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UPGRADES & OPTIONS FOR THE GLOBAL COORDINATE SYSTEM, ZED 261

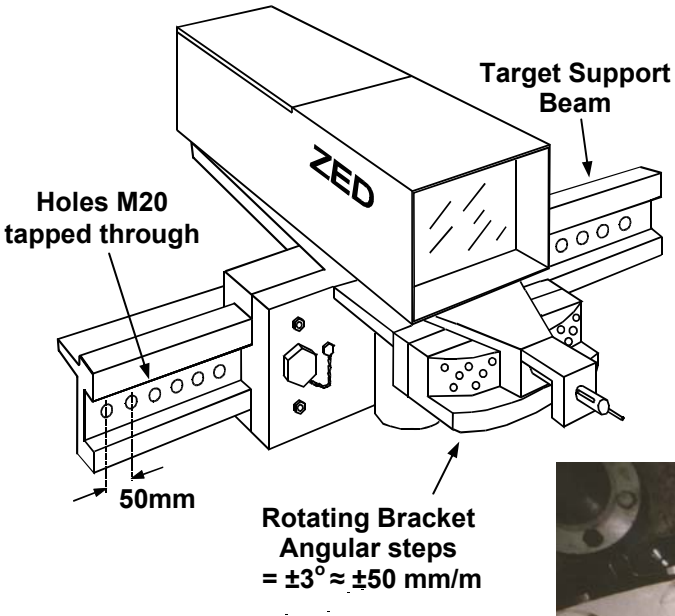
Installation & Commissioning

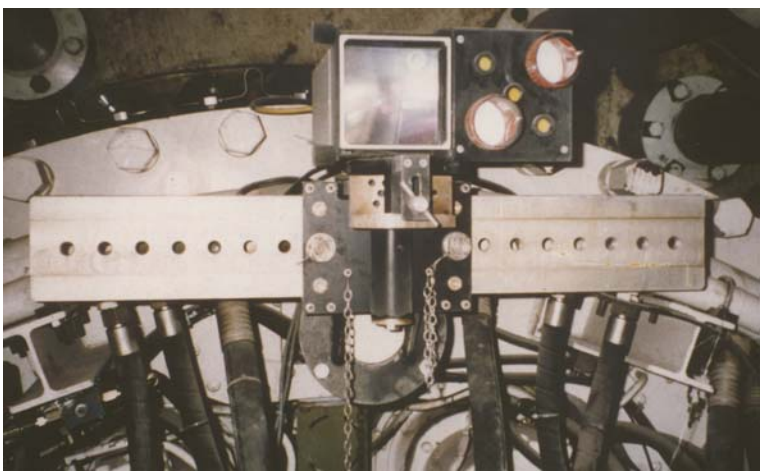
- Quick and straight forward installation onto the TBM.
- Typically, 2 to 3 days, on-site training of survey staff is sufficient.
- Development of close links with the site to encourage the speedy resolution of any problems, if they occur, once tunnelling starts.

Rotating Target Mounting Bracket

When a TBM excavates, typically, a horizontal curve, a mounting can be supplied by ZED that permits movement in the **Y** axis, in fixed steps, to help keep the laser on the glass screen. If the unit were fixed rigidly to the TBM then moving the laser can be time consuming.

The mounting also includes a bracket that permits rotation to ensure that the angle of incidence of the laser is kept well within the targets range of measurement, ±100 mm/m. The mechanical arrangement preserves the attitude of the target with respect to the machines axes as originally determined during the setup / installation phase.



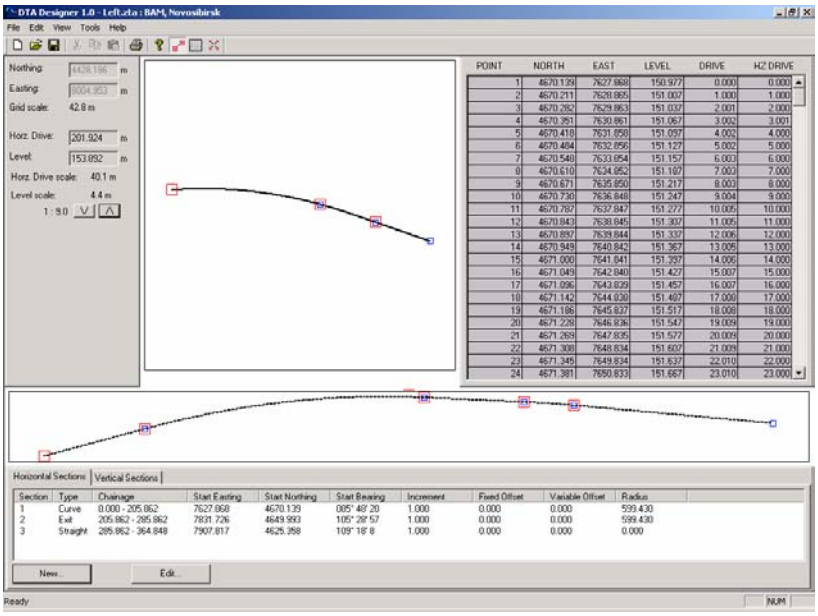


Delivery Tunnel North
Lesotho Highlands Water Project
HMC Tunnel Venture

DTA Designer

A stand alone software option to generate a DTA table / file from the original project survey data. As the data defining each section, i.e. straight or circular & transition curves, for the alignment, horizontally and vertically is entered, the corresponding file is generated, together with a graphical representation.

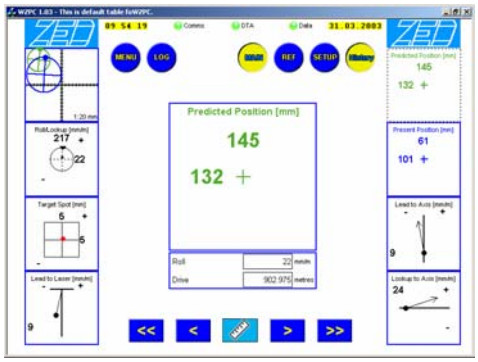
DTA Designer display

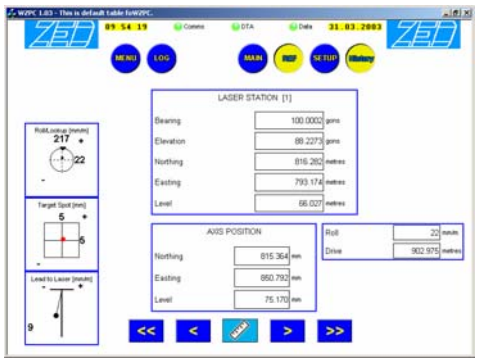


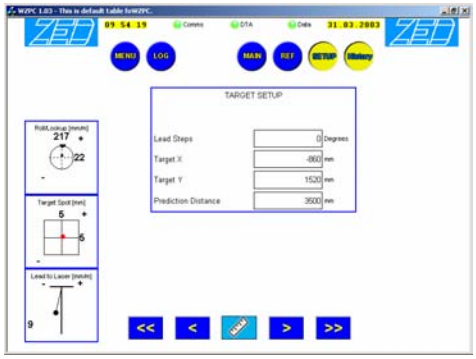
Data Logging

A software upgrade permitting data logging of all guidance & associated survey values within the PDU. Logging can be setup to trigger on time, distance and / or a manual command from the PDU. The data is transferred manually via a flash memory device from the PDU to a PC, running ZED software called ViewStation, which if connected to a suitable A4 colour printer, will provide documentation suitable for direct submission, or inclusion within, reports to the Client.

Example displays available for printing



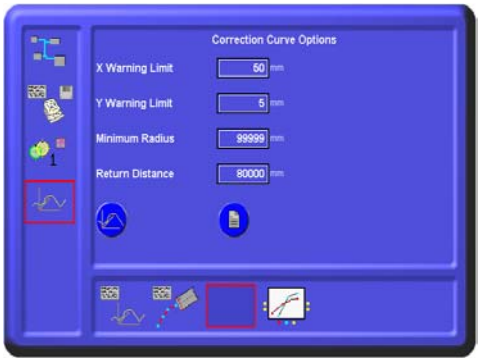




Correction Curve

A software module, uploaded and incorporated within the guidance program, to calculate and graphical display a 'Correction Curve', to help the machine operator maintain a smooth response in returning the TBM tangentially to the DTA when off line. User settable thresholds to initiate and authorise the correction curve mode.

Correction Curve setup display



Link to additional PC / PLC at other locations

A data / communications link between the system on the TBM and PC's sited elsewhere, either locally on the machine backup / trailing gear or in an aboveground office giving project Surveyors / Engineers real-time access to, and views of, the present status of the TBM with regards to the guidance and ring build, if applicable. The link maybe extended further, perhaps to a contractors headquarters, for real-time, data presentation. The link from the machine to the surface is established either via Ethernet or RS422, using cores provided in the TBM's umbilical. ZED software, ViewStation (Full) provides full interactive access, password protected, to the systems database, permitting :-

- Uploading of historical logged data
- Up / downloading of DTA files
- Graphical & numerical displays to view current and historical status.
- If connected, printing of current / historical data for high quality Client reporting

Alternatively a connection can be made directly to, for interrogation by, the TBM's own PC or PLC, allowing full access to all guidance data for viewing or data logging by the customers own systems.

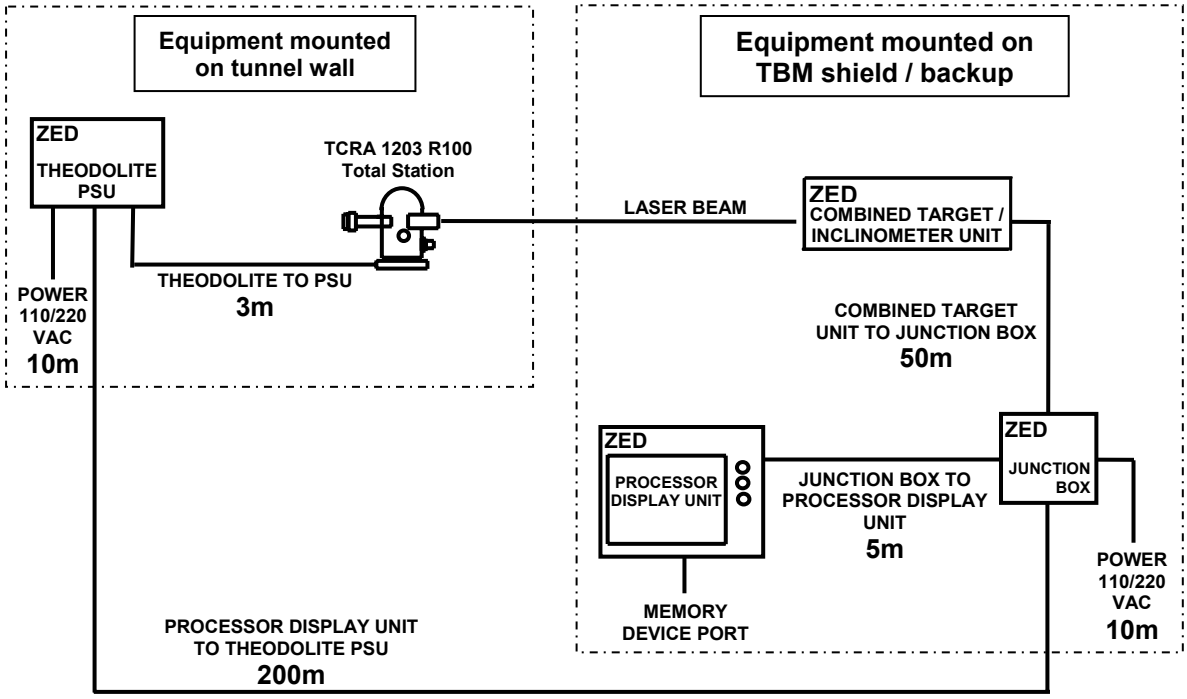
Interface with a Leica TPS 1200 Series Total Station, TCRA 1203 R100

The upgrade replaces the standard tunnelling laser with a standard 'off the shelf' total station, typically the TCRA 1203 R100, manufactured by Leica GeoSystems Ltd. The upgrade establishes a communications link between the system and the instrument, enabling additional features :-

- The laser assembly is mounted co-axially in the telescope, providing for easier setting up, determination of position and the direct reading of the laser beams angles.
- The system monitors the laser beams position on the target unit's screen and if it exceeds ± 30mm window it will command the total station to reposition it back to the centre. The tracking of the machine as it excavates maximises the usable laser window to the target, extending the time before the station is repositioned to follow the TBM. Additionally, it reduces intervention by personnel on the TBM to manually redirect the laser if it comes off the target during tunnelling.

- Reflector-less, electronic distance measurement, directly off the target units front glass screen, permitting the automatic determination of the real-time value of Drive, with no additional reflectors or the need for manual entry required.
- No special survey equipment required. The type of total station specified here, is one, which a contractor may already own or would consider purchasing for other survey jobs, including tunnel guidance.
- The instruments 'Automatic Target Recognition' (ATR) feature permits the system to perform a 'back-sighting' procedure to check on the accidental misalignment of the theodolite station by measuring and then comparing it's position to a previously learnt coordinate of a prism(s) placed back along the tunnel alignment, perhaps that of the last station.
- The automatic calculation of a new laser station position following re-sitting of the instrument to keep up with the TBM. This means that the task can be accomplished by the Shift Engineer or another responsible person underground, freeing the Surveyor for other jobs. Alternatively, the survey data, maybe entered manually either at the instrument or Processor Display Unit

Example system interconnection with standard cable lengths :-



An important advantage of having this type of equipment is to greatly reduce the downtime when repositioning the laser station, For example, Morgan-Est (formerly Miller Civil Engineering), a UK contractor working on a sewer project in Hull, in the UK, with forward planning, were able to reposition the instrument in less than 30 minutes; basically the time required to physically move the total station and rearrange the cabling.

In the event of damage or problems with the total station or Interface Unit the system can be downgraded to operate with a conventional tunnelling laser. Tunnelling can then continue but with the manual inputting of the survey data and Drive until repairs can be carried out and the system is returned to its full operational capacity.

The survey equipment may be supplied by ZED's or the customer can approach Leica directly, following our specification.

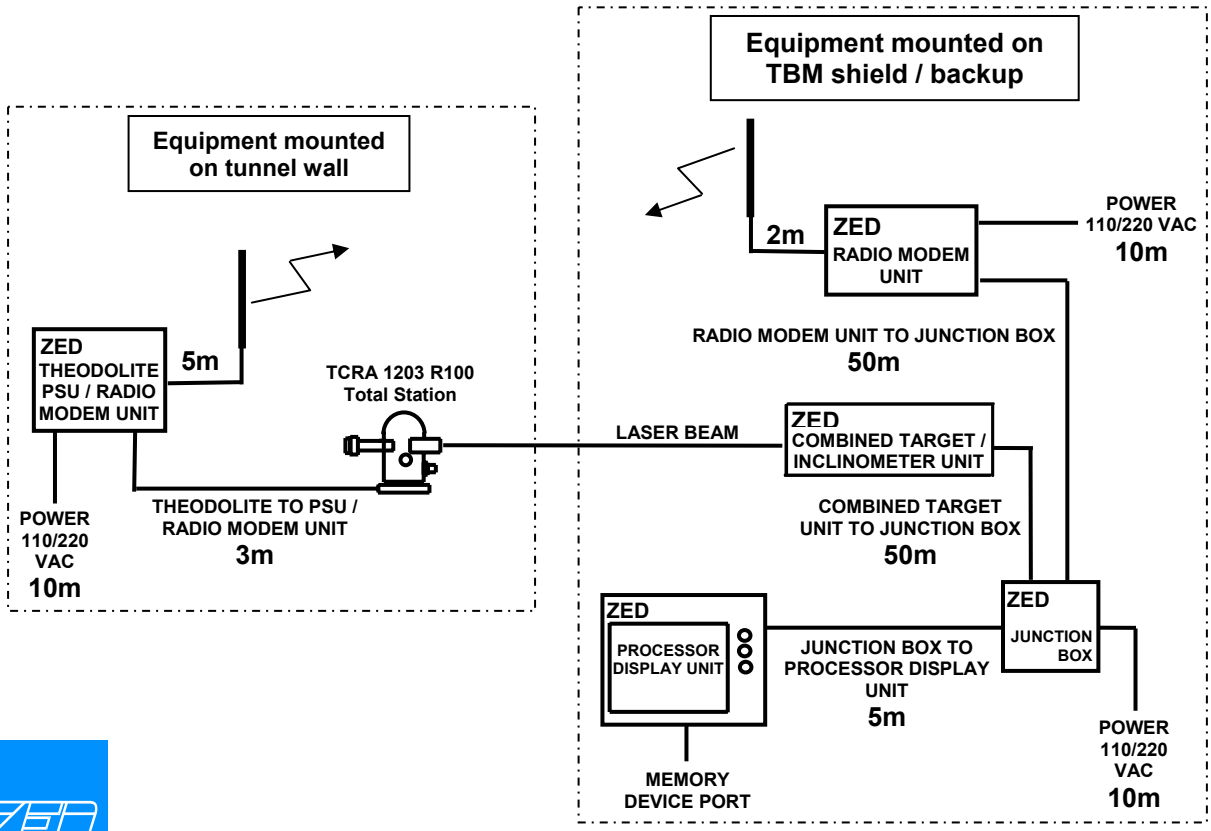
Radio Modem Units

With system configurations upgraded to include the Leica total station, consideration must be given to, and the management of, the cable linking the Theodolite PSU, which is mounted on the tunnel wall by the instrument, with the Processor Display Unit positioned on the moving TBM. To remove the potential threat of downtime, due to damage to this cable, the hardwired link can be replaced by a radio modem that utilises the latest spread spectrum, frequency hopping, technology.

To ensure the best possible reception the two aerials are placed within the laser window, allowing line of sight between them.

Jay Dee / Michels / Traylor JV
Big Walnut Augmentation / Rickenbacker Interceptor, Ohio, USA

Example system interconnection with standard cable lengths :-



Infra Red Combined Target Unit, (IRCTU)

This unit is a direct replacement for the Combined Target Unit. The IRCTU operation is based on Automatic Target Recognition or ATR, recently developed theodolite technology, which allows the Leica TCA or TCRA total station to self-centre and lock onto a prism or reflector.

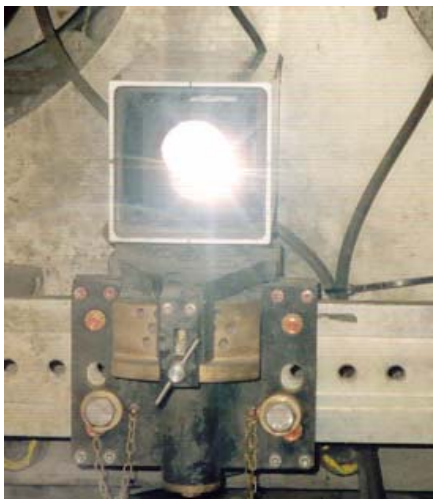
The target unit incorporates a specially engineered internal prism on to which the ATR locks and associated optical sensors sensitive to the infra-red laser emitted from the instrument to measure the angle of incidence or Lead. The target unit transmits the same data format as with the original laser based version but with the Spot Position, X & Y laser beam coordinates on the target, = 0 and the Lead as measured.

The system is linked electronically to the total station, via a cable / cable reel or radio modem, enabling it to interrogate the instrument for the changing horizontal and vertical angles associated with the locked ATR on the target prism, as the TBM excavates, tracking the machine. It also monitors the distance to the prism using the total stations own integrated EDM (electronic distance measurement).

The main advantage of using this type of reference is the extended range, or separation distance between the target on the TBM and the total station, when compared to a conventional laser based system. Typically, lasers are limited to <200m, due to a breakdown of the beams quality with diffraction and absorption, but with the method highlighted here, longer separation distances are possible, under similar atmospheric conditions.

If used with the TCRA instrument, the visible spotting laser is also activated by the system to help define the line of sight between the total station and the target helping to prevent tunnel workers obscuring the otherwise invisible, infra red beam. Note, the visible laser has no effect on the IRCTU operation.

Infra-Red Combined Target Unit



IRCTU on the Abdalajis Tunnel West-Tube, Spain
UTE Abdalajis Oeste

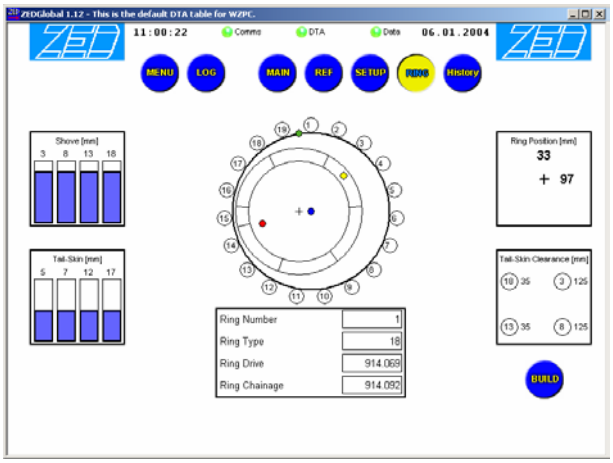
Ring Placing Module

A sophisticated software and interface module that is connected serially to the TBM PLC / PC monitoring the shove ram extensions and tailskin articulation to determine the best build position of the next tapered ring. The clearances of the last ring built, lying in the tailskin, are measured at four points around the shield circumference and entered manually into the system, the results is displayed graphically, showing the new ring build type and orientation. From any start chainage, a predicted sequence of ring types and build positions can be calculated and displayed.

All associated data, including the build parameters, global position, offset from the Designed Tunnel Axis (DTA), etc are logged and can be viewed, graphically on the machine or transferred manually using a memory device or uploaded directly if an above ground link has been selected, to the surface for high quality Client reporting

Lot 5, Turin Metro, Italy
Grandi Lavori Fincosit, Seli, CCC, Rodio, Interstrade & CO.GE.FA. JV

Ring Build display



Articulation Interface

Depending on the specific details of a TBM's geometry it maybe possible to calculate and display the 'Predicted Position' of the cutter-head of a double shielded machine, but where, because of insufficient room or through poor line of sight to the laser, the target unit has to be mounted on the rear or second shield.

Where the articulation between the two shields is currently measured by 3 or 4 linear extensiometer transducers with a 4 to 20 mA output, the upgrade comprises of a software module, which is incorporated within the guidance software running on the Processor Display Unit. An additional box is also required to provide an interface between the current loop and the PDU, containing a power supply and A to D conversion. The system monitors, with the target unit, in the normal way the position of the rear shield then uses the TBM geometry and articulation ram extensions, as measured by the linear extensometers, to determine the angular relationship of the two shields to each other and hence the Predicted Position, coincident with the cuter-head.

One important aspect that must be appreciated, if acceptable results are expected in the calculation of the cutter-heads position with respect to the designed tunnel axis, is that the method use here assumes that the joint linking the two shields is fixed, similar to a ball & socket, with little translational movement in the vertical and horizontal planes.

A TBM, maybe retrofitted with this upgrade but it must comply with the following, if the system is to operate correctly and as expected :-

- The TBM design meets the requirement noted above concerning the linkage between the shields
- There is room to permit the fitting and subsequent operation of 4 linear transducers adjacent to the articulation rams in protected positions.
- The installation and mounting of the linear transducers will be the responsibility of the customer.

TBM Autosteering Interface

The upgrade offers a software module and possibly additional hardware to interface between the guidance system and the TBM steering controls. The designed purpose of this option is to remove differences in steering characteristics between TBM operators, for example, at shift change, to produce a smooth and consistent response from the machine as it follows the tunnel alignment.

The module is initial setup, during installation & commissioning, with user editable steering parameters, to provide a suitable response between the guidance data and the particular TBM's preference in moving through the current ground conditions. The methodology used requires good / consistent ground conditions, if the geology changes, then it might be necessary to adjust the steering parameters. In poor ground where a human operator finds the machine difficult to steer, then the system will also have problems.

To ensure a successful outcome from using this option, each module supplied has to be tailored in some degree for each TBM and project, so two factors are essential :-

- The establishment of a firm electrical specification for the interface to the TBM
- That informative and open communication is made between ZED and the TBM manufacturer with regards to the machines hydraulic steering system

Not commonly selected as an upgrade, the last system provided was to CAVET (Consorzio Alta Velocita Emilia Toscana), the JV responsible for the Bologna to Firenze section of the high speed rail link between Milano and Napoli, in Italy, which finished at the end of 2003. Although the system supplied for this project was based on the last technical specification of ZED equipment, the methodology and algorithms used are the same as offered here.

Autosteering upgrade for Consorzio Alta Velocita Emilia Toscana (CAVET)