistants, technicians, scientists and engineers from Boart Longyear, Curtin University, CSIRO, Imdex, OmniLogix, University of South Australia and the DET CRC. In addition, the Geological Surveys of South Australia and Victoria provided permitting, logistical, safety and geological expertise.

- The Real-Time Drill Site (RTDS) project was supported by the Minerals Industry Participation Office of the South Australian Department of State Development and involved collaboration with the Geological Survey of South Australia, Imdex Limited and information technology companies Australian Semiconductor Technology Company (ASTC), SRA Information Technology and Innodiv.

We see the Wireless Sub as being a game changer for the industry.

JOHN BROCKLESBY (FMR) ANGLO AMERICAN

<table>
<thead>
<tr>
<th></th>
<th># INDIVIDUAL RESEARCHERS</th>
<th>CASH FTE YEARS</th>
<th>IN-KIND FTE YEARS</th>
<th>TOTAL FTE YEARS</th>
<th>NUMBER OF ORGANISATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESEARCH ORGS</td>
<td>190</td>
<td>88</td>
<td>126</td>
<td>214</td>
<td>7</td>
</tr>
<tr>
<td>INDUSTRY</td>
<td>110</td>
<td>27</td>
<td>78</td>
<td>105</td>
<td>12</td>
</tr>
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<td>TOTAL</td>
<td>300</td>
<td>115</td>
<td>204</td>
<td>319</td>
<td>19</td>
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</table>

Breakdown by research organisations and industry organisations of the number of individual researchers, cash and in-kind-funded FTE years and number of organisations supported by DET CRC resources.
Unsuccessful Projects
Not all DET CRC Projects achieved their goals. The Commonwealth Government and sponsors recognise that research progress cannot be guaranteed, despite the best endeavours of all parties. Initial (Phase I) project contracts ended around the time of DET CRC’s Major Performance Review (late 2013-early 2014). The outcomes of the Major Performance Review and guidance from the Science Steering Committee led to three projects not continuing into Phase II and to two projects being combined.

With respect to the projects that did not continue into Phase II, opinions on the causation of such would vary depending on those canvassed. A key point to note is that DET CRC sought greater focus at this time in order to try to ensure the success of its core, three pillar projects.

DET CRC developed a project management process that helped address the risks of project non-delivery, which included:

- Detailed and carefully reviewed Project Agreements (research contracts) typically of two, three or four years’ duration
- Outcome-oriented annual and quarterly milestones (the former set in Project Agreements at project commencement and the latter set annually reflecting ongoing progress/developments)
- Use of KDPs (key decision points) for clear decision-making around project priorities as research evolves
- Clarity around the technology readiness levels (TRLs) at which projects operate and successfully complete
- SMART (Specific, Measurable, Attainable, Realistic, Time-bound) project performance targets
- All combined with quarterly project reporting reviewed by the programme leader, industry reviewer and CEO, resulting in a simple traffic light assessment of each project each quarter

The extent to which projects were meeting quarterly milestones provided a responsive indication of project progress and the status of quarterly milestones played an important role regarding whether projects continued into Phase II.
SUPPORTERS
Affiliates