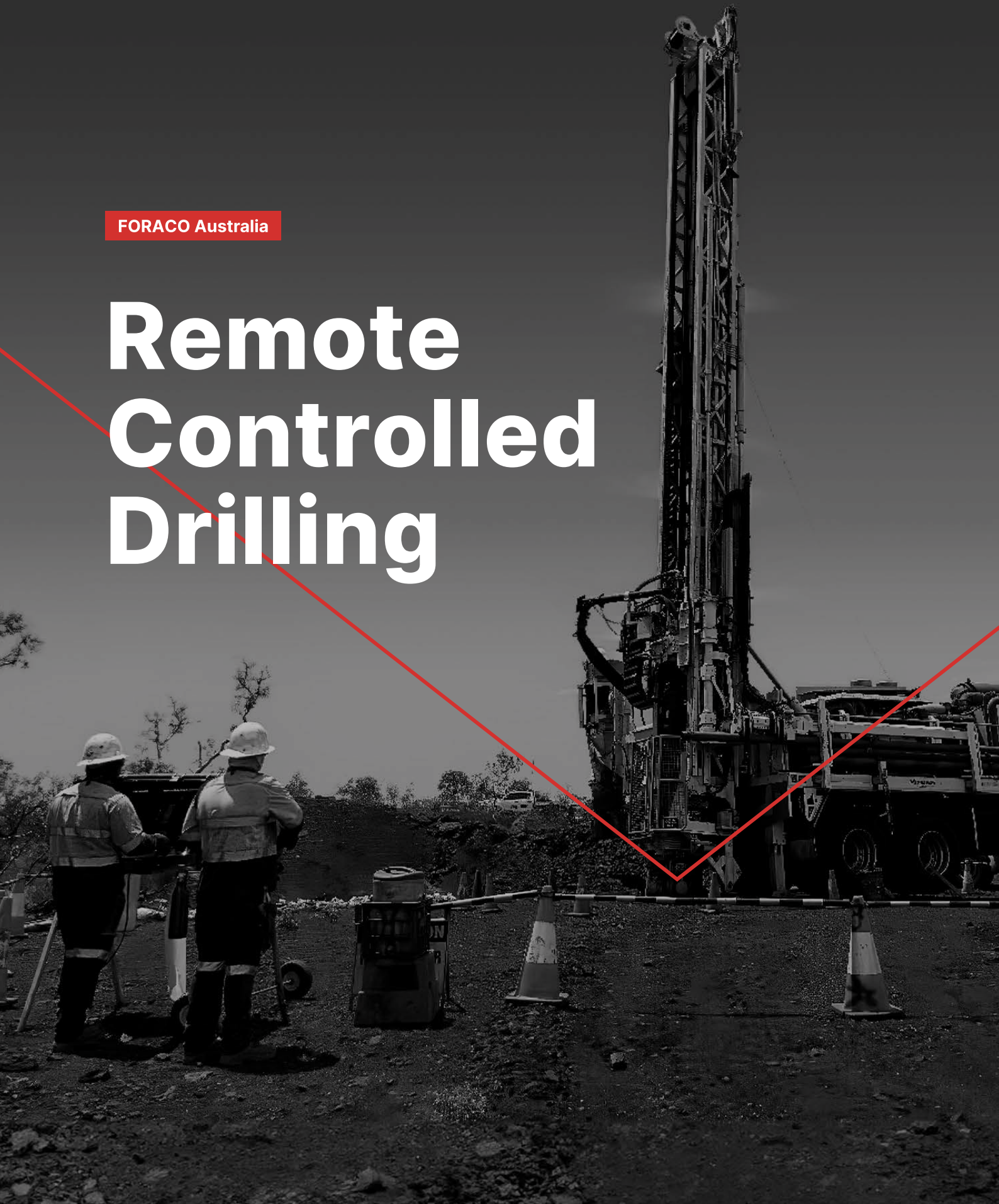


FORACO

FORACO Australia

Remote Controlled Drilling



FORACO



**Integrity. Innovation.
Involvement.**

Introduction

Sometimes it takes a specific singular event to enact real change, and for FORACO Australia, that came at the 2012 Australian Drilling Industry Association annual convention in Adelaide, South Australia.

The Keynote speaker opening the event was the General Manager of a major Iron Ore producer in the Pilbara, whose opening line was, “Other than putting on a hard hat and some long pants, you drillers haven’t changed a lot over the past 20 years.”

As harsh as some might have viewed such a statement (to a room full of industry stalwarts), it was not without merit. Although many attendees believed innovations such as mechanised rod handling, rod spinners and lots of yellow safety rails and signage had completed their safety transformation, it dawned on FORACO Australia that we were a long way from where we needed to be, and the keynote address was a call to action.

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That event crystallised our belief that we had to change. An employee had just suffered a serious hand injury which included a broken finger and thumb and multiple lacerations; a lost time injury that would take 3 months of rehabilitation.

We simply could not continue with business as usual, which would follow a well-worn path of incident investigation, making some changes and restarting operations without knowing when and where (not if) the next incident would materialise.

—
Nathan Elford
VICE PRESIDENT



Driller with wireless remote control and rig camera screen inside climate-controlled Driller's cabin.

Following the 2012 ADIA convention, the company's vision was set to separate people from equipment.

“We had a history with wireless remote-controlled rod handlers and hypothesised that if we could control these functions with this technology, why couldn't we extend this to the entire rig?” commented Nathan.

“We were also acutely aware that attempting to introduce a complex piece of advanced equipment would not have a sustained improvement across the company, unless we enacted a cultural shift in the business before it entered service.”

As Brendon Smith (our longest-serving employee and RC Supervisor at the time) stated, “My good guys can work on old equipment all day long and not get hurt, but if you give me a bunch of dickheads on the shiniest and newest gear, I will guarantee you it will be all over by lunchtime.”

Brendon had been around long enough to know that attitude, risk-based decision making, and being able to work as a team had a much greater impact on improving safety performance than buying some shiny new drill rig.

FORACO Australia headed down parallel paths to change the culture of the companies it had inherited through acquisitions when it entered the Australian market in 2008, and to design the next generation of equipment that would improve safe work practices and enhance the working environment for the field crews.

Safety Management System (SMS)

The company beefed up its HR and Safety departments, which laid the foundations of their current Safety Management System (SMS). This involved overhauling and documenting many processes such company policies, people management (select, hire, train, and retain), safe work procedures and system processes and certification to standards to maintain consistency across the business.

Today, the FORACO Australia SMS encompasses formal certification to the following international standards:

ISO 9001	Quality System
ISO 14000	Environmental Management System
ISO 45001	OHS Management System



Formal certification of systems and processes are complex, time-consuming and costly. However, the benefits are many and far outweigh the costs:

- Transforms operations from “detection” to “prevention” mode
- Creates consistency throughout the organisation
- Improves business performance and facilitates continuous improvement
- Less dependency on key individuals
- Provides a blueprint for controlled and disciplined growth
- Strengthens regulatory compliance
- Ensures consistent training
- Improves management oversight

FORACO Australia's Safety Management System (SMS) contains over four hundred documents that are detailed and specific to the activities the business undertakes across Australia with deep hole directional drilling, Reverse Circulation, and water well drilling. These are reviewed and updated on a regular basis, and act as the enabler to bring a consistent level of service delivery across the business.



Driller on traditional rig control panel drilling 17.5" Large Diameter Flooded Reverse (LDFR) water wells.

The Drill of the Future

As our cultural journey commenced post-2012, the company embarked upon the early conceptualisation of what the “Drill of the Future”, or DOTF as it became known, could look like. It was decided to use Rig 7, (KWL 700RC Reverse Circulation rig) as the test bed for the DOTF concept.

The non-negotiable deliverables were:

- Separation of people and equipment
- Crew (Driller and Fitter) acceptance of the technology
- Reduced learning curve for Trainee Drillers
- No loss of productivity
- Improved data acquisition and feedback from the drill rig
- Acceptable (non-excessive) levels of downtime as the new technology was embedded
- Adaptable to other modes of drilling undertaken by the company – i.e. diamond drilling and water well drilling

Separating people from equipment

An RC rig is powered by an 850 hp diesel engine driving a high-pressure air compressor (1,550 cfm / 500 psi) and hydraulic system (4,000 psi).

Traditionally, the Driller stood on an operator's platform at the rear of the drill rig, exposed to high-pressure air and hydraulic hoses, noise (in excess of 100 dba), hot air (over and above high ambient temperatures) from large heat exchangers, and vibrations from the rig (via the operator's platform, which is connected to the drill rig).

In addition to the above, the Driller was in the footprint of potential falling objects from the drill mast. As rigs had become more complex over time with safety systems such as rod handlers and rod retention devices added into the drill mast (above head height), the potential for “a falling object” had increased proportionally.

From their experience using wireless radio remote controllers for the drill rig rod handler, FORACO's goal was to position the Driller more than 8m away from these high energy sources, significantly reducing their exposure to risk should something go wrong.



Rig camera screen on LH side and MWD screen on RH side.

If the Driller is away from the rig, (although highly undesirable) it could fall over, catch fire or self-destruct without causing bodily injury.

The other two significant tangible benefits of a drill rig being remotely controlled from a distance were:

- An enhanced view of the drill pad, and where the crew/field hands were working.
- Reduced fatigue levels at the end of the shift.

Control Station

FORACO made the decision early on to adopt industry standard wireless remote-controlled transmitters (such as those used on construction equipment) as opposed to heading down a custom-designed control panel layout.

The industry standard units were robust, small, and lightweight. These could be positioned into a larger “control station” which housed the Measurement While Drilling (MWD) screen. When required, the Driller could remove one of the remote-control transmitters and walk to the most advantageous location around the rig to activate a certain function whilst maintaining close eye contact with the task.

One good example of this is setting the drill rig up. The Driller can walk around the rig while the hydraulic jack legs are being lowered to ensure they are securely located on the jacking plates.

They can do the same as the mast is being raised to ensure that there aren't any hoses or winch lines getting caught or snagged.

The control station for Rig 7 consists of a lockable Pelican case mounted on a lightweight aluminium frame (with wheels for ease of mobility) which can be quickly disassembled for transport when moving the rig.

The Pelican case houses the MWD screen (RH side) and camera screen (LH Side).

The rig has 4 x cameras mounted at the breakout table, rod bin, behind the mast, and one where the top tool joint makes up (approximately 6m up the mast). The Driller can toggle between screens to gain the best view of the specific task or function they are undertaking. This high-resolution outdoor screen is rated to IP 67 and viewable in full daylight.

The Wireless Remote Control System

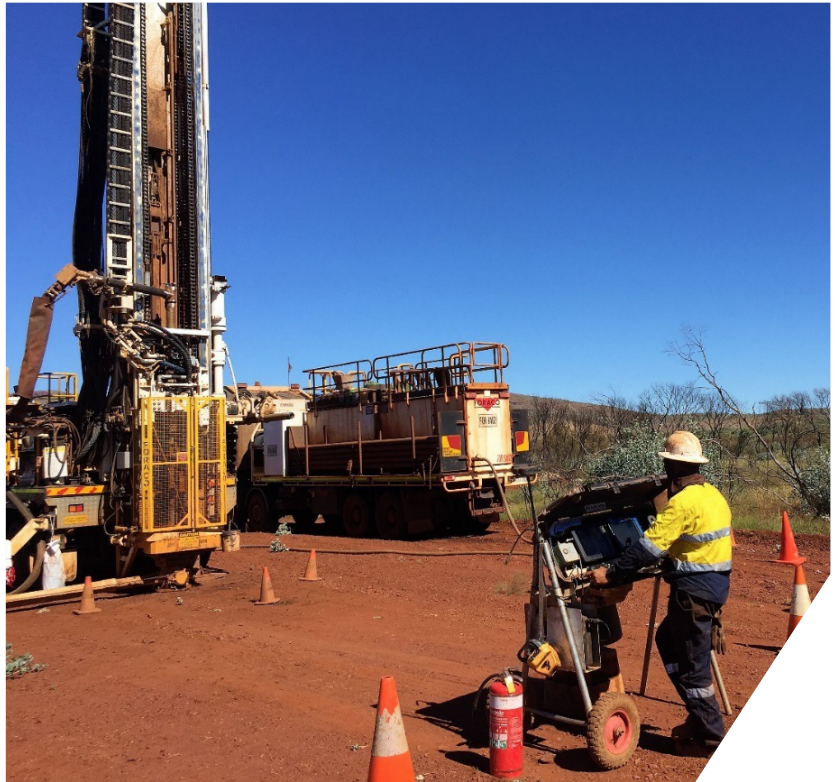
The wireless remote control system consists of 3 separate transmitters:

- 1 Setup
- 2 Drilling / Rod Pulling
- 3 Rod Handling

The setup wireless remote transmitter controls functions such as jacklegs, mast raise/lower, mast dump, cyclone setup etc. Once the rig has been setup on the hole at the desired angle, this controller is packed away and not required until it is time to rig down.

When collaring and advancing the hole, the Operator focuses on the Drilling wireless remote transmitter. This controls all drilling functions such as RPM, weight on bit (WOB), rate of penetration (ROP), holdback and pulldown pressures, rod breakout and make up and auxiliary functions such as cyclone operation and compressor and booster controls.

The final wireless remote transmitter is for the rod handler and is operated by the Offsider.



RC drilling with remote controlled drill rig with full 8m x 270° rod handler no entry exclusion zone.



Wireless Remote Control Transmitter (WRCT) for Rig 29 – NGBF 800 55T pullback Hydro Rig.

Enhanced view of the drill pad

On a traditional drill rig, the operator stands on a platform attached to the rear of the drill rig. They are exposed to vibrations from the rig, and locked into a position with their face about 50cm from a bank of hydraulic pressure gauges which monitor rig performance.

Often the Driller has their neck craned up at 90 degrees watching the drill head as it traverses up and down the drill mast. This is

extremely tiring, uncomfortable and has poor ergonomics when undertaken over a twelve-hour shift.

The Driller's field of view is extremely limited as they can only see down the side of the rig that the control panel is located on, and have limited awareness as to what is happening behind them, or on the blind side of the rig.

With a wireless remote-controlled drill rig, the Driller can be located anywhere outside of the footprint of the drill rig "potential falling objects danger zone", which is typically around 8m. From this vantage point, the line of sight to the drill rig mast is < 45 degrees off horizontal (no more neck strains) and the control panel can be positioned in the best place to give a wide-angle view of all activities on the pad (and hopefully under the shade of a tree).

Reduced fatigue

We have already mentioned the improved "Driller line of sight" being away from the drill rig. Not having to look 90 degrees up to the top of the mast all day long significantly reduces neck cramps, muscle fatigue and longer-term ergonomic issues.

The Drillers on the first DOTF commented that they felt much "fresher" at the end of shift as they were not subjected to the vibrations of the drill rig all day long through the operator's platform.

They also benefitted from a significant reduction in noise levels when removed from the rig's footprint and escaped the additional hot air being generated from the rigs heat exchangers.

It is a proven concept that people make better decisions when they are in a more comfortable working environment, without sensory inhibitors (such as high noise levels and limited line of sight). Sound risk-based decision making is the pre cursor for improved safety outcomes and increased productivity.

Improved data acquisition and feedback from the drill rig

A traditional RC drill rig is monitored by the driller from a mix of sensory feedback (noise, harmonics, vibration, rate of advancement and sample flow) and readouts from a bank of hydraulic and air pressure gauges showing values within each circuit (rotation, feed, torque, air pressure, water pumps etc).

These hydraulic pressure readings did not relate to any actual values such as weight on bit (kg), torque (kg/m force) or air pressure (psi) and flow (cfm), they were merely a “needle flickering on a gauge”, displaying the system pressure within a specific hydraulic, water or air circuit.

This resulted in the traditional pathway from Offsider to Trainee Drilling being marred with interpretation (older Drillers were not necessarily the best teachers) and a lot of “trial, error and experimentation.”

Although the “good” Trainee Drillers learnt quickly and adapted to this hybrid mode of feedback, others more often suffered low productivity, excessive tooling wear and sometimes damage to equipment and loss of the drill hole as they were not sufficiently experienced or knowledgeable to adapt to the changing conditions from the feedback they were receiving.

MWD Systems

For many years, FORACO Australia sister companies around the world had adapted Measurement While Drilling (MWD) systems to their larger rotary drill rigs. Adoption of MWD is standard practice on oilfield rigs and has been in use for many years.

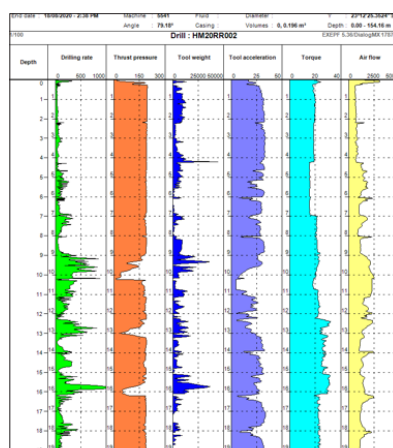
MWD consists of a series of sensors placed on the drill rig to monitor specific outputs. In the case of FORACO, this included:

- Rate of penetration (ROP - in/cm per min)
- Revolutions per minute (RPM - rev/min)
- Torque (ft lbs or kg/m)
- Weight on Bit (WOB - lbs or kg)
- Holdback (lbs or kg)
- Pulldown (lbs or kg)
- Water flow (gpm or lpm)
- Water pressure (psi or kPa)
- Air flow (cfm or lpm)
- Air pressure (psi or kPa)
- Hammer blows per min (bpm)
- Location (GPS)
- Mast/hole angle (degrees)
- Hole depth (ft or m)

The values displayed by the MWD system are real units (e.g. torque being actual kg/m generated by the drill head) and in real time. They give the Driller immediate continuous feedback, so they are not reacting to a “flickering needle” on a hydraulic gauge. Data can be streamed to any location in real

time (providing you have 4G signal), retained onboard the touchscreen, or transferred to a portable storage device (USB, hard drive).

Limits can also be set which alert the Driller when they are moving outside of the recommended operating window for the type of drilling they are undertaking. This is an extremely useful tool when upskilling Trainee Drillers.



Top: Digital MWD drill hole printout.

Bottom: MWD screen with rig in operation.

FORACO Australia Vice President Nathan Elford commented, “What we end up with is a rich set of data from the drill rig and hole. The Driller has real values to monitor the performance of the drill rig/hole, as opposed to the “flickering needle” on the hydraulic gauge. Trainee Drillers learn much faster as they are dealing with actual values and can “hone in” on the operating parameters utilised by more experienced Drillers much quicker than via the traditional trial and error mode of learning.”

Cost per meter can be optimised as operating parameters can be correlated to consumable life (through the MWD data). The Contractor and Client can see rig

activities as they happened in real time – eliminating the “he said/she said” arguments about drill plod activities.

Rig operating parameters for a specific project can be stored, so when drilling returns to the same project in subsequent years (with a new crew), the usual “learning curve” is significantly reduced.

Drilling market downturn

As (bad) luck would have it, the Australian Exploration drilling sector entered a prolonged cyclical downturn following the 2012 Adelaide ADIA conference, which continued through to 2017 before some “green shoots” of recovery appeared, and mineral exploration levels started to increase.

Undeterred (other than a few false starts and dead ends), FORACO Australia continued with their cultural transformation, delivering Rig 7 (the Drill of the Future) to the field in 2015.

Adjusting to the separation

Being the first wireless remote-controlled RC rig in the Pilbara, Rig 7 generated a lot of interest with its inherent safety features (separation of people from equipment, improved comfort, and reduced fatigue levels for the driller) and comprehensive MWD system.

Nathan Elford takes up the story, “We were a bit concerned as to how the Drillers would react to being separated from their drill rig. They often describe how the rig “talks to them”, through harmonics, engine pitch and vibration. Our plan was to get the Driller to move back 1m from the rig each day, so by the end of the week they were >7m away from the rig, and hopefully not too traumatised by “separation anxiety”.

Surprisingly, at the end of the first shift, the Driller was remotely operating the rig from > 8m away. When quizzed about whether he was suffering from “separation anxiety” he commented, “The further I am away from that noisy, hot, vibrating, grease spitting lump of iron the happier I am.”

He then went on to explain how he felt much fresher after a long 12 hour shift due to not being “shaken to pieces” on the vibrating operating platform all day long.

Case Studies



Rig 7

The benefits of Rig 7 were immediately obvious, and it went on to deliver 8 solid years of service in the Pilbara Iron Ore region, before being pulled out of service for an overhaul.

“During this period, we learnt a hell of a lot about many things – our people and equipment,” commented Nathan.

“The cultural transformation of our work methodology, collaboration with our crews, and a risk-based approach to decision making was now our standard way of doing business. It has become a defining part of our DNA, driven by our corporate values of integrity, innovation, and involvement.”

“Rig 7 was our first, and very successful foray into wireless remote-controlled drill rigs. Since 2015, along with our technology partner ACS, we have refined the hardware and software of our remote fleet. We are now on Gen #3 of our operating system, having adapted this to 6 rigs in our current fleet, with a further 4 remote-controlled rigs under build at a cost of approximately \$2m each.

By the end of 2024, 36% of our rig fleet will be remote-controlled with MWD data acquisition systems. The remote rigs will include 2 x RC, 2 x Water Well, and 5 x Diamond Drills.”

“Our remote rigs have enabled the company to undertake some unique and technically challenging projects which wouldn't have been possible without our journey of cultural renewal and technical innovation” said Nathan.

Rig 17 and Rig 33

Rig 17 and Rig 33 are wireless remote controlled UDR 1200 drill rigs that are contracted (along with several other FORACO deep hole diamond drills) on a long term, deep hole directional drilling program with a major global mining company. The program calls for multiple cuts from each drill collar with extensive navi drilling to depths of 2,500m.

One of the unique attributes of Rig 17 is that it is manned by an all-female drill crew, led by Patrice (Patty) Marinelli. In less than 12 months after joining FORACO as a green Offsider, Patty had attained her Cert III in Mineral Exploration drilling. She now runs Rig 17 with an all-female crew, and is currently working towards her Cert IV (Supervisory qualifications).



Top and bottom-right: Reduced Angle Drilling (RAD) RC holes at -35° on the flanks of iron ore ranges in the Pilbara region of Western Australia.

Bottom-left: Rig 7 crew on completion of Reduced Angle Drilling (RAD) RC program $\sim 1,000\text{m}$ of drilling from 7 drill holes at -35° and -45° in a 270° azimuth fan from a single drill pad.



Rig 29 and Rig 30

Rig 29 and 30 (remote FORACO NGBF 800) are high-capacity hydro rigs that will undertake Large Diameter Flooded Reverse (LDFR) wells with 55 tonne of pullback and 30" table openings.

These high-capacity remote-controlled drill rigs will have tilting drill heads and dual 20" hydraulic breakouts for hands-free rod handling, state of the art Driller's control cabins, Safe T Load pipe trailer, and modular mud and air systems capable of drilling 24" wells to 500m.

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Our tentative first steps over 10 years ago to explore and then embrace remote-controlled drill rigs has reaped huge rewards. In parallel with our cultural transformation, we now have a unique and differentiated operating model.

Our philosophy towards our equipment innovation is aligned with our employee development – select the best, train, retain, recognise, and reward exceptional performance.

Nathan Elford
VICE PRESIDENT

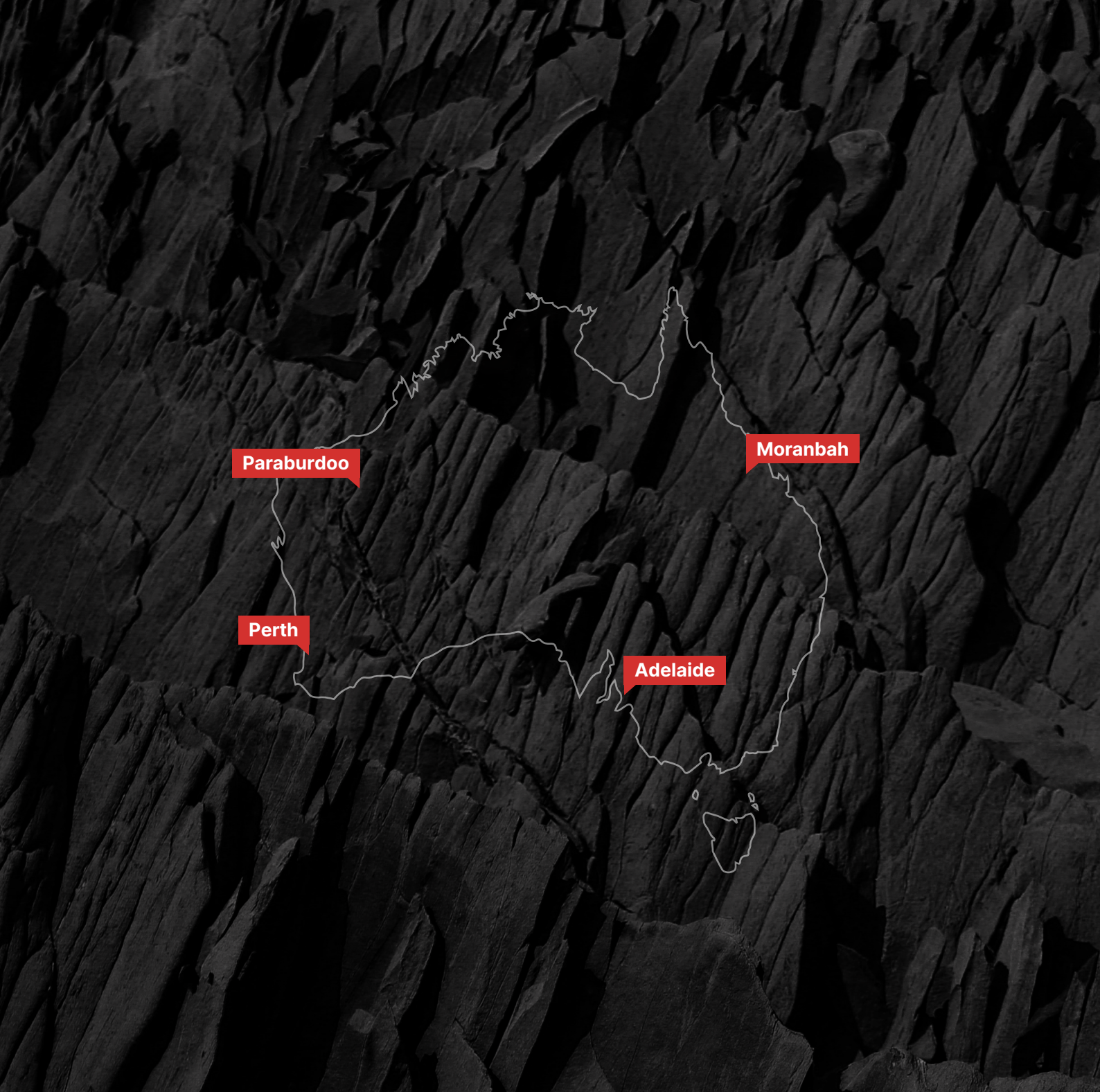


Top: Rig 17 (remote UDR 1200 multipurpose drill) with climate-controlled Dog House / Mud Skid (far right) undertaking 6" Large Diameter Coring (LDC).

Middle: Rig 17 (remote UDR 1200) crew.

Bottom-left: Climate-controlled dog house on Rig 25 (remote UDR 1000 multipurpose drill).

Bottom-right: Rig 29 remote-controlled NGBF 800 Hydro rig – 55T pullback capacity on road legal platform.



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