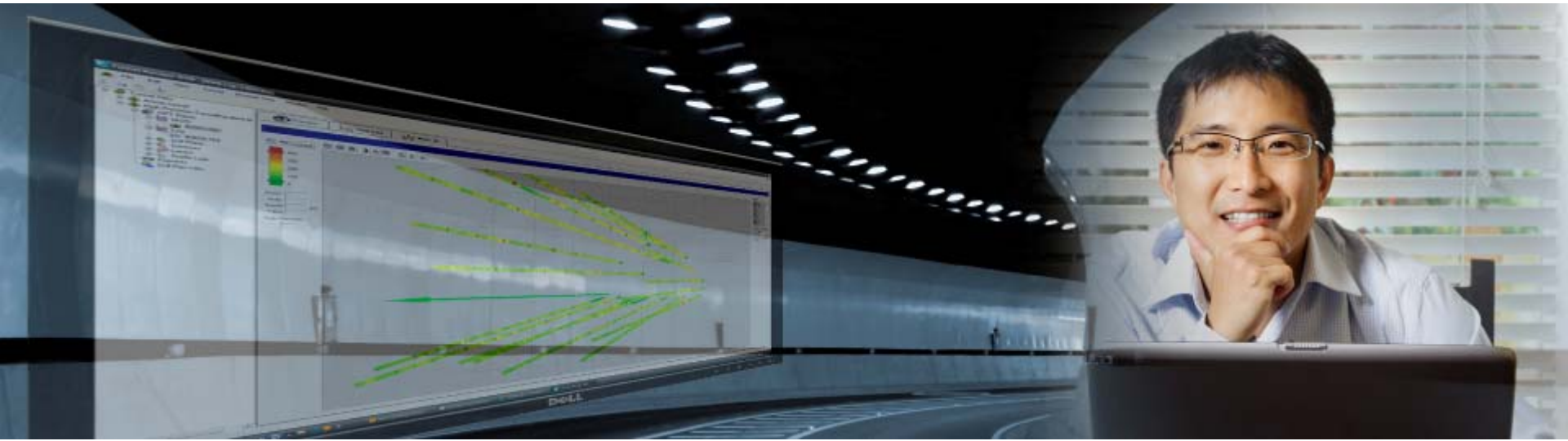


Advanced Technologies in Underground Mining



Stevan Topalovic

Business Line Manager Tunneling and Mining

Atlas Copco Australia



Advanced Technologies in Underground Mining

- Tunnel Manager
- Rig Remote Access (RRA)
- Total Station Navigation
- Tunnel Profiler
- Measure While Drilling (MWD)

Tunnel Manager

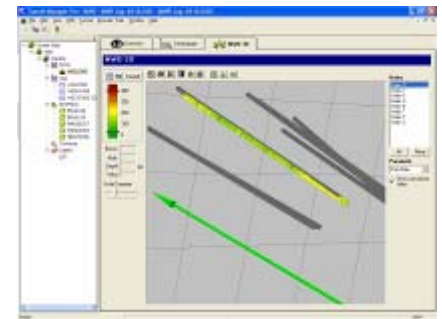
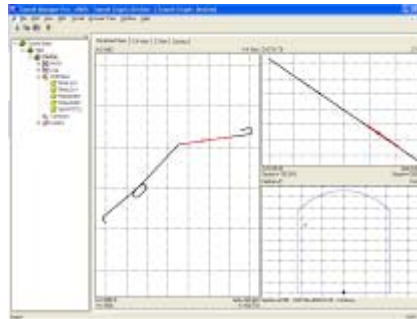
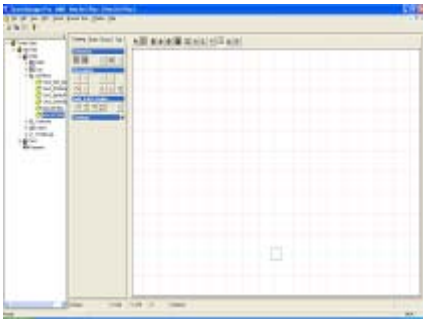
What is?

Tunnel Manager

Drill plans

Tunnel projects

Logging



Intelligent options available for Boomer rigs

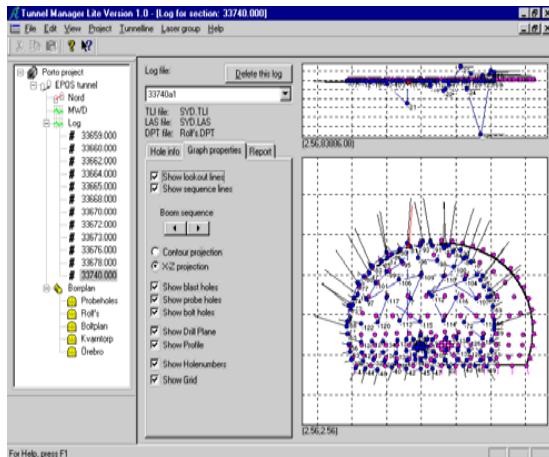
Tunnel Manager products

■ Features

- Drill plan design
- Bolt plan design
- Tunnel line definition
- Tunnel laser definition
- Drill round reports
- Measurement While Drilling

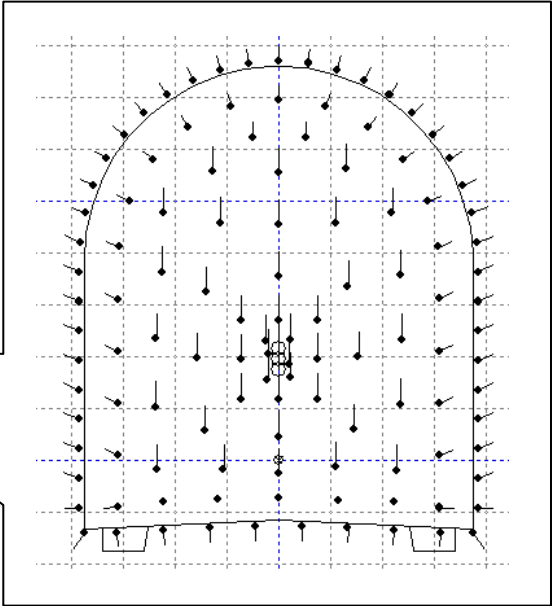
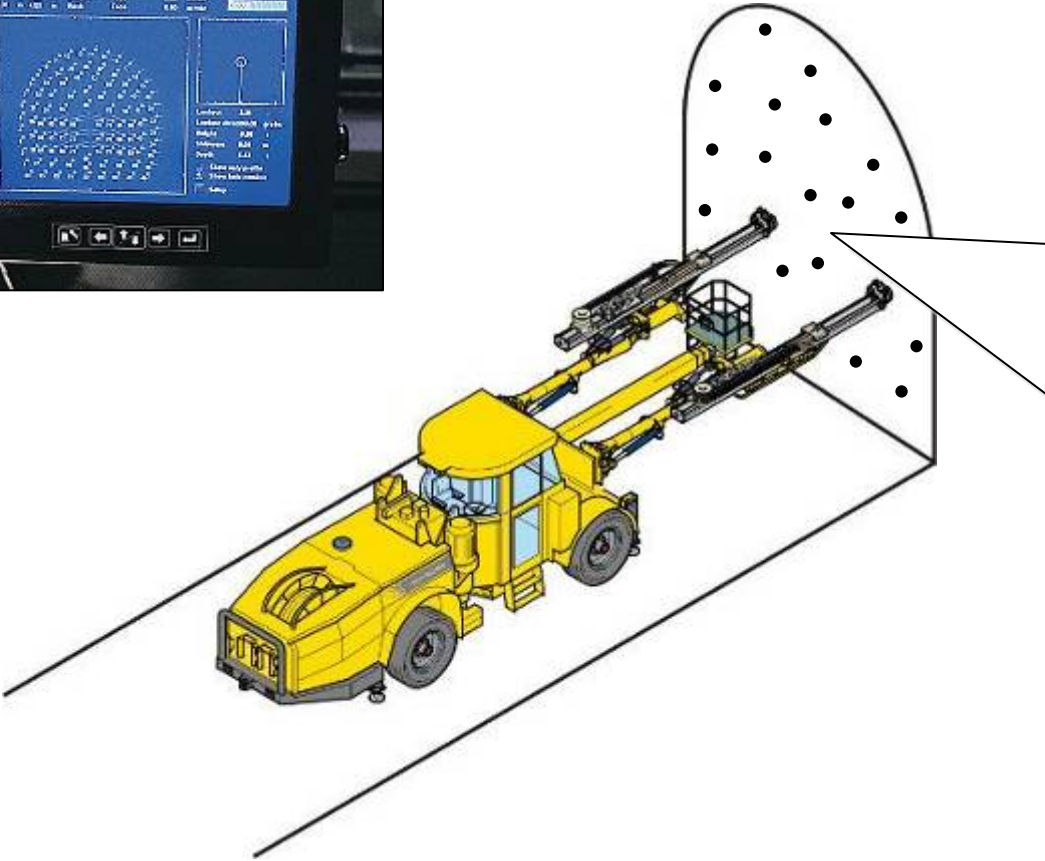
■ Benefits

- Advanced Boom Control (ABC)
- Accurate input data
- Boom navigation
- Reduced overbreak
- Tunnel quality
- Productivity



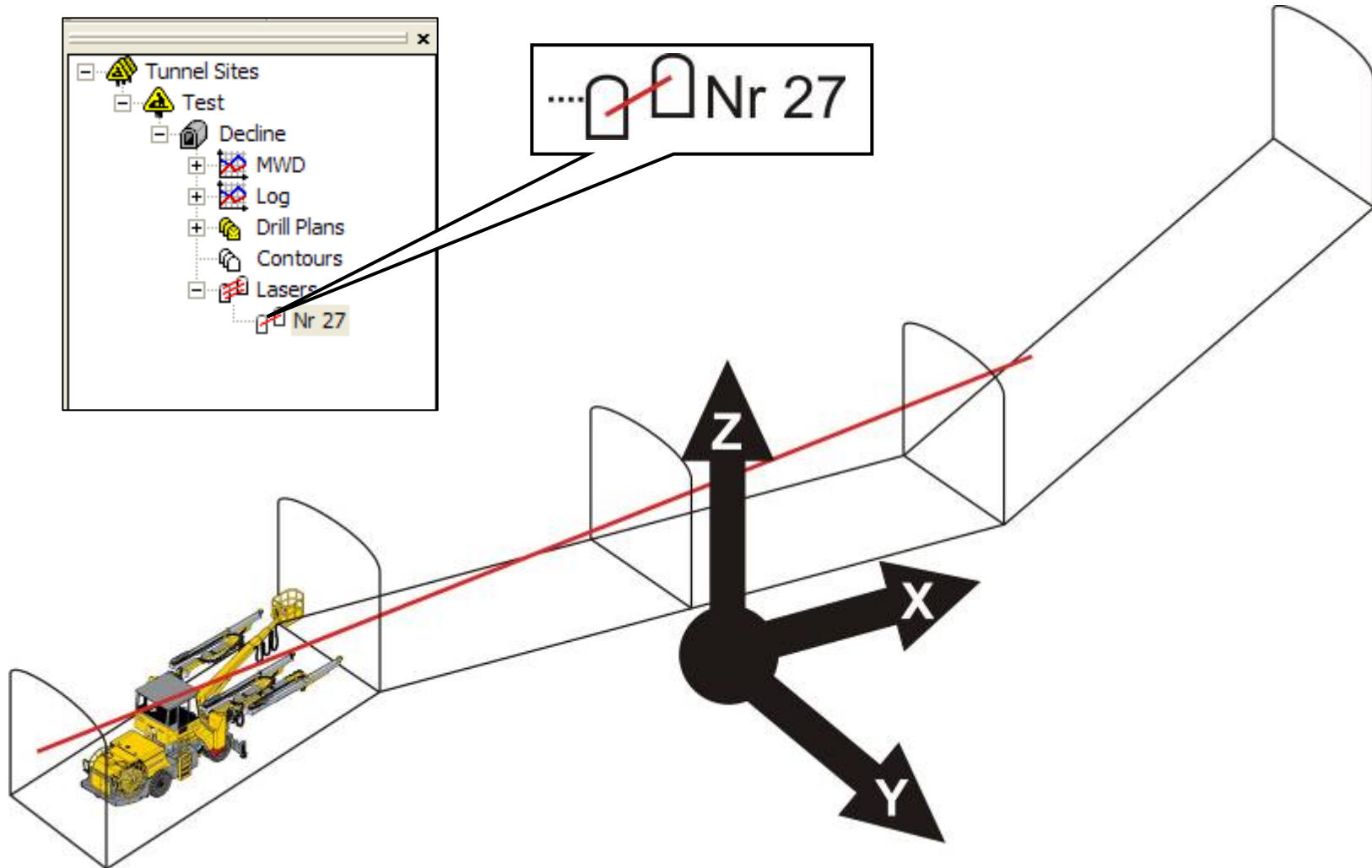
Drill Plan Designer

What is a drill plan?



Tunnel Manager

Laser line



Tunnel Manager

Logging - Round log report in Word

Hole info | Graph properties | Report

Area:

At Face: m²

At Bottom: m²

Contour: m²

Project: Tunnel Project
Date: 2006-02-15
File: C:\obra\Tunnel Project\log

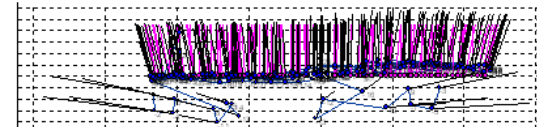
Tunnel Manager Lite - Round Report

Round Data

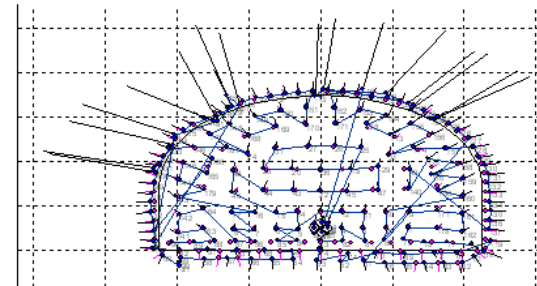
Tunnel line:	Tiear18	Laser:	lasera18s		
Drill Plan:	APIL A.DEC	Total Drilling [no.m]	200	1144	
Section number:	374000	Blast Holes [no.m]	182	1068	
Started Drilling:	2009/07/13 19:02:16	Bolt Holes [no.m]	18	76	
Finished Drilling:	2009/07/14 00:24:16	Injection Holes [no.m]	0	0	
Drilling Time:	05:22	Uspg. Holes [no.m]	0	0	
Rig ID:	8991329200	hwahd Holes:	0		

	Holes Blast	Holes Bolt	Holes Inject.	Holes Uspg.	Total Drilling [m]	Average Pen. Rate [m/min]	Net Drilltime
Boom 1	67	10	0	0	434	2.61	02:46
Boom 2	44	8	0	0	289	2.32	02:04
Boom 3	71	0	0	0	422	2.77	02:32

Drill Graph



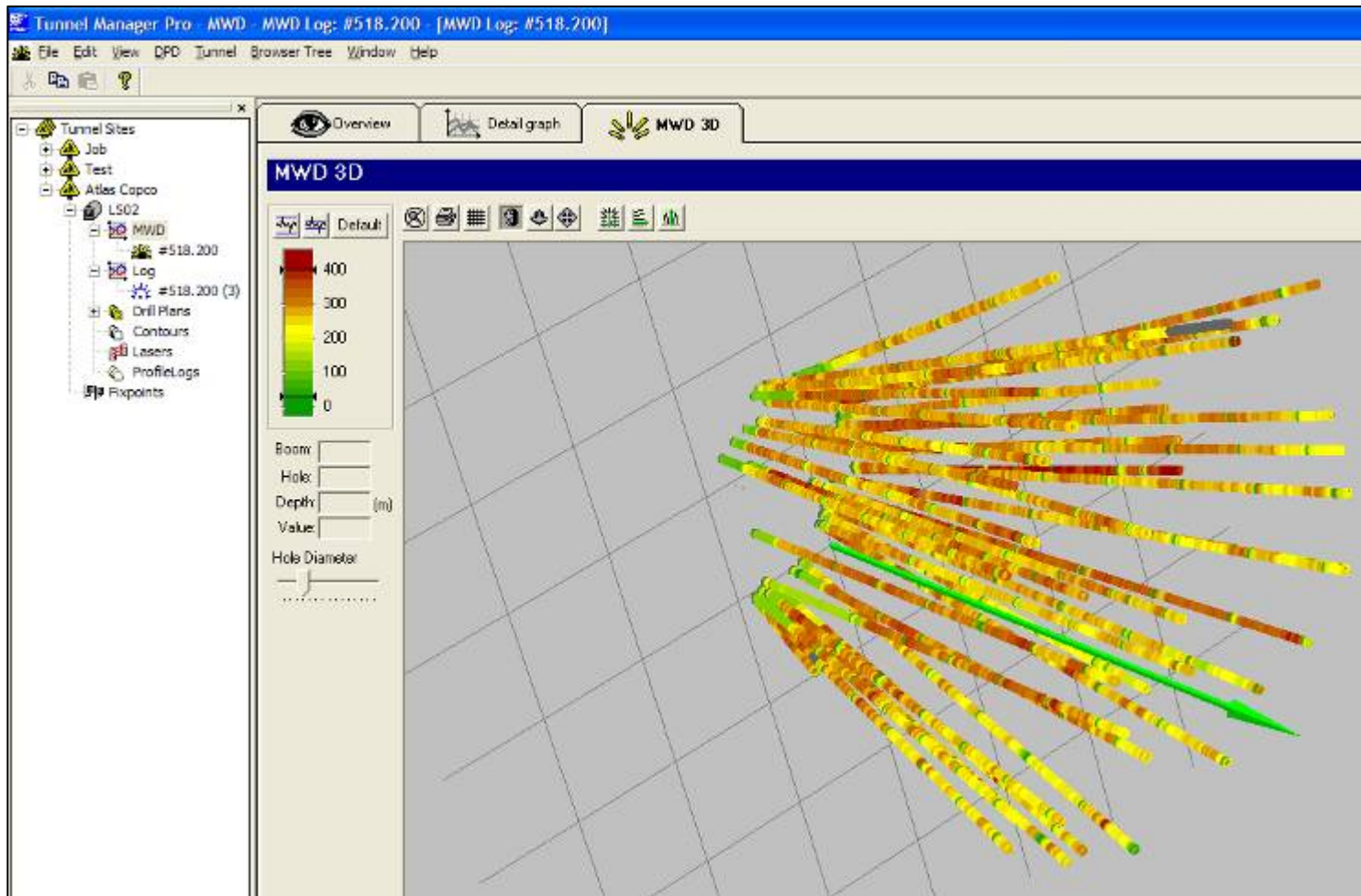
(2.56,1.28)



(2.56,2.56)

Tunnel Manager

Logging - MWD log



Data handling in Tunnel Manager Pro

The screenshot displays the 'Tunnel Manager MWD - [Fixpoints]' software interface. On the left is a project tree with the following structure:

- Tunnel Sites
 - Vising
 - Mine main drift
 - MWD
 - #9205.400
 - Log
 - #9220.550
 - Drill Plans
 - DP 2
 - Contours
 - Contour 1
 - Lasers
 - Demo Laser
 - Profile Logs
 - 9201.655
 - Fixpoints
 - Drill Plan rules
 - My Rule

On the right, a data table lists fixpoint information:

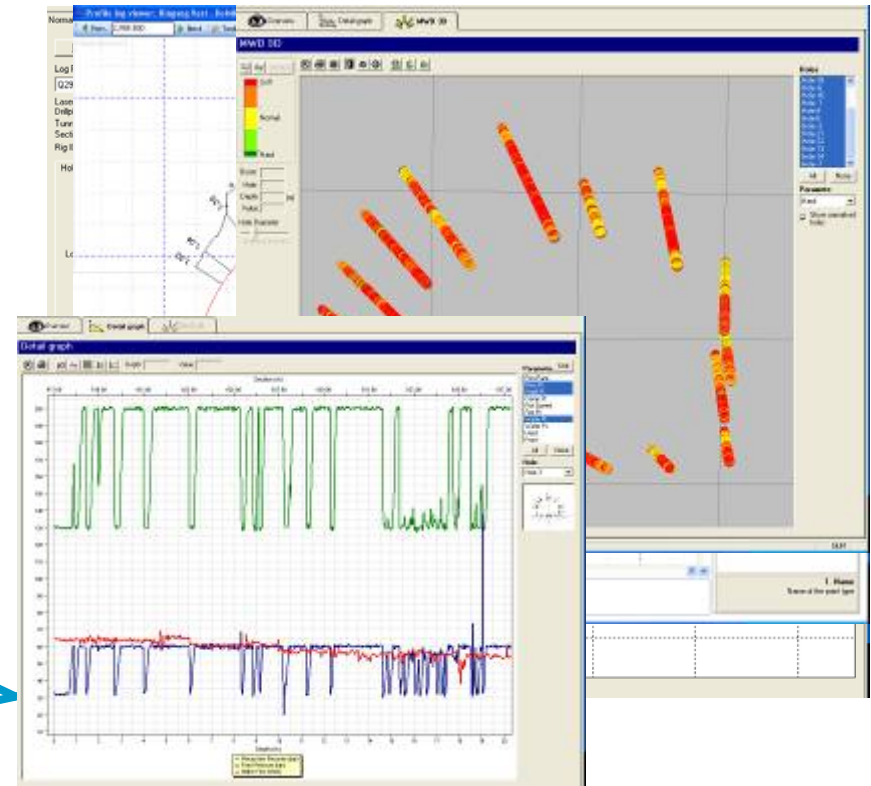
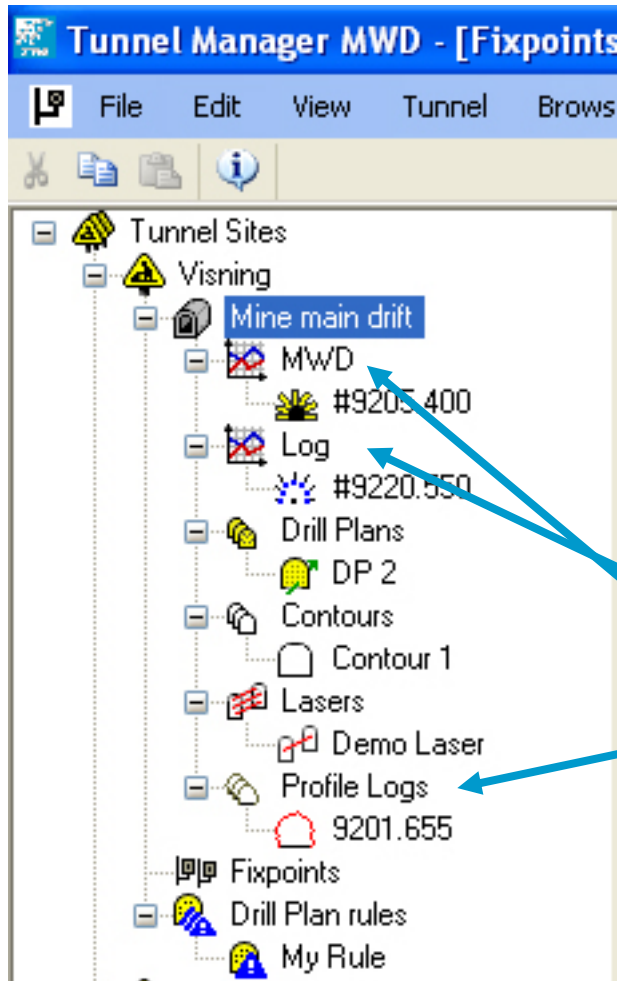
Id	Name	X	Y	Z	Type
1	X01	42772.301	589996.282	-7.379	FPtype1
10	0004	42809.044	589409.037	-6.468	FPtype1
11	LL05	42815.818	589435.055	-5.724	FPtype1
12	YG01	43034.068	590839.229	8.803	FPtype1
13	PO02	43033.010	590832.759	8.956	FPtype1
14	SK03	43031.712	590814.135	8.586	FPtype1
2	V02	42780.478	589321.746	-7.988	FPtype1
3	SA03	42762.305	589303.561	-8.161	FPtype1
4	OY04	757.864	589285.246	-8.206	FPtype1
5	FV05	42750.992	263.039	0.000	FPtype1
6	FV06	42742.196	589335.050	-8.775	FPtype1
7	PK01	42794.532	589361.956	15.000	FPtype1
8	FF02	42798.097	589373.703	-6.877	FPtype1
9	AC03	42805.344	589397.435	-6.481	FPtype1

Blue arrows indicate data flow from the table to the project tree:

- From the 'Tunnel Sites' header to the 'Tunnel Sites' folder.
- From the 'Mine main drift' row to the 'Mine main drift' folder.
- From the 'MWD' row to the 'MWD' folder.
- From the '#9205.400' row to the 'Drill Plans' folder.
- From the '#9220.550' row to the 'Contours' folder.
- From the 'Lasers' row to the 'Lasers' folder.
- From the '9201.655' row to the 'Fixpoints' folder.

Other interface elements include a 'Lasers' window showing a laser beam visualization, a 'Fixpoints' window showing a grid of points, and a 'Tunnel Cor Drill plans' window showing a tunnel profile. The bottom right corner features the Atlas Copco logo.

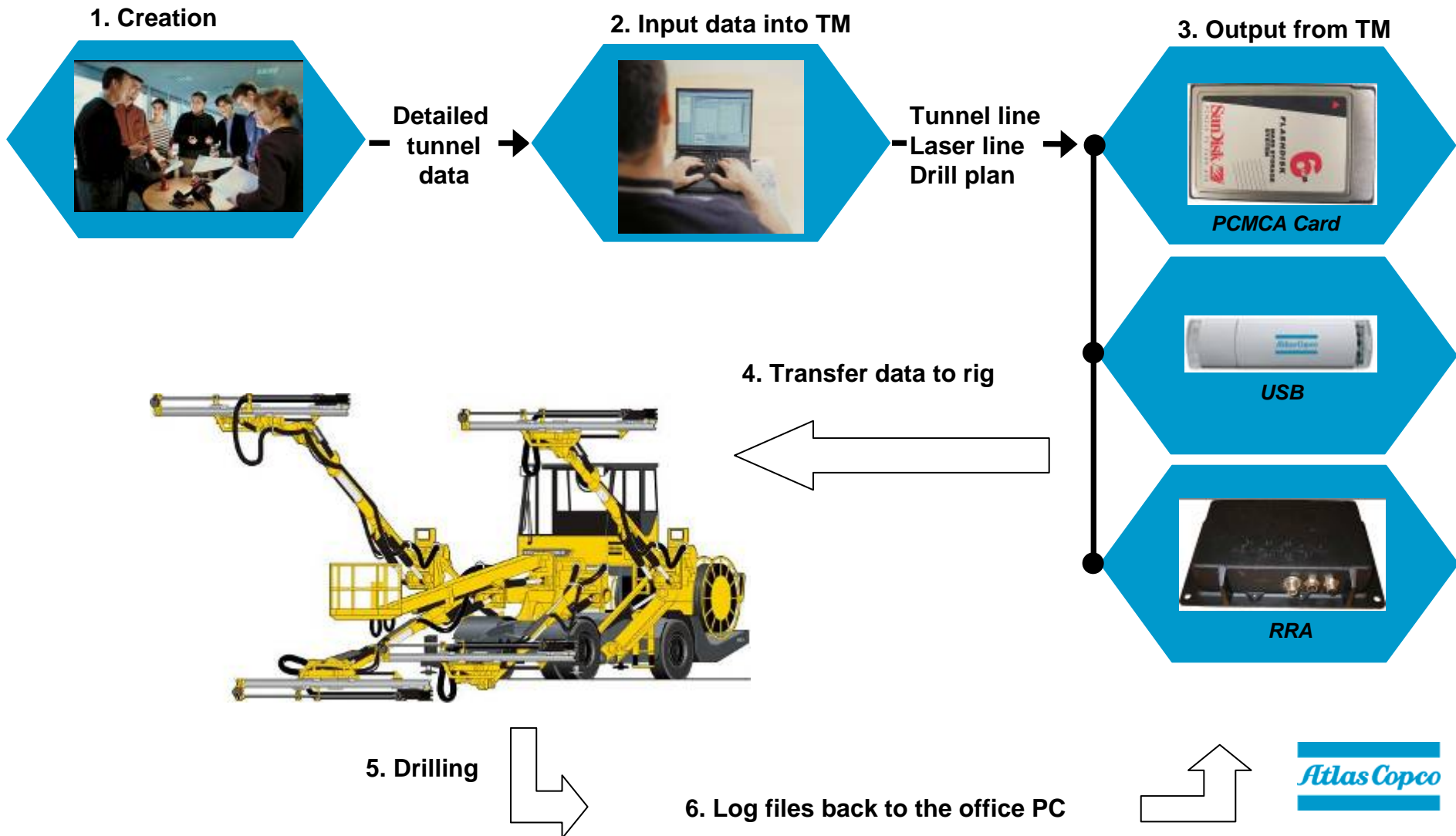
Data handling in Tunnel Manager Pro



MWD log

Tunnel Manager

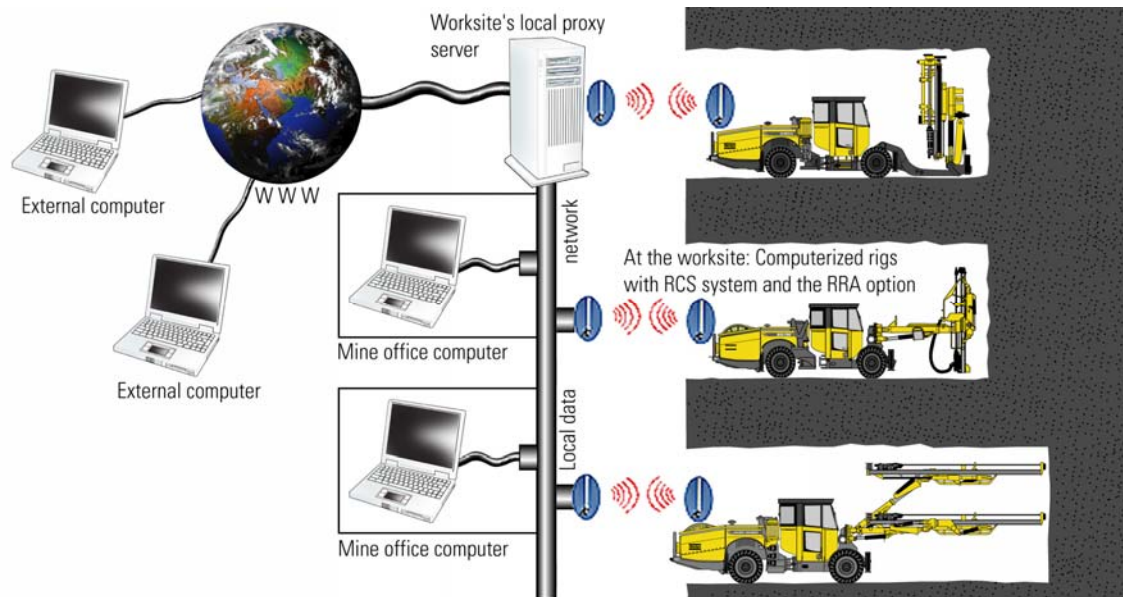
Chain of events



Rig Remote Access

Atlas Copco's solution – Rig Remote Access (RRA)

- Safe storage of vital information
- Fast delivery of drill plans and log files
- Always consistent and up to date information
- Status of the drill rigs can easily be monitored



Rig Remote Access

Features

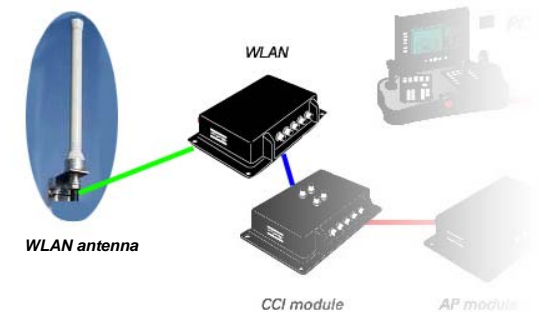


- Information from to/drill rig is available in many ways
 - File transfer of tunnel lines, navigation data, drill plans and log files
 - Remote display function to supervise autonomous operation
 - Service assistance to make remote diagnostics
- Information is available even if the drill rig is temporary off-line
 - Using the optional PC software called RRA Server
- Information in an international standard format
 - RRA supports IREDES, an open format available to everybody
 - RRA is not using an internal format (proprietary format)

Rig Remote Access

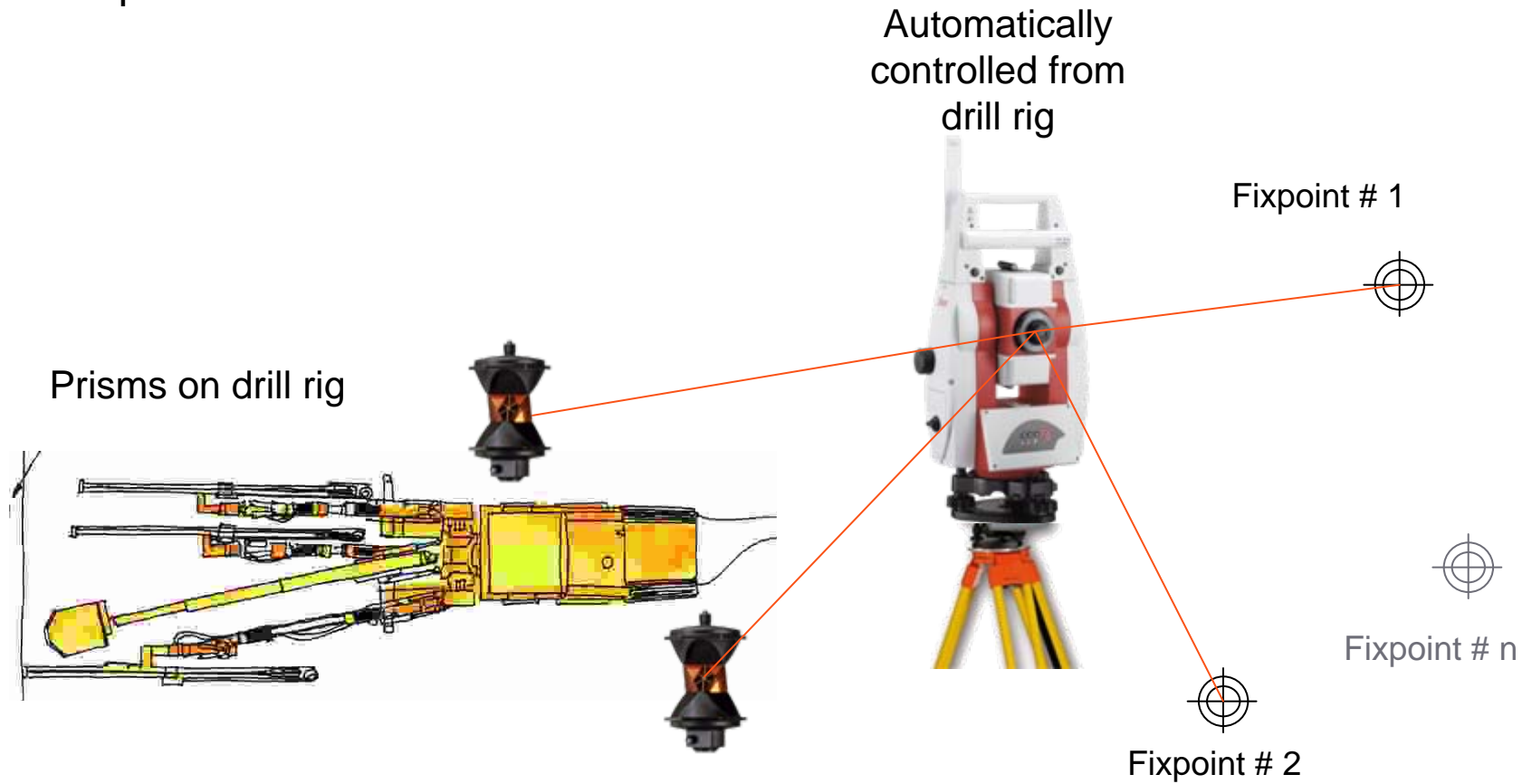
Features

- Large amount of data can safely be stored on the drill rig
 - A dedicated computer module for data storage and communication
- A number of different options for data communication
 - Cable (Ethernet)
 - Wireless (WLAN)
 - Memory stick (USB)
- Standard communication protocols
 - Using well-know and available PC technology

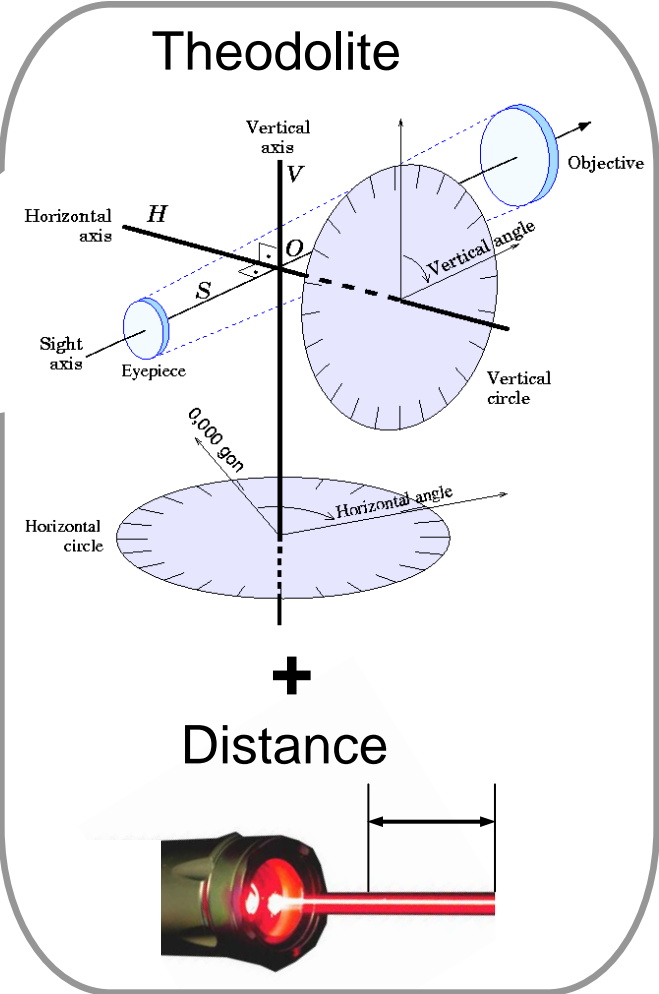


Drill rig navigation

with a tripod-mounted Total Station



Leica Red Line Total Station



Prisms

- On rig supplied by Atlas Copco
- Tunnel prisms supplied by the customer
 - Mounts for the tunnel wall
 - Types can be recommended by Atlas Copco



Preparations in Tunnel Manager

- Tunnel line
- Fixpoints
- Link between them
- Export

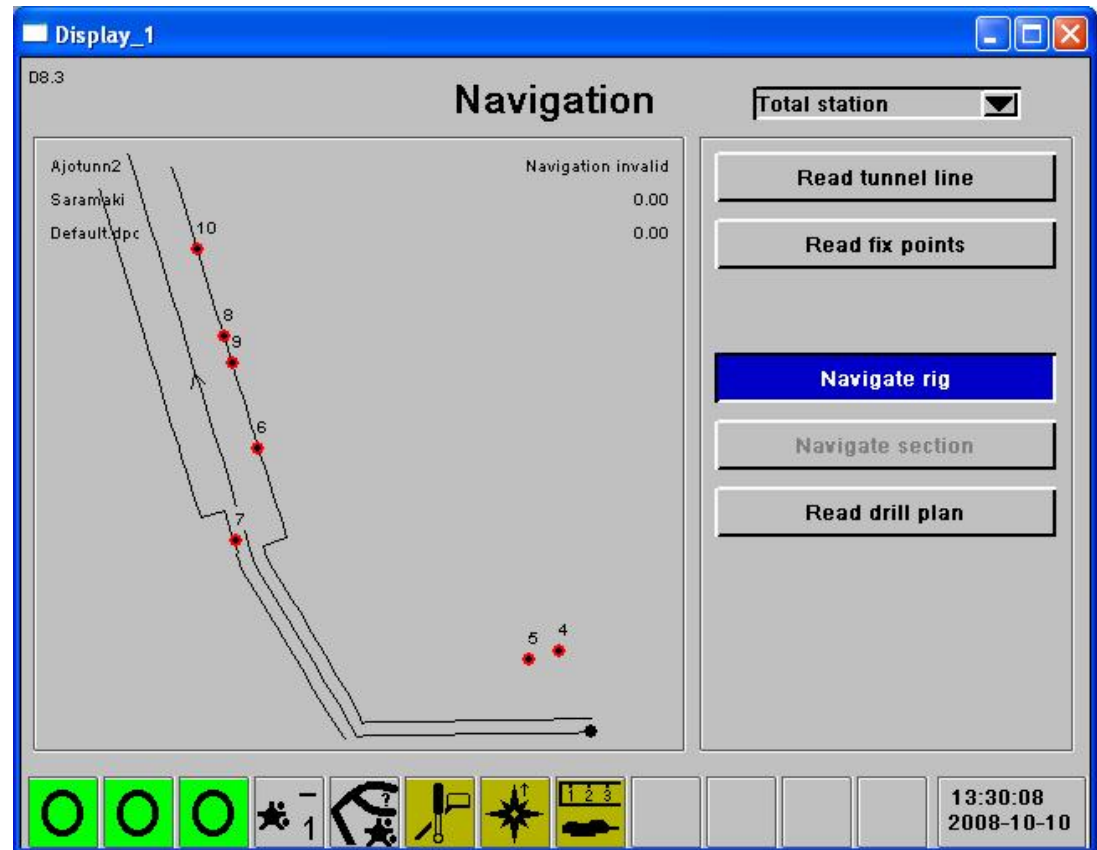
The screenshot displays the Tunnel Manager MWD software interface. The main window shows a data table for 'Tunnel 2' with columns for Section, X-North, Y-East, Z-Height, Camber, Contour, Drill Plan, Bot Plan, and Inj. Plan. Below the table, a 'Fixpoints - Example project' dialog box is open, showing a table with columns for Id, Name, X, Y, Z, Type, Dir X, Dir Y, Dir Z, Origin, and Date. A 'Link...' button is visible at the bottom of the dialog box.

Section	X - North	Y - East	Z - Height	Camber	Contour	Drill Plan	Bot Plan	Inj. Plan
49000,000	23333,154	53677,838	491,675	0,000				
49001,000	23333,848	53678,558	491,627	0,000				
49002,000	23334,542	53679,278	491,579	0,000				
49003,000	23335,236	53679,998	491,531	0,000				
49004,000	23335,930	53680,718	491,483	0,000				
49005,000	23336,624	53681,438	491,435	0,000				
49006,000	23337,318	53682,158	491,387	0,000				
49007,000	23338,012	53682,878	491,340	0,000				
49008,000	23338,706	53683,598	491,292	0,000				
49009,000	23339,400	53684,318	491,245	0,000				
49010,000	23340,094	53685,038	491,197	0,000				
49011,000	23340,788	53685,758	491,150	0,000				
49012,000	23341,482	53686,478	491,102	0,000				
49013,000	23342,176	53687,198	491,055	0,000				
49014,000	23342,870	53687,918	491,007	0,000				
49015,000	23343,564	53688,638	490,960	0,000				
49016,000	23344,258	53689,358	490,913	0,000				
49017,000	23344,952	53690,078	490,866	0,000				

Id	Name	X	Y	Z	Type	Dir X	Dir Y	Dir Z	Origin	Date
*										

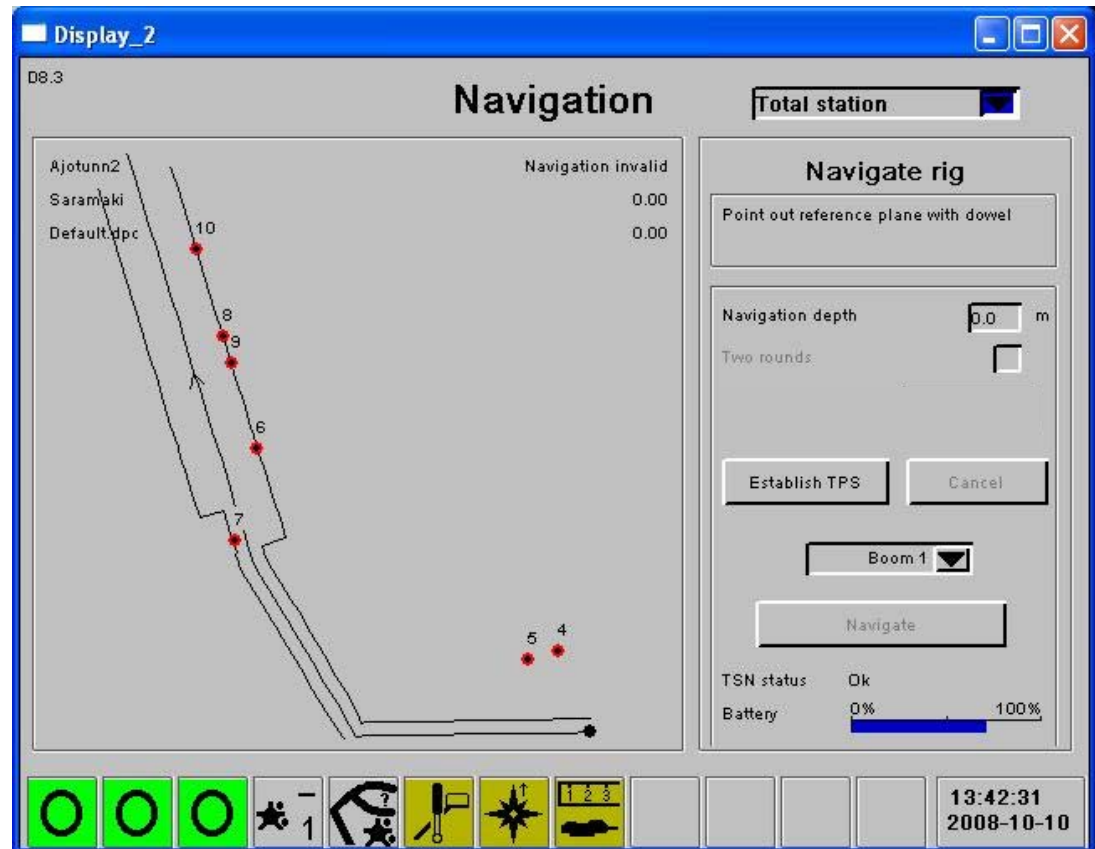
Preparations in the rig before navigation

- Read tunnel line
- Read fixpoints
- Navigate



Navigation

1. Mount the total station
2. Establish
3. Navigate
 - Status



Feature and Facts

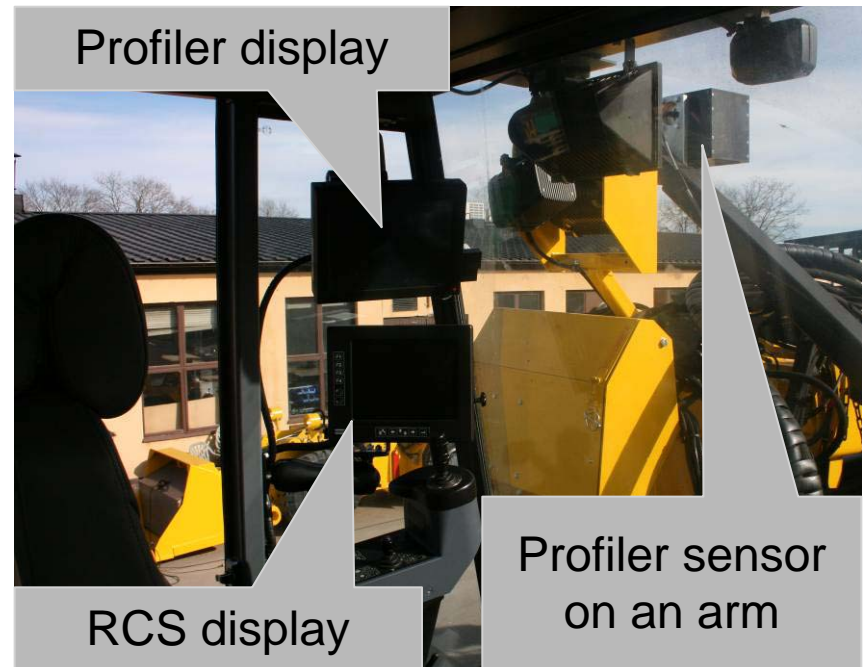
- Drill rig precisely navigated
 - 1 cm compared to >10 cm
- Navigation is fast.
 - <5 minutes compared to 10-30 minutes
- Performed by operators
- No surveyor needed at drill rig set up
- Fully integrated with RCS system



Get your true profile measured and logged

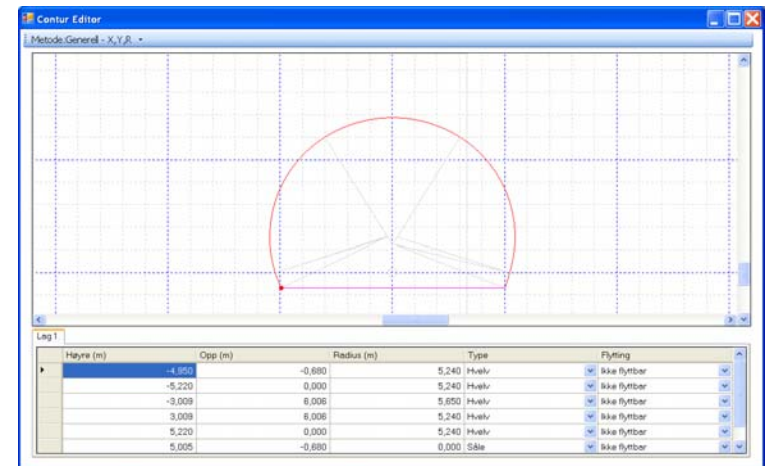
Introducing a fully integrated tunnel profiler

- Contour (design) handling integrated in Tunnel Manager Pro
- Profile scanner integrated on Boomer RCS3/4 rigs
- Scan result handling in Tunnel Manager



Preparation

- Contours
 - imported from CAD system or
 - designed in Tunnel Manager
- Contours linked to tunnel sections
- Sent to drill rig via PC-card, USB or network
- Drill rig navigated relative to reference-/fixpoints



Section	X - North	Y - East	Z - Height	Camber	Contour	Drill Plan	Bolt Plan	Inj. Plan
6220.000	150686.058	-19132.577	47.898	0.00	ES3_W			
6230.000	150676.167	-19134.045	47.651	0.00	ES3_W			
6240.000	150666.275	-19135.513	47.400	0.00	ES3_W			
6250.000	150656.384	-19136.981	47.147	0.00	Tunnel_10rr			
6260.000	150646.492	-19138.449	46.890	0.00	Tunnel_10rr			
6270.000	150636.600	-19139.917	46.629	0.00	Tunnel_10rr			
6280.000	150626.708	-19141.380	46.366	0.00	Tunnel_10rr			
6290.000	150616.814	-19142.833	46.099	0.00	Tunnel_10rr			
6300.000	150606.919	-19144.277	45.829	0.00	ES3_W			
6310.000	150597.022	-19145.710	45.555	0.00	ES3_W			
6320.000	150587.124	-19147.134	45.282	0.00	Tun_10m			
6330.000	150577.224	-19148.547	45.009	0.00	Tun_10m			
6340.000	150567.323	-19149.951	44.736	0.00	Tun_10m			

Get your true profile measured and logged

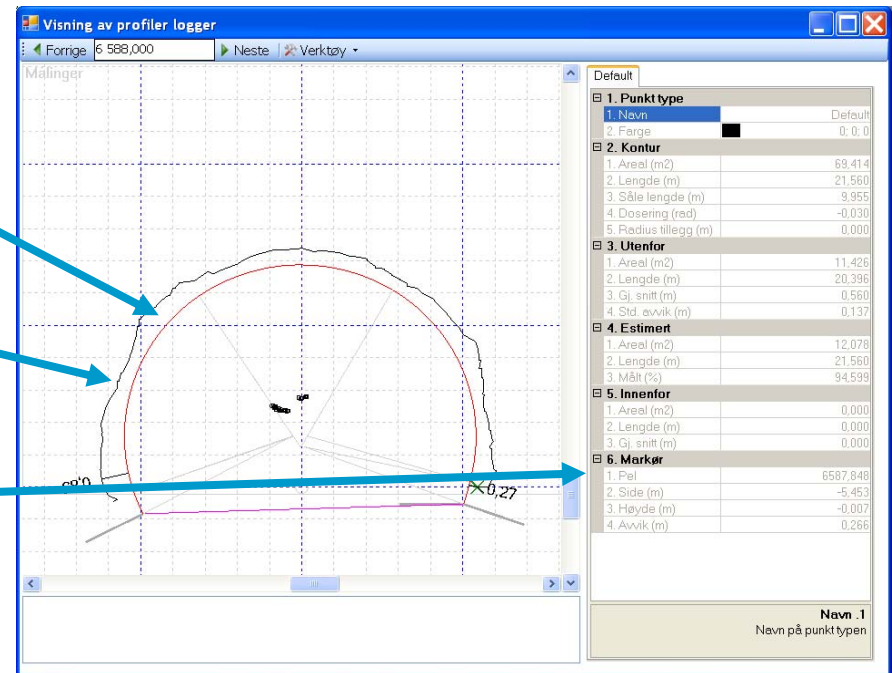
Benefits

- Tunnel profiling as a normal operation during round drilling
- Fast profiling, 5 minutes to scan a 65 m² roof
- Result data, profile and drill log, combined
- One set-up and navigation only
- Operator is advised about underbreaks
- Overbreak is calculated/presented
- Reduced need for surveying work
- Scanning while drilling next round



Profile evaluated in drill rig or at office

- Scanned profile compared to theoretical contour
- Overbreak and underbreak highlighted
- Area outside and inside theoretical contour calculated and documented
- Volumes calculated over tunnel sections and reported with Microsoft Excel



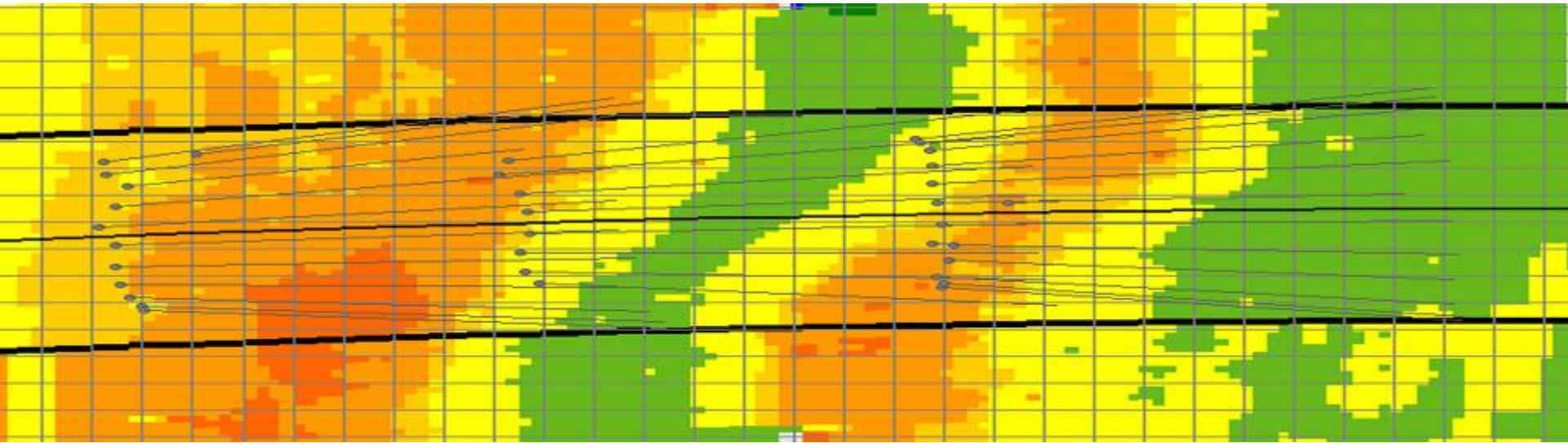
Get your true profile measured and logged

Technical specification

- Sensor accuracy
 - Angular 0.1 degree absolute
 - Angular 0.01 degree relative
- Total accuracy
 - 3-5 cm on scanned surface
- Typical scanning speed
 - 2 m/sec
 - 10 points/sec
 - 65 m² in 5 minutes
 - Grid size 25 x 25 cm



Measurement While Drilling, MWD



MWD processes

- The MWD technology consists of two separate processes
 - registration of data
 - evaluation/interpretation of data
- The registration part has developed as the drill rigs get more and more computer capacity, but is still a critical process
- The evaluation/interpretation took a great step forward when Håkan Schunnesson published his doctor's thesis "Drill process monitoring in percussive drilling for location of structural features" at Luleå University of Technology in 1997.

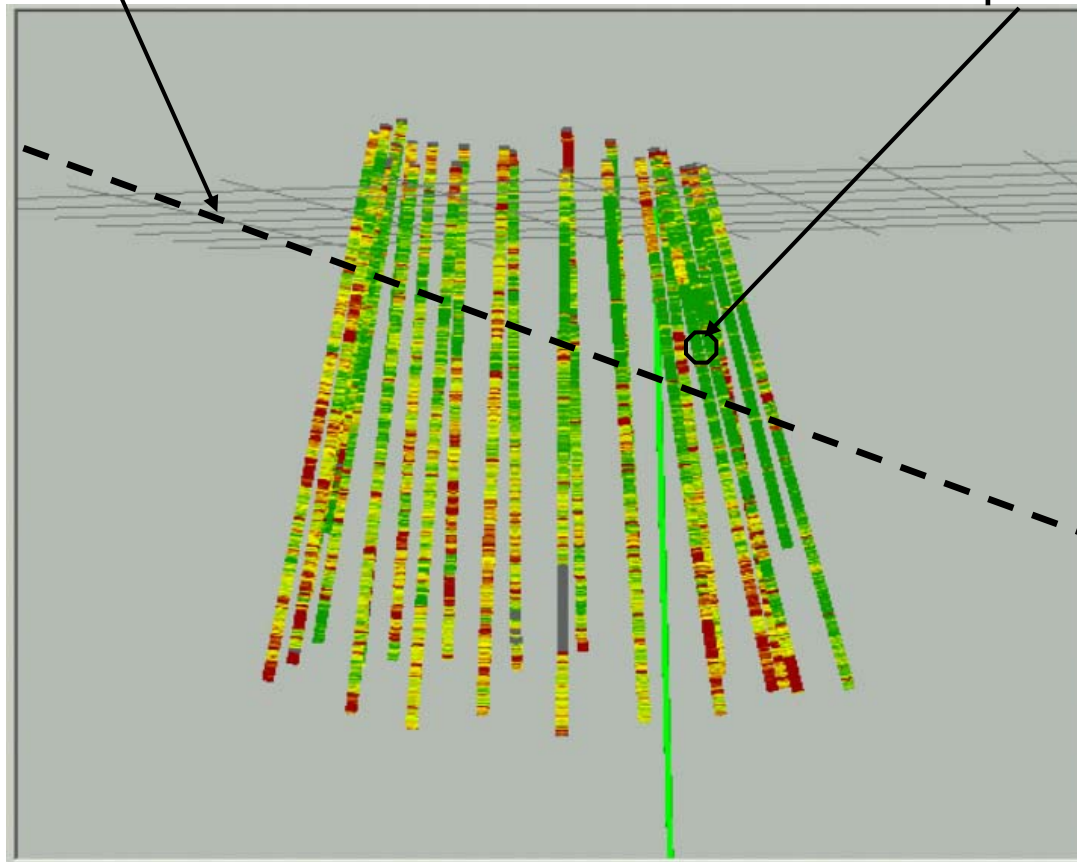
Why MWD?

Rock mass classification must be representative for the entire rock mass

Diamond drilling gives high quality data.

Rock mass characterization in single points for example uniaxial compressive strength.

MWD technique provide detailed characterization of large rock masses, with very high resolution.



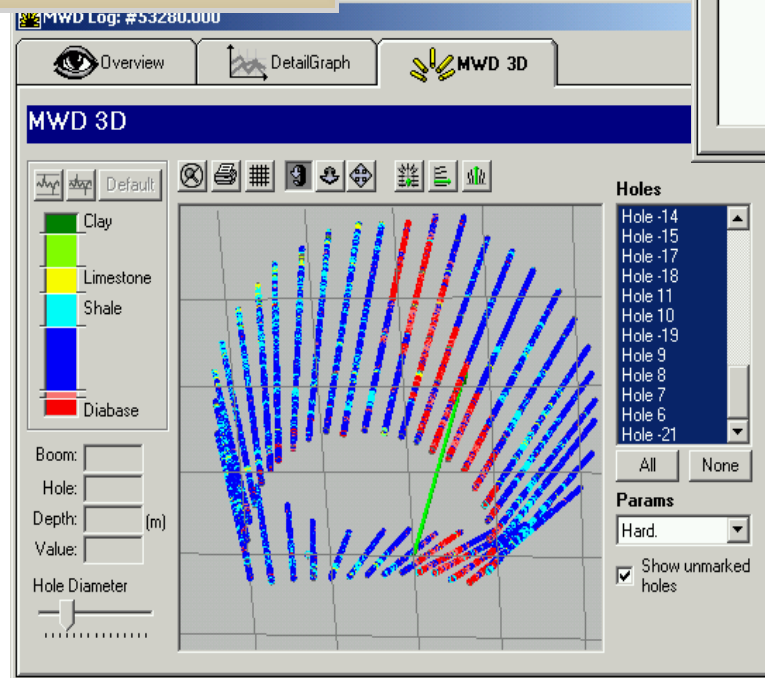
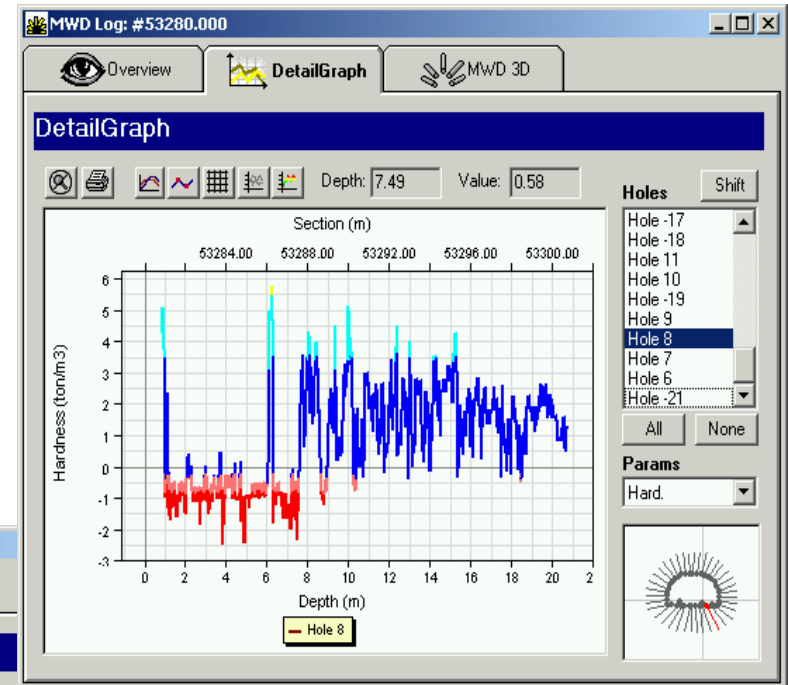
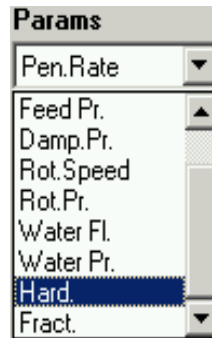
MWD in Tunnel Manager – Why MWD

	Geology	Fractures	Mechanical properties	Chemical properties	Sample handling time	Time to Result	Provided rock mass resolution	Cost including analysis
Geological Mapping	X	X			Average	Short	High	Average
Analysis of Drill cuttings	X			(x)	Average	Long	Average	Average
Diamond drilling	X	X-x	(x)	(x)	Long	Long	Low	High
Bore hole Geophysics	(x)	(x)	x		Average	Short	Very high	Average
MWD	(x)	X	X		No	Very short	Very high	Low
Single rock samples	X		(x)	(x)	Short	Long	Very low	High
Visual hole inspection	X	X			Average	AverageLong	High	Average

X To large extent
X To small extent
(x) After analysis/correlation

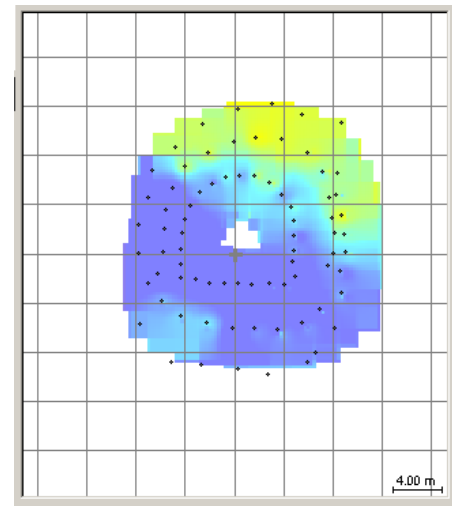
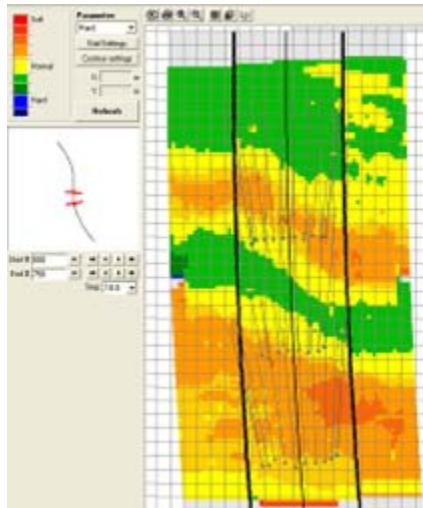
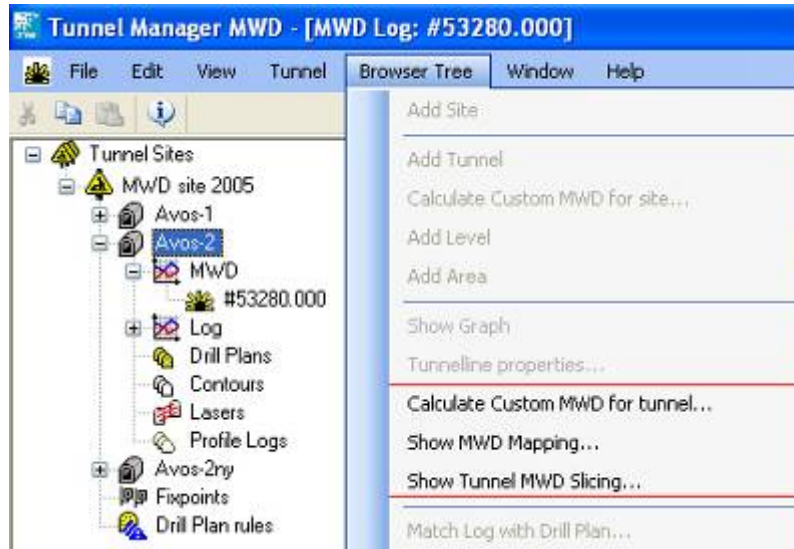
MWD in Tunnel Manager – Program features

- **MWD provides:**
- Handling of MWD data.
- Analysis of raw data.
- Different data presentation tools
- Foundation for geological mapping



Tunnel Manager MWD

2b



Tunnel Manager MWD

2b

- Tunnel Manager MWD is a powerful tool for the **geologist** on the worksite
- Rock hardness and rock fracturing indices are calculated by the program
- Rock hardness and rock fracturing indices are calibrated towards geological observations **by the local geologist**
- Tunnel slicing and mapping are used by the work site office
- Calibration is checked periodically by the geologist

Committed to sustainable productivity



Atlas Copco

