The complete resource for all personnel working in all facets of the microtunnelling industry

- Types of microtunnelling machines explained in easy-to-understand language
- Advantages and challenges associated with microtunnelling systems
- History of microtunnelling
- Servicing machinery
- Directory of microtunnelling equipment providers, contractors and advisors in Australasia
# Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine purchasing timeline</td>
<td>4</td>
</tr>
<tr>
<td>Overview on microtunnelling</td>
<td>5</td>
</tr>
<tr>
<td>Applications</td>
<td>6</td>
</tr>
<tr>
<td>Accuracy</td>
<td>6</td>
</tr>
<tr>
<td>Spoil Removal</td>
<td>6</td>
</tr>
<tr>
<td>Ground Support</td>
<td>6</td>
</tr>
<tr>
<td>Tunnelling in solid ground</td>
<td>6</td>
</tr>
<tr>
<td>Tunnelling in soft ground</td>
<td>6</td>
</tr>
<tr>
<td>Slurry microtunnelling</td>
<td>7</td>
</tr>
<tr>
<td>Freeboring</td>
<td>9</td>
</tr>
<tr>
<td>Australasian Achievements</td>
<td>9</td>
</tr>
<tr>
<td>Pipe jacking</td>
<td>10</td>
</tr>
<tr>
<td>Pipe jacking with microtunnelling</td>
<td>11</td>
</tr>
<tr>
<td>Vacuum microtunnelling</td>
<td>12</td>
</tr>
<tr>
<td>History of microtunnelling</td>
<td>13</td>
</tr>
<tr>
<td>Selecting the right type of machinery</td>
<td>14</td>
</tr>
<tr>
<td>Equipment options; type, application, flexibility</td>
<td>15</td>
</tr>
<tr>
<td>Selecting the right contractor</td>
<td>16</td>
</tr>
<tr>
<td>Servicing your machine</td>
<td>17</td>
</tr>
<tr>
<td>Featured products and services</td>
<td>18</td>
</tr>
<tr>
<td>Need more info?</td>
<td>19</td>
</tr>
<tr>
<td>About <em>Trenchless Australasia</em></td>
<td>20</td>
</tr>
<tr>
<td>About No-Dig Down Under 2015</td>
<td>20</td>
</tr>
<tr>
<td>About the Publishers</td>
<td>20</td>
</tr>
<tr>
<td>Directory</td>
<td>21</td>
</tr>
</tbody>
</table>
Editor’s welcome

On behalf of Trenchless Australasia, I’m pleased to issue this invaluable resource for the trenchless industry.

This year, the ASTT celebrates ten years of publishing its official magazine, Trenchless Australasia. Through this decade, Trenchless Australasia has expanded into a range of leading professional development resources for individuals and organisations working in the installation and rehabilitation of infrastructure and assets. Our involvement in the trenchless industry spans our renowned magazine, trenchless e-newsletter and professional development events.

Such offerings have allowed us to develop an established network of industry professionals, consisting of asset owners and managers, contractors, engineers and academics who inform us of the sector’s needs.

Through our network, we know that the industry lacks an unbiased, detailed account on microtunnelling systems and their best application.

While there are numerous academic papers on microtunnelling, and specific information on microtunnelling systems available from manufacturers, the industry lacks a guide that is accessible for contractors, utility workers and project managers without extensive knowledge on microtunnelling equipment.

This e-guide will serve both those who are looking to contract works and needing to know the fundamentals on whether they should choose microtunnelling as a preferred option, as well as utility owners and contractors looking to contrast microtunnelling features to make a purchasing decision.

I would like to thank valued supporters of this e-guide, without whom this free resource for the industry would not have been possible – Sponsors Akkerman, Pezzimenti Tunnelbore and Project Support.

We hope your company or organisation benefits from Trenchless Australasia’s Comprehensive Guide to Microtunnelling and that it’s a useful companion for you in finding the most appropriate equipment, suppliers, and microtunnelling support.

Kind regards,

Editor
Trenchless Australasia

FREE Trenchless Australasia e-newsletter
The latest news, events and job listings emailed fortnightly

CLICK HERE

Follow us on Twitter @TrenchlessOz

www.trenchlessaustralasia.com.au
+61 3 9248 5100

SPONSORS
Machine purchasing timeline

1. Establish your organisation’s microtunnelling needs – if you are purchasing for a specific project, what ground conditions will you encounter and how will this affect your selection?

2. Research equipment and suppliers based on your organisation’s identified needs.

3. Create a shortlist of contractors you know of that use this equipment. Case studies often mention the equipment a contractor was using; you could search the Trenchless Australasia news and magazine articles to find contractors. Contact these contractors/organisations as references to review how they find using the equipment.

4. Select a microtunnelling manufacturer. If possible, visit the manufacturer to speak with them and view the machinery. If a successful visit, confirm the purchase.

5. Select key staff to undergo training with the machinery.

6. Have a staff member create a manual (or add to the given manual from the manufacturer) to assist other staff with their use of the equipment, adding any company-specific information you want all staff to be aware of when using the equipment.

7. Conduct any further in-house training with staff, co-ordinated by trained staff and using the developed manual.

8. Begin phasing the use of your new equipment into existing and upcoming projects, and promoting your company’s expanded capabilities with your machinery.

9. Enjoy the benefits of your equipment!
Microtunnelling is a trenchless construction method used to install pipes under roads, railways, environmentally sensitive areas or where the pipe is required to be at a significant depth. Microtunnelling was developed within the water industry for the accurate installation of gravity sewers and stormwater pipes. It is now used for the installation of other utility services.

As a generic term, microtunnelling has been adopted to describe the installation of small-diameter pipes underground including:
- Pipe jacking
- Pipe jacking with microtunnelling
- Horizontal auger boring/thrust boring
- Small-diameter boring
- Guided boring
- Free-boring
And, sometimes
- Horizontal directional drilling.

However, in this e-guide microtunnelling will be specifically defined as a steerable remote-controlled shield for installing pipe with an internal diameter less than permissible for man-entry.

Microtunnelling will often utilise a laser guidance system to maintain the line and level of the installation, though with larger pipe jacking installations, both laser guidance and survey techniques can be utilised.

Systems are available for installing both main pipelines and branch connections.

Most microtunnelling drives are straight between shafts, although specialised systems are available for curved drives. In situations where line-of-sight is not possible between the shafts due to curvature, alignments systems based on extra devices (such as gyroscopic steering) may be used as an alternative.

CURVED MICROTUNNELLING

In larger diameters (man-entry sized), technological improvements in guidance systems have led to curved microtunnels being achieved over longer distances.

We are standing at the threshold of one of the biggest advancements to come along in quite some time, the curved microtunnel. While curved tunnels are nothing new to the large-diameter tunnelling world, where they utilise tunnel segments and cast-in-place linings, curved pipe jacking is just beginning to become accepted in the realm of smaller-diameter, remote-controlled microtunnelling. The biggest contributing factor in the advancement of curved microtunnelling is the availability of guidance systems that can ‘see’ around corners.

The implementation of new-generation gyro compasses, robotic theodolites and prismatic targets have ushered in a new era of microtunnelling.
Applications

The primary reasons to microtunnel are:
- The importance/value of the surface above the pipeline e.g. road, railway, river, buildings, Aboriginal artefacts, environmentally sensitive areas, one does not own the land
- The cost of open-trenching e.g. very deep pipes, highly congested utility services in urban areas
- Specialist applications e.g. drilling through existing dams for lower inlet level take-offs, canopy tubes to allow large-scale tunnelling.

Accuracy

The critical characteristic of microtunnelling, as opposed to other trenchless construction techniques, is its ability to achieve high accuracy of 10 mm in 100 m. This requires a system designed for controlled steering and for vertical and horizontal alignment. Microtunnelling is most often guided by a laser or sometimes more sophisticated guidance systems.

Spoil Removal

A microtunnelling head excavates through the ground. The head is cylindrical and contains steering mechanisms, power systems and spoil transfer systems.

The spoil is transported from the excavation chamber (behind the cutters, which are on the front of the microtunnelling head) back to the surface by vacuum, slurry or by auger. In smaller diameters soft ground can be displaced and not removed from the microtunnel (pilot tube).

Ground Support

TUNNELLING IN SOLID GROUND

In stable ground that is self-supporting, such as stiff clays and rock, it is not necessary for an encasing pipe (steel, concrete or GRP) to support the ground behind the drilling head. This technique is known as freeboring and was pioneered in Australia by Pezzimenti Laserbore in 1986.

Approximately 100,000 metres have been freebored in Australia over the last 28 years. Once the self-supporting bore has been completed, the carrier pipe is sliplined into the freebore and the annulus then grouted.

TUNNELLING IN SOFT GROUND

In very soft soils, which are below the water table, full support is required at the excavation face. Slurry shield systems are usually used for this application.
Slurry microtunnelling is typically employed to accurately install pipe between 762-2,438 mm (30-94.5 inch) OD. It is the best pipe jacking method for wet and unstable ground conditions or contaminated soils.

Slurry microtunnelling machines may be comprised of systems with several pieces of machinery that function together, managed by an operator who monitors and controls tunnelling operations from a console inside a container on the surface, alongside the shaft. Operators are able to monitor and adjust the cutter head’s location, rotation, torque, jetting, pipe jacking thrust, steering, slurry flow and various pressures from a two-monitor console. The operator controls the main microtunnel boring machine (MTBM) drive and feed, return and booster pumps by way of variable frequency drives (VFDs) for efficient function.

Akkerman MTBMs range in size from 762-2,438 mm (30-94.5 inch) OD. The MTBM excavates materials at the cutter face and guides the pipe through the ground. A steerable, rotating, bi-directional MTBM cutter face is selected for soft ground, mixed ground or rock for precise ground excavation.

The forward advancement of the pipe line, combined with the rotating action of the cutter face, removes the material in place and forces the cuttings at the front of the MTBM rearward, to the crusher cone. Cobbles are crushed to pass through the slurry inlet holes for transport into the slurry lines. Feed, return and booster pumps keep the slurry moving to the separation tank where it is then re-circulated back to the cutter face in a closed system.

The MTBM is typically launched through a shaft seal, which acts as a gasket around the pipe to prevent loss of ground and slurry in the launch shaft. After the jacking frame pushes each length of pipe, MTBM rotation and slurry flow is stopped, another piece of pipe and new tunnel connections are added and mining is resumed.

The pipeline is advanced via jacking force from a jacking frame made up of horizontally mounted hydraulic cylinders that push on the end of the pipe, which in turn, pushes the MTBM forward.

Jacking frames are designed to provide high-capacity specifications while minimising launch shaft requirements. The slurry circulation system removes spoil from the cutter face. Slurry is formed by mixing the ground-up cuttings with water by injecting water or a water/bentonite clay mix into the MTBM’s crushing cone area. Water can be controlled and monitored by the operator, including volume, pressure and flow rate.

Balancing the input and output of the slurry by volume and pressure is vital to avoid removing too much soil, thereby causing settlement in front of and above the MTBM. Sensors and flowmeters in the system...
constantly check, display and record this data during the operation of the system in the control console. The slurry is moved through the system’s circuit by specially designed feed, return and booster pumps are regulated through a VFD. These pumps are capable of passing particles as large as 76 mm (3 inch) in diameter.

It is imperative to maintain the alignment of the design criteria. The active laser target, housed inside heavy-duty steel cylinders, is mounted in the back centre of the MTBM. The guidance system reports the MTBM’s pitch, yaw, X and Y co-ordinates to a monitor in the control console for operator’s assessment while anticipating the MTBM’s location at the cutter face 3 m (10 ft) ahead. The MTBM features articulated steering joints to allow for active steering control. The beam is directed up the tunnel at the proper angle and line for the design criteria and enters on the back of the MTBM’s light-sensitive target.

As microtunnelling operation proceeds, new pipe is lowered into the shaft with slurry trunk line sections at the base. A variety of cables including cutter face power, booster pump, MTBM power, guidance system and communications trail behind in the pipe string. The slurry trunk lines provide a foundation for the cables inside the pipe. During setup, a stationary set of cables is routed from the bulkhead connection in the control container on the surface to the jacking frame in the launch shaft. Crew members keep tally of when additional cabling will be needed and the new sections are lowered inside the corresponding pipe section.

Slurry microtunnelling requires a higher initial investment than some other methods of pipe jacking. However, when project conditions call for this method, there are no other alternatives that would achieve a successful installation. Slurry microtunnelling is the best means to install pipe in geology that is underneath the water table and it can be used in gaseous/explosive ground.

A watertight shaft with pit seals is most often recommended for microtunnelling operations. An experienced crew is necessary for microtunnelling operations. In the instances where project lengths are on the longer end of the scale, ancillary equipment such as Intermediate Jacking Stations (IJS), additional slurry pumps and adjustable beam lasers may be required to achieve these distances.

A high pressure jetting pump provides high velocity jetting to the cutter face for clay and silty soil. In most cases, and especially for swelling soil conditions, a bentonite pump provides lubrication to the outside of the pipe, reducing friction between the pipe and ground, thus decreasing jacking thrust.
Freeboring

Freeboring is a method of microtunnelling developed by Aurelio Pezzimenti. This method can only be employed when the ground conditions are self-supporting, generally the case in all ground conditions ranging from stiff clay through to basalt.

With freeboring, the more economical (standard) carrier pipes can be used as there is very little axial load required to slipline the pipes into the completed bore.

Firstly, the bore is completed and the drilling head and rods are removed either from a receiving pit or, if this is not possible, retracted back through the microtunnel. This leaves a clean and empty microtunnel.

Following this, the carrier pipe is sliplined into the bore; this is due to the fact that the microtunnel is self-supporting and there is no need for an expensive encasing pipe to be installed, although this can be carried out if the client requires.

The removal of the encasing pipe results in substantial economic savings, requiring the supply of only one pipe. Furthermore, as the carrier pipe is not required to provide ground support and is only being sliplined into the open microtunnel, the axial load on the carrier pipe is significantly reduced.

This means a more conventional and economical carrier pipe can be used, again resulting in further cost savings.

Freeboring allows great flexibility in design and drilling, including:

- Intercept microtunnels over long distances (possibly up to 400 m)
- Drilling into existing manholes and structures
- Because the drilling head can be retracted back through the open microtunnel, it is possible to change the cutting wheels if a change in ground conditions is encountered
- Access to the excavation if obstructions are encountered, such as disused services
- Superior drilling speed when compared to slurry microtunnelling and pipejacking.

Technically, an exit shaft is not required, i.e. freeboring allows for the possibility to drill into a ‘dead end’. Some examples include:

- Drilling directly into an existing manhole
- Drilling where the exit point needs to be opened up at a later date
- Where intercept bores are required
- Partial drilling through dam walls
- Where sub-surface drainage is required to lower the water table.

Where the ground requires support during microtunnelling a jacking pipe (concrete, GRP, steel, etc) is jacked behind the microtunnelling head to support the ground. An exit shaft is required to remove the head. The jacked pipe can either act as the carrier pipe as well as the outer casing (GRP) or be used to house a carrier pipe which is sliplined into the jacked pipe - i.e. ‘pipe-in-a-pipe’ (concrete jacking pipe + PVC carrier pipe).

Australasian achievements

- World first development of vacuum microtunnelling by Pezzimenti Laserbore in 1986. This technique is now used by many contractors around Australia and the world.
- Development of Freeboring technique.
- Development of long distance (400 m) Intercept Microtunnelling, which is used to drill through hills, starting at each end and meeting bore to bore ‘in the middle’, without the need for a deep and expensive intermediate shaft.
A COMPREHENSIVE GUIDE TO MICROTUNNELLING

Pipe jacking

Pipe jacking and microtunnelling are essentially from the same family of pipeline installation techniques. A pipe jack is defined as a system of directly installing pipes behind a shield machine by hydraulic jacking from a drive shaft, such that the pipes form a continuous string in the ground. The pipes, which are specially designed to withstand the jacking forces likely to be encountered during installation, form the final pipeline once the excavation operation is completed.

One of the most common pipe jacking applications is for gravity sewers, where not only is the line and level critical but the depth is such that the techniques tend to become more cost-effective when compared with open-cut installation.

Pipe jacking systems are more often than not supplied with jacking frames, which are designed to provide the level of jacking pressure likely to be required by the shield being used. The requirements for the jacking frame on any project are determined by the ground conditions, length of drive and the type of shield being used. Probably the most important aspects of design in respect of pipes for a pipe jack project are the allowable degree of joint deflection and the joint face geometry. In general, the deflection at the pipe joint face should not exceed 0.5°. To ensure squareness, the joint face should be manufactured to the recognised standards, or the local equivalent, and in the case of rigid jacking pipe (e.g. concrete or vitreous clay), must also be fitted with a suitable packer material to ensure the even distribution of the jacking force across the joint. If CC-GRP jacking pipe is being used, no packer rings are needed.

Pipe jacking is the process where a pipe is jacked into the microtunnel immediately behind the microtunnelling head to ensure full ground support at all times. Generally the difference between the OD of the pipe and the microtunnel diameter is approximately 20-30 mm.

Pipe jacking doesn't necessarily have to be used in combination with microtunnelling. Other tunnelling devices employed with pipe jacking include:

- Guided tunnel boring
- Auger boring
- Freeboring.
Pipe jacking with microtunnelling

When pipe jacking is used in combination with microtunnelling, the tunnel lining is installed by jacking the pipe behind a microtunnel tunnel boring machine MTBM positioned at the leading end of a string of pipe sections. The pipe string is extended by the addition of pipe sections at the jacking shaft and is progressively pushed or ‘jacked’ into the ground. At the completion of each run of pipes the MTBM and jacking system is removed, leaving the pipe string as a permanent pipeline.

With modern MTBMs and pipe jacking technology, it is possible to install underground sewerage or stormwater pipelines to more than 600 m in length without any intermediate shafts. These pipelines are generally in the size range of 600-2,500 mm diameter and can be manufactured from reinforced concrete, vitreous clay, glass reinforced plastic or polymer bound concrete.

PIPE JACKING PROCESS

Boring of the tunnel is achieved via the rotating cutter head, which is electrically driven and equipped with a series of disc cutters. Located directly behind the cutter head are two ‘cans’, which contain ancillary equipment.

A typical MTBM features cutting discs mounted on a cutting-head which is trailed by a section containing ancillary equipment including slurry pumps, drive motors and guidance systems.

The thrust required to advance the machine forward is provided by a series of thrust jacks located in the jacking shaft. These thrust jacks have a capacity of up to 1,200 tonnes and thrust both the machine and the consecutive pipes forward until breaking through to the receiving shaft.

The microtunnelling–pipejacking method of tunnel excavation enables the ground to be fully supported as the machine advances and installs the pipeline at the same time. As a result the tunnel is lined and completed in a single pass. Once the bore is completed a grout mixture is pumped into the void area surrounding the jacking pipe. In the case of a slurry-shield system this displaces the bentonite lubricant and provides permanent protection against ground settlement.

In the case of the Pezzimenti Laserbore™ Microtunnelling system, no bentonite or other additives are generally used.

Control over the microtunnelling machine is achieved from a surface-mounted control container. As a result there is no need for personnel to be within the confines of the tunnel during jacking operations. The benefits of using this system include a high level of operator safety.

Removal of excavated material can be achieved in a number of ways. The Pezzimenti Laserbore™ system uses a high pressure vacuum to extract the material in all diameters up to 1,000 mm. In diameters above 1,000 mm, the system uses a unique auger and bucket elevator combination to bring the spoil to the surface, generally in a dry non-slurry form.

Alternatively, with a slurry system, it works on the principle that the cutter head and face are pumped with water and a bentonite lubricating agent, which is then returned via the pipeline to the surface.

Pipe jacking is usually required for

- **Soft ground**: When the ground is too soft to support itself during the microtunnelling, pipe jacking is required e.g. in saturated clayey sand. Pipe jacking allows tunnelling in these soft grounds.
- **Large-diameter**: Pipe jacking will often be used in large-diameter microtunnels where the diameter is too great to safely expect the ground to self-support. The pipe jacking technique provides required support.
- **Third Party Preference**: Pipe jacking might be the preferred technique by third parties e.g. railway, highway owners, etc.
Vacuum microtunnelling

This method has the advantage of being relatively more flexible in that it can be used in both pipe jacking (softer ground) and freeboring (self-supporting ground) modes.

With vacuum microtunnelling, spoil is removed from the cutting face to the surface under an airflow stream created by a vacuum unit. The spoil is typically conveyed directly into sealed vacuum tanks, minimising the likelihood of loss of slurry to the environment and the requirement to treat the spoil on site.

Another major environmental benefit of vacuum microtunnelling as opposed to horizontal directional drilling and slurry microtunnelling is that it is not possible for a ‘frac out’ to occur (where there is a loss of drilling fluid to the environment, e.g. into creeks, roadways or adjacent services such as tunnels or stormwaters).
History of microtunnelling

Slurry microtunnelling was developed by the Japanese in the early 1970s. The first US slurry microtunnelling operation took place in South Florida in 1984, a 183 m (600 ft) crossing with 1.8 m (72 inch) product pipe. Microtunnelling was introduced into Australia by Aurelio Pezzimenti in 1986. He designed and fabricated the first MTBM in Melbourne – it was 375 mm in diameter. Akkerman began manufacturing slurry microtunnelling systems for the domestic market in 1995 and is the only US manufacturer of this type of equipment.

Microtunnelling has seen a lot of advancement in the three decades since it landed on the shores of the New World.

Most aspects of the microtunnelling process have seen some sort of improvement, such as MTBM efficiency, jacking pipe technology and lubrication capability. However, the biggest steps can be seen in the guidance and MTBM control systems.

The move to digital technology continues to open new doors. With the use of high speed, high bandwidth internet communication, the operator has much more information at his fingertips to monitor and keep the MTBM system functioning at optimum efficiency. Modern digital guidance systems have allowed tunnels to be longer than ever.

Advancements in microtunnelling over the last three decades include:
• Larger diameters (diameters ranging between 30-3,000 mm)
• In all ground conditions, ranging from sand to basalt
• With greater accuracy (+/- 10 mm deviation up to 100 m)
• Over longer distances.
Selecting the right type of machinery

There is no one type of machinery right for every type of project. Before deciding on the equipment you will need, it is important to ask:

What are the ground conditions?
Slurry microtunnelling is most suitable for saturated, flowing and pressurised soil but performs in a wide range of ground conditions from sands to rock. The lowest blow count (N-Value=0-3) can be difficult and will require a skilled crew for successful negotiations.
If the ground conditions appear to be self-supporting then freeboring may be used and the need for jacking or encasing pipes will be eliminated. If it is not clear whether the ground conditions are self-supporting, then pipe jacking can be employed; the contractor can either use a vacuum or slurry method of spoil extraction.

What is the microtunnel diameter?
Tailored assemblies from manufacturers may be available for diameter adjustments, based on project ground conditions.

What is the maximum drive length?
Typical drive lengths for slurry microtunnelling are generally no longer than 305 m (1,000 ft). Ancillary equipment such as Intermediate Jacking Stations (IJS), additional slurry pumps and adjustable beam lasers may be required to achieve longer distances.
Depending on the ground conditions, the Pezzimenti Laserbore™ system has carried out a single drive of 265 m and is capable of carrying out lines over 400 m in length using the Intercept Method.

What is the accuracy required?
By definition, slurry microtunnelling is designed to achieve the tight line and grade tolerances required for gravity flow installations.

What is the depth of installation?
Slurry microtunnelling technology minimises surface footprints to reduce launch shaft requirements. For example, a 4.8 m (16 ft) diameter shaft can accommodate up to 1.5 m (60 inch) diameter pipe in 3 m (10 ft) lengths.
The appropriate machine technique in microtunnelling is selected depending on the geological and hydrogeological conditions. Even the hardest rock formations can be overcome when using this technology. The adaptation of the MTBM to the geological conditions is paramount to the success of a project.

To ensure optimum performance, a detailed geotechnical analysis has to be carried out prior to equipment selection. Rock strengths of up to 300 Mpa can be mastered when using certain machinery types.

The characteristic parameters which are essential to determine the optimum machine type in any soil condition are the soil grading curve and the permeability. These parameters decide whether a hydro shield or an Earth Pressure Balance (EPB) machine will be used.

**SLURRY OR MECHANICAL**

The material excavated by the MTBM can be transported to the launch shaft using either slurry or mechanical means. For slurry machines, a hydraulic slurry circuit is used to extract the excavated material. When using hydraulic conveyance, tunnelling is possible in all types of soil over long distances. On the surface, excavated material is separated from the pumping medium, which is then fed back to the slurry circuit.

With a vacuum extraction system, cuttings are sucked directly from the drilling head into sealed mobile vacuum tanks.

For earth pressure shields, the excavated material is removed from the face area using a screw conveyor. Further transport through the tunnel is ensured by belt conveyors, muck skips or by means of muck pumps.

**SURVEY CONTROL/GUIDANCE SYSTEMS**

Surveying of a proposed bore is essential in order to provide direction for the machine and secondly to monitor any ground movement, which may occur on the surface.

The first step is to provide surface control points, which are then transferred down the shafts to a survey station. The on-board guidance system uses the survey station as a reference. The guidance system supplied with modern microtunnelling systems makes it possible to determine the precise position of the machine at any point in time, even when the tunnelling process is underway. The machine position is permanently displayed to the machine operator and enables him to carry out the required control operation. The guidance system consists of a laser theodolite, an active laser target and prisms, installed in the forward area of the tunnel.

For small tunnel cross sections, a Gyro Tunnelling System (GTS) system is deployed; a declinometer installed in the machine measures the position of the machine using a gyroscopic compass and an inclinometer. The measurement of level is achieved using hydrostatic principles. The GTS system enables controlled guidance, even through curves, for small-diameter tunnels.
Selecting the right contractor

If you are contracting your project, questions to ask yourself about the contractor include:
- Has a geotechnical report been conducted to assess the ground conditions?
- Does the contractor have microtunnelling experience?
- Independent references for the contractor should be sought
- What type of microtunnelling system are they proposing to use?
- Is the system capable of successfully delivering the requirements, in terms of:
  - Ground condition
  - Length/distance
  - Accuracy – is high accuracy required? e.g. gravity sewers
- What are the fall-back options in the event of:
  - changing ground conditions
  - obstructions
  - mechanical failure of the head
- On-site conditions, e.g. pit size, work area required, accessibility

WORKING WITH CONTRACTORS

It is essential that independent advice on your microtunnelling project is obtained as advice from contractors can be biased towards the particular machine or system they have available, which may be inappropriate for the geological conditions.

When going out to tender, a pre-selection process should be undertaken to ensure that only contractors who have the technical experience and commercial capability are permitted to tender on the works. Tender documents should include a geological factual and a geological interpretative report and a detailed specification.
Servicing your machine

**Most equipment maintenance** on slurry microtunnelling equipment should be performed between drives. Significant maintenance rituals include replacing the main bearing’s oil and inspecting the lip seals for wear. The slurry pumps will be maintained dependent on ground conditions.

If a lot of abrasive or solids are encountered, common wear items are pump housings, stuffing box wear plates and pump impellers. These pumps should be inspected between drives but can be serviced at any point during microtunnelling operations with minimal down time if spare parts are kept in inventory. Cutter teeth, cutter head hard facing and the crushing cone chamber should be inspected for wear. Worn teeth can be replaced and hard facing should be built up between drives. Your equipment manufacturer should provide detailed maintenance schedules in the equipment’s operator and parts manuals.
Featured products and services

AKKERMAN
Since 1973, Akkerman has developed, manufactured and supported quality pipe jacking and tunneling systems that accurately install a variety of underground infrastructure.
They have been offering slurry microtunneling systems for the installation of 762 2,438 mm OD pipe for over 20 years.
Akkerman partners with contractors to explore project solutions for an extensive range of geology, pipe diameters and lengths.

PEZZIMENTI TUNNELBORE
Pezzimenti Tunnelbore specialises in microtunneling – the drilling of highly accurate, laser-guided bores ranging in diameter from 325-3,000 mm in ground ranging from sandy clay to basalt in lengths up to and beyond 300 m.
Born out of the water industry and the installation of new sewers and stormwater lines, Pezzimenti Tunnelbore today works in all infrastructure construction sectors in New South Wales, Australian Capital Territory, Queensland, Northern Territory and Western Australia.
The Pezzimenti Tunnelbore system utilises a range of microtunnelling heads, in a variety of sizes, with interchangeable cutters that can be adjusted to suit ground conditions. All Pezzimenti microtunnelling equipment is designed and manufactured in-house and can be purpose-built to suit specific requirements for unique and difficult microtunnelling projects.

PROJECT SUPPORT
Project Support, with tunnelling manager Geoff Brewster, has over 35 years experience in tunnelling and microtunnelling. Project Support can provide advice on your microtunnelling project, including equipment/contractor selection, constructability advice, cost estimating, contract management and construction supervision.

To read more about Akkerman Microtunneling Systems, CLICK HERE
To read more about Pezzimenti Tunnelbore CLICK HERE
To read more about Project Support CLICK HERE
Need more info?

We hope this guide has assisted you in the process of purchasing microtunnelling equipment. For other helpful articles and advice, please visit trenchless-australasia.com
Interested in any of the featured products or want to know more about microtunnelling equipment?

**Akkerman**

58256 266th Street
BROUNSDALE MN 55918 United States

**PHONE:** +1 800 533 0386
**EMAIL:** akk@akkerman.com
www.akkerman.com

Contact: Troy Stokes
Sales Engineer

**AREA SERVICED:** Worldwide

**Pezzimenti Tunnelbore Pty Ltd**

18–24 Smith Street
EMU PLAINS NSW 2750 Australia

**PHONE:** (02) 4735 6676
**FAX:** (02) 4735 6678
**MOBILE:** 0408 286 692
**EMAIL:** jim.shooter@pezzimenti.com.au
www.pezzimenti.com.au

Contact: Jim Shooter
NSW Operations Manager

**AREA SERVICED:** Australia

**Project Support Pty Ltd**

Level 2, Savoir Faire Tower, 20 Park Road
MILTON QLD 4064 Australia

**PHONE:** (07) 3367 3733
**FAX:** (07) 3367 3566
**MOBILE:** 0414 319 052
**EMAIL:** andrewp@projectsupport.com.au
www.projectsupport.com.au

Contact: Andrew Plail
Senior Estimator

**AREA SERVICED:** Australia, New Zealand, Pacific Region
About Trenchless Australasia

Trenchless Australasia is the official publication for the Australasian Society for Trenchless Technology (ASTT). Published quarterly, it includes a range of features, project stories and industry news.

Trenchless Australasia is directly mailed to over 2,770 individuals with a readership estimated at approximately 10,000. The magazine is also distributed at various events throughout the year, including the ASTT’s national event.

ABOUT NO-DIG DOWN UNDER 2015

The ASTT’s No-Dig show will be returning in 2015, this time to the beautiful Gold Coast. The event will run from 8–11 September 2015 at the Gold Coast Convention and Exhibition Centre.

The conference program will feature acclaimed international experts on rehabilitation and installation, Super Panels that will tackle contemporary trenchless issues, speakers who have worked on recent large no-dig projects the world over, and streamed technical sessions.

No-Dig Down Under also features an exhibition of the leading suppliers and is a great opportunity to receive free professional advice and discover the latest offerings. For more information CLICK HERE

ABOUT THE PUBLISHERS:

Trenchless Australasia is published by Great Southern Press on behalf of the ASTT. Great Southern Press was formed in 1972 and is a specialist industry publisher providing print and online information which covers infrastructure, construction, minerals and energy both in Australia and across Asia.

As a specialist industry publisher, Great Southern Press understands the needs of business and is highly competent in helping create successful advertising campaigns for companies of all sizes. Our team is committed to the growth of our clients’ businesses and to the overall advancement of the Trenchless Technology industry.

Great Southern Press builds on traditional publishing values blended with new technology to ensure first rate customer service. Visit the Great Southern Press website. For more information, please email us.
Directory

AJ Lucas Drilling Services
394 Lane Cove Road
MACQUARIE PARK NSW 2113
Australia
LOCKED BAG 2113
NORTH RYDE NSW 1670 Australia
PHONE: (02) 9490 4000
FAX: (02) 9490 4200
EMAIL: john.sr@lucas.com.au
www.lucas.com.au
Contact: John Stuart-Robertson
AREA SERVICED: Worldwide

Akkerman
58256 266th Street
BROWNSDALE MN 55918 United States
PHONE: +1 800 533 0386
FAX: +1 507 567 2605
EMAIL: akk@akkerman.com
www.akkerman.com
Contact: Troy Stokes
Sales Engineer
AREA SERVICED: Worldwide

AND Engineers and Associates
47A Rakhal Das Auddy Road
ALIPORE WEST BENGAL 700027
India
PHONE: +91 98304 12567
FAX: +91 33 2468 4461
MOBILE: +91 98304 12567
EMAIL: ayan1973@gmail.com
Contact: Ayanangshu Dey
Partner

Australian Tunnelling Services
13 Hopbush Avenue
SUNBURY VIC 3429 Australia
PO BOX 80
SUNBURY VIC 3429 Australia
PHONE: (03) 9740 7007
MOBILE: 0437 362 117
EMAIL: enquiry@austun.com.au
www.austun.com.au
Contact: Neil Bracken
Proprietor
AREA SERVICED: Australia, New Zealand, Pacific Region, Fiji, PNG, Asia

AMCOL/CETCO Drilling Products
94 Balham Road
ARCHERFIELD QLD 4108 Australia
PO BOX 87
ARCHERFIELD QLD 4108 Australia
PHONE: (07) 3277 9586
MOBILE: 0447 097 432
EMAIL: joshua.noble@cetco.com
www.cetco.com/dpg
Contact: Josh Noble
Regional Sales Director
AREA SERVICED: Worldwide

Austunnel Pty Ltd
37 Kate Street
KEDRON QLD 4031 Australia
PO BOX 12
CHERMSIDE SOUTH QLD 4032
Australia
PHONE: (07) 3359 5335
FAX: (07) 3256 4636
EMAIL: alexei.bebek@austunnel.com.au
www.austunnel.com.au
Contact: Alexei Bebek
Managing Director
AREA SERVICED: Worldwide

Bamser Holdings Pty Ltd
Suite 40, 1 Park Road
MILTON QLD 4064 Australia
PHONE: (07) 3217 5153
FAX: (07) 3503 9117
EMAIL: bencrosby@bamser.com.au
www.bamser.com.au
Contact: Benjamin Crosby
Managing Director
AREA SERVICED: Worldwide

Bastow Civil Constructions
49 South Creek Road
SHANES PARK NSW 2747 Australia
PHONE: (02) 9835 3866
FAX: (02) 9835 3877
EMAIL: jason@bastowcivil.com
www.bastowcivil.com
Contact: Jason Bastow
AREA SERVICED: Worldwide

Blick Industrial
21 Kahu Crescent
TE RAPA HAMILTON 3200 New Zealand
PO BOX 10157
TE RAPA HAMILTON 3241 New Zealand
PHONE: +64 7 849 2366
FAX: +64 7 850 6279
MOBILE: +64 27 470 0777
EMAIL: tim@blick.co.nz
www.blick.co.nz
Contact: Tim Babbage
Director
AREA SERVICED: Australia, New Zealand, Pacific Region
A COMPREHENSIVE GUIDE TO MICROTUNNELLING

SPONSORS

Bothar Boring
114 Ingleston Road
WAKERLY QLD 4154 Australia
PHONE: (07) 3907 0777
FAX: (07) 3907 0888
MOBILE: 0412 148 433
EMAIL: info@botharboring.com.au
www.botharboring.com.au
Contact: Steve Mitchell
AREA SERVICED: Worldwide

Bullseye Boring
2 Tincombe Grove
BALDIVIS WA 6171 Australia
MOBILE: 0407 775 335
FAX: (08) 9524 2197
EMAIL: admin@bullseyeboring.com.au
www.bullseyeboring.com.au
Contact: Leon DeLuis
AREA SERVICED: Australia

Coe Drilling Pty Ltd
11-13 Gibbs Street
LABRADOR QLD 4214 Australia
PHONE: (07) 5500 5222
FAX: (07) 5500 6444
MOBILE: 0419 794 336
EMAIL: e.foley@coedrilling.com.au
www.coedrilling.com.au
Contact: Eamon Foley
HDD Manager
AREA SERVICED: Worldwide

D.J. Mac Cormick Contractors
Ground Floor, 200 Adelaide Terrace
Perth WA 6000 Australia
PHONE: (08) 9221 5121
FAX: (08) 9221 5124
EMAIL: malcolm@djmaccormick.com.au
www.djmaccormickcontractors.com.au
Contact: Malcolm Mac Cormick
Director
AREA SERVICED: Australia

Derrick Equipment Company
15630 Export Plaza Drive
HOUSTON TEXAS 77032 United States
PHONE: +1 281 590 3003
FAX: +1 281 590 6187
EMAIL: bhclark@equipment.com
www.derrick.com
Contact: Ben Clark
Area Manager, Underground Construction Applications
AREA SERVICED: Worldwide

Directhit Trenchless Pty Ltd
227 Bahrs Scrub Road
BAHRS SCRUB QLD 4207 Australia
PHONE: (07) 3804 0200
FAX: (07) 3804 0211
MOBILE: 0418 791 505
EMAIL: directhit@bigpond.com
www.directhit.com.au
Contact: Albert Hendrickx
Director
AREA SERVICED: Worldwide

Ditch Witch Australia
35 David Road
EMU PLAINS NSW 2750 Australia
PHONE: (02) 4777 7100
FAX: (02) 4777 7124
EMAIL: cmalan@dwaus.com.au
www.dwaus.com.au
Contact: Christopher Malan
General Manager
AREA SERVICED: Australia, New Zealand, Pacific Region, East Timor, Fiji, PNG

Ditch Witch New Zealand Ltd
24K Allright Place
MT WELLINGTON 1060 New Zealand
PO BOX 132381
SYLVIA PARK 1644 New Zealand
PHONE: 0800 396 9583
FAX: +64 9 570 4488
MOBILE: +64 021 970 136
EMAIL: info@ditchwitchnz.com
www.ditchwitchnz.com
Contact: John Grant
General Manager
AREA SERVICED: New Zealand

Downer EDI Works
Level 2, 650 Lorimer Street
PORT MELBOURNE VIC 3207
Australia
PHONE: (03) 8645 0858
FAX: (03) 8645 0840
MOBILE: 0429 437 128
EMAIL: majid.majeed@downergroup.com
www.downergroup.com
Contact: Majid Majeed
Manager Water
AREA SERVICED: Australia

Coles Inc
PO BOX 601
CLEVELAND QLD 4163 Australia
MOBILE: 0429 862 070
EMAIL: colescp@gmail.com
Contact: Peter Coles
Project Manager/Supervisor
AREA SERVICED: Worldwide

SPONSORS

Akkerman
Pezzimenti Tunnelbore
Project Support
Kwik-ZIP Spacers
3 Barnard Street
BUNBURY WA 6230 Australia

PHONE: (08) 9725 4678
FAX: (08) 9725 4700
MOBILE: 0408 932 002
EMAIL: sales@kwikzip.com
www.kwikzip.com

Contact: Jason Linaker
Managing Director

AREA SERVICED: Worldwide

March Cato Ltd
171 McLeod Road
TE ATATU AUCKLAND 0645 New Zealand
PO BOX 69097
GLENDEANE AUCKLAND 0645 New Zealand

PHONE: +64 9 835 3800
FAX: +64 9 835 3801
MOBILE: +94 21 996 732
EMAIL: adam@marchcato.co.nz
www.marchcato.co.nz

Contact: Adam Cato
Director

AREA SERVICED: New Zealand

Midcoast Under Road Boring Pty Ltd
2 Broadway Street
STROUD NSW 2425 Australia
PO BOX 105
STROUD NSW 2425 Australia

PHONE: (02) 4994 5211
FAX: (02) 4994 5003
MOBILE: 0418 652 448
EMAIL: john@midcoastboring.com.au

Contact: John Kidde
Managing Director

AREA SERVICED: Australia

Nacap Australia Pty Ltd
Level 1, 601 Doncaster Road
DONCASTER VIC 3108 Australia
PO BOX 103
DONCASTER VIC 3108 Australia

PHONE: (03) 8848 1888
FAX: (03) 8848 1899
EMAIL: w.moon@nacap.com.au

Contact: WAYDE MOON
Estimating Manager

AREA SERVICED: Australia, New Zealand, Pacific Region

Parsons Brinckerhoff
Level 27, 680 George Street
SYDNEY NSW 2001 Australia
GPO BOX 5390
SYDNEY NSW 2001 Australia

PHONE: (03) 9861 2363
EMAIL: gaskellc@pbworld.com
www.pbworld.com

Contact: Christopher Gaskell
Section Executive Tunnels

AREA SERVICED: Worldwide

Pezzimenti Trenchless
Unit 2/85 Heatherdale Road
RINGWOOD VIC 3134 Australia
PO BOX 2500
NORTH RINGWOOD VIC 3134 Australia

PHONE: (03) 9872 4596
FAX: (03) 9872 3293
EMAIL: info@pezztrenchless.com.au

Contact: Joe Pezzimenti
Director

AREA SERVICED: Australia

Pezzimenti Tunnelbore Pty Ltd
18–24 Smith Street
EMU PLAINS NSW 2750 Australia

PHONE: (02) 4735 6676
FAX: (02) 4735 6678
MOBILE: 0408 286 692
EMAIL: jim.shooter@pezzimenti.com.au
www.pezzimenti.com.au

Contact: Jim Shooter
NSW Operations Manager

AREA SERVICED: Australia

PipeWorks
18 Gabador Place
MOUNT WELLINGTON AUCKLAND 1060 New Zealand
PO BOX 62 077
MOUNT WELLINGTON AUCKLAND 1060 New Zealand

PHONE: +64 9 573 1901
FAX: +64 9 573 1903
MOBILE: +64 27 228 3924
EMAIL: zuhairs@fcc.co.nz
www.pipeline.co.nz

Contact: Zuhair Shehadeh
Business Development Manager

AREA SERVICED: New Zealand

SPONSORS

[Akkerman](#)
[PEZZIMENTI TUNNELBORE](#)
[PROJECT SUPPORT](#)
<table>
<thead>
<tr>
<th>Sponsors</th>
<th>Contact</th>
<th>Area Serviced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Support Pty Ltd</td>
<td>Andrew Plail</td>
<td>Australia, New Zealand, Pacific Region</td>
</tr>
<tr>
<td>Rightline Plumbing and Civil Excavation</td>
<td>Ryan Ingleton</td>
<td>Australia</td>
</tr>
<tr>
<td>Rob Carr Pty Ltd</td>
<td>Angelo Soumboulidis</td>
<td>Australia, New Zealand</td>
</tr>
<tr>
<td>Rocla</td>
<td>Andrew Hooper</td>
<td>Australia, New Zealand</td>
</tr>
<tr>
<td>Smythe Contractors Ltd</td>
<td>Simon Payne</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Rod Davies Infrastructure Pty Ltd</td>
<td>Rod Davies</td>
<td>Australia, New Zealand</td>
</tr>
<tr>
<td>Shoota Drilling &amp; Civil</td>
<td>Steve Schut</td>
<td>Australia, New Zealand, Pacific Region, Fiji</td>
</tr>
<tr>
<td>The Robbins Company</td>
<td>Craig Allan</td>
<td>Worldwide</td>
</tr>
</tbody>
</table>
## SPONSORS

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
<th>Website</th>
<th>Contact</th>
<th>Area Serviced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiess</td>
<td>Level 23, 52 Martin Place, Sydney NSW 2000 Australia</td>
<td>(02) 8045 1000</td>
<td>(02) 8045 1111</td>
<td><a href="mailto:jmilner@thiess.com.au">jmilner@thiess.com.au</a></td>
<td><a href="http://www.thiess.com.au">www.thiess.com.au</a></td>
<td>John Milner</td>
<td>Australia, New Zealand,</td>
</tr>
<tr>
<td></td>
<td>GPO Box 4128, Sydney NSW 2001 Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Business Development Manager</td>
<td>Pacific Region</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiess Services Pty Ltd</td>
<td>9-11 Green Street, Doieton VIC 3177 Australia</td>
<td>(03) 9215 2100</td>
<td>(03) 9794 0702</td>
<td><a href="mailto:mwade@thiess.com.au">mwade@thiess.com.au</a></td>
<td><a href="http://www.thiess.com.au">www.thiess.com.au</a></td>
<td>Marcus Wade</td>
<td>Australia, New Zealand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Business Development Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiger Fluids</td>
<td>Teewatin QLD 4565 Australia</td>
<td>(07) 3420 5455</td>
<td>(07) 3420 5855</td>
<td>info@tt-asia pacific.com</td>
<td><a href="http://www.tt-asia">www.tt-asia</a> pacific.com</td>
<td>John Walsh</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>PO Box 1214</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>National Sales Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trenchless Civil</td>
<td>Unit 9/75 Lorimer Street, Docklands VIC 3008 Australia</td>
<td>(03) 9279 4600</td>
<td>(03) 9279 4699</td>
<td><a href="mailto:andrewb@trenchlesscivil.com.au">andrewb@trenchlesscivil.com.au</a></td>
<td><a href="http://www.trenchlesscivil.com.au">www.trenchlesscivil.com.au</a></td>
<td>Andrew Banks</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Docklands VIC 3008 Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Construction Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunnel Boring Australia Pty Ltd</td>
<td>Unit 5, 53-57 Link Drive, Yatala QLD 4207 Australia</td>
<td>(07) 3801 8813</td>
<td>(07) 3801 8815</td>
<td><a href="mailto:mail@tunnelboring.com.au">mail@tunnelboring.com.au</a></td>
<td><a href="http://www.tunnelboring.com.au">www.tunnelboring.com.au</a></td>
<td>Stephen Mellish</td>
<td>Australia, New Zealand</td>
</tr>
<tr>
<td></td>
<td>Yatala DC QLD 4207 Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Director</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TT Asia Pacific Pty Ltd</td>
<td>6 Devlan Street, Mansfield QLD 4122 Australia</td>
<td>(07) 3420 5455</td>
<td>(07) 3420 5855</td>
<td>info@tt-asia pacific.com</td>
<td><a href="http://www.tt-asia">www.tt-asia</a> pacific.com</td>
<td>John Walsh</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Mansfield QLD 4122 Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>National Sales Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunnelcorp</td>
<td>33/28 Burnside Road, Yatala QLD 4207 Australia</td>
<td>1300 886 635</td>
<td>0439 449 250</td>
<td><a href="mailto:jim.perry@tunnelcorp.com.au">jim.perry@tunnelcorp.com.au</a></td>
<td><a href="http://www.tunnelcorp.com.au">www.tunnelcorp.com.au</a></td>
<td>Jim Perry</td>
<td>Worldwide</td>
</tr>
<tr>
<td></td>
<td>Yatala DC QLD 4207 Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>General Manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SPONSORS