# Lynx Mine Modeling System

3D Geological Modeling

LYNX Geological modeling is based on proven surface and volume modeling technology allowing 3D interpretation and modeling of complex geological structures. The geological modeling functions are fully integrated with **LYNX** hole data, data analysis, geostatistical estimation and engineering applications.
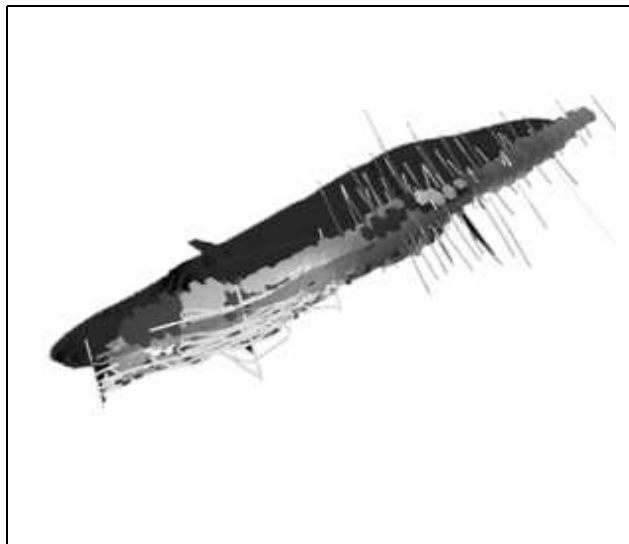
3D interactive geological interpretation

- **Background displays** of any combination of data structures in a wide range of display formats
- Interactive 3D interpretation of volume boundaries into complex irregular shapes
- **Interactive geological sectioning** at any view plane orientation through defined geological units.
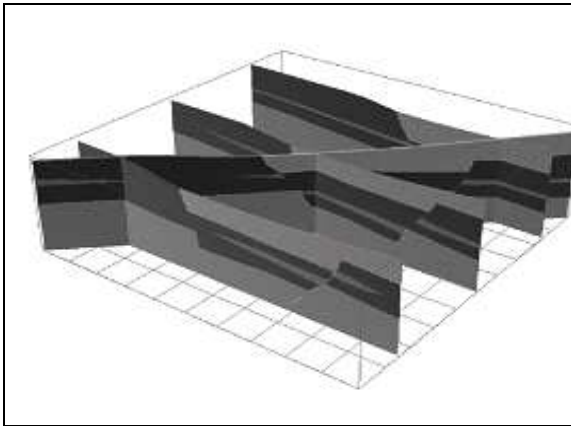

Surface- based modeling tools provide an alternative modeling option to interactive interpretation. They allow rapid generation of geological models from structural and stratigraphic surface information. Surface-based techniques are particularly appropriate to relatively simple geological conditions, such as layered stratigraphy.

3D visualization and interpretation

Proven **volume modeling** technology and interactive view plane manipulation capabilities allow complex geological conditions to be interpreted using methods that are familiar to all geologists. Interpretation progresses from sections, to intersecting fence sections, to a fill 3D interpretation of geological volumes. Any degree of subsurface complexity may be modeled. Interpretation may be made at any orientation on 2D sections or in a full 3D modeling environment.

3D Geological modeling from surfaces
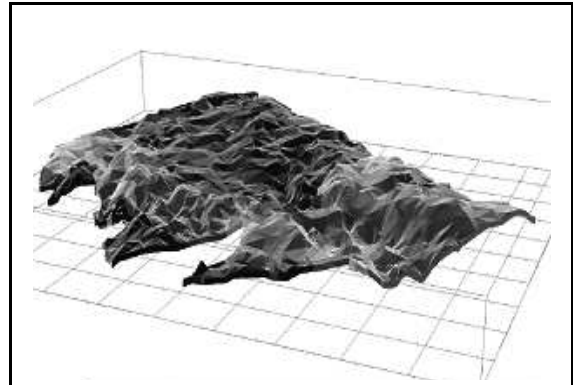
Functionalities

- **Map data manipulation tools**, for contouring, thinning, clipping, intersection and coordinate transformation
- **TIN surface modeling** for the triangulation of surface, with feature-honoring tools
- **Surface manipulation** of multiple TIN surfaces for generation of structural and stratigraphic modeling information
- **Surface clipping / truncation** between TIN surfaces to handle outcrop, erosion and pinchout conditions
- **Structural surface modeling** for representation of topography, fault surfaces and geological contacts
- **Stratigraphic modeling** of variable thickness units by auto-generation of volume elements between TIN surfaces

3D interpretation and visualization provides presentation-quality perspective views for all LYNX data structures. Manipulation tools include interactive rotation, panning, zooming, scaling, color-map definition and data selection. Editing and interpretation in a full 3D modeling environment are available to the user.

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3D Geostatistics and Estimation

\The **LYNX** geostatistical analysis and estimation applications are a windows based implementation of GSLIB 3D geostatistics. **LYNX** also includes Direct Volume Estimation for the estimation of complex volumes, eliminating the need for a 3D grid and grid sub-blocking.

Data Functions and Compositing

- **Arithmetic, log or trip functions** of project variables
- Logical functions of characteristics and/or variables
- **Compositing** of hole data samples
- **Intersection of hole / geology** to assign geological model characteristics to hole data structures
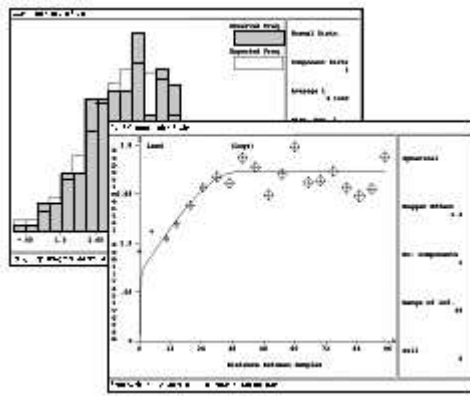
Hole data functions allow generation of variable and characteristic functions that are tailored to the project. Sample compositing for regularization of samples in hole data structures, including the honouring of geological intersections.

Statistical Analysis

- **Univariate statistics** including mean, sample size, standard error, histogram, probability, correlation, etc.
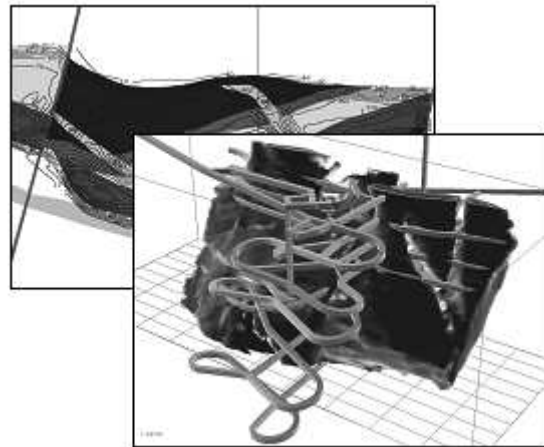
Geostatistical Analysis

- **Data transformation** capabilities, including log, indicator, rank order and normal scores transforms.
- Semi-variogram analysis of the spatial variability of project variables, including 3D trend surfaces.
- **Semi-variogram models** include nested spherical, gaussian, exponential and power models in any combination.

Estimation capabilities include a range of kriging options and semi-variogram model types, and all necessary facilities for dealing with variable sample density, anisotropy, non-normal distributions and underlying spatial trends. These ensure that the estimation process can deal with cases of complex spatial variability.

3D grid manipulation capabilities provide a means of combining estimated variable values using complex arithmetic or logical functions. 3D grid import / export facilities provide the options of using external prediction facilities where appropriate, and of exporting grid data structures for external analysis.

Direct volume estimation provides a unique method for estimating variables directly into complex volumes eliminating the need for a 3D grids or sub-blocking.

Geostatistical Estimation

- **3D kriging estimation** of variable values using normal or universal kriging and point or volume kriging algorithms.
- **3D inverse distance interpolation** of variables for instances when kriging prediction is inappropriate.
- **Geological control** of sample and grid cell selection for prediction of geologically influenced variables.
- **Spatial data control** of sample selection by octant search.
- **3D grid manipulation** allows combination of estimated values using a wide variety of functions.
- **Direct volume estimation** for kriging into irregular volumes.

The geostatistical analysis toolkit includes facilities for identifying and isolating geological influences, directional influences due to anisotropy, and underlying data trends. A range of data transformation options extends the analytical capabilities to deal with cases of non-normal value distribution. All facilities and results are accessible through an interactive, point-and-click graphics interface.

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Underground Mine Design & Planning

LYNX Underground Engineering provides a 3D platform for interactive design and layout of underground workings. A range of design, layout and survey control options facilitate the creation, management and maintenance of complex excavation geometries for a wide variety of deposits, mining methods and design conditions.

Interactive 3-D layout tools

- **Background display** for any combination of geological, geostatistical, excavation, mine development, or database information
- **Interactive definition** of excavation boundaries and assignment of engineering parameters for planning
- **Assembly** tools for replicating and positioning standard excavation units
- **3D perspective views** in any orientation to assist in rapid visual appreciation of the spatial relationships of mine geometry
- **Analysis tools** such as an interactive analyze option for instant quick views of volumes and reserves during the design process
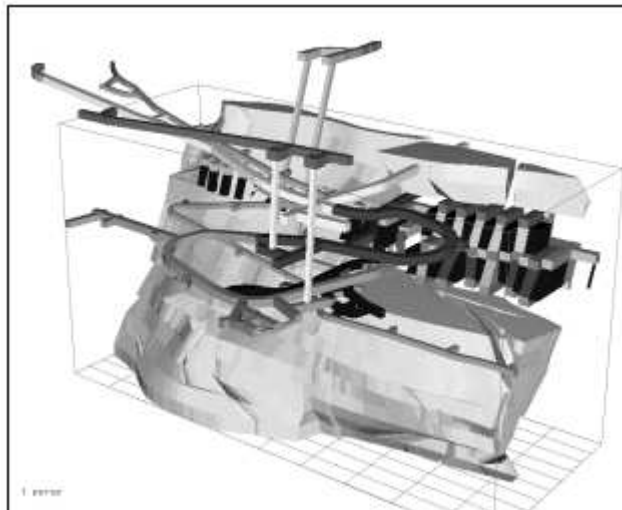

Survey volumes

Mine models representing "as mined" volumes based on surveyed excavation limits is the basis to excavation control, reconciliation of production, and means to an effective grade control process.

Grade control

- Use of in-situ sample information.
- Grade entry via digitizer or direct file transfer.
- Analysis of grade variance and distribution.
- Direct Volume Estimation of production workings.
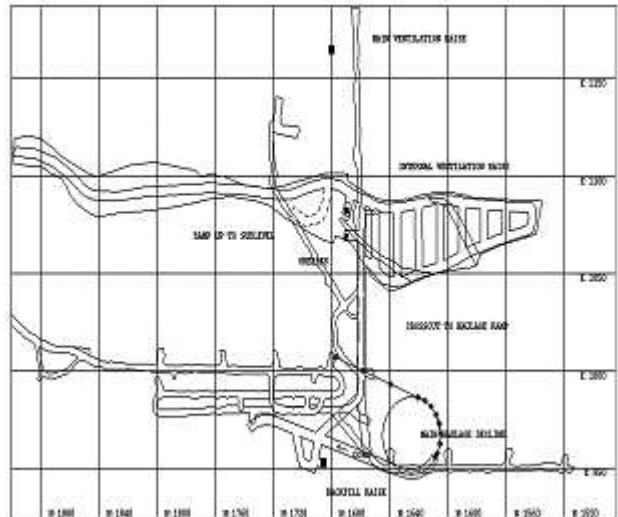
Mine development design tools

- **Ramp and development design** with variable grade, elevation and profiles along centerlines
- **Geometric design tools** such as curve, straight line and vertical functions
- **Profile definition** for rectangular, arched and circular excavation profiles
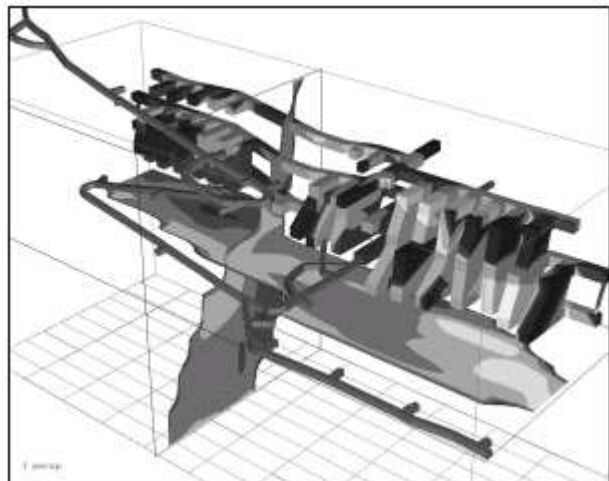
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Geo-Engineering Design

LYNX geo-engineering design provides a 3D geoscience platform for interactive design, planning and construction control of surface and underground excavations and other engineering structures such as dams, waste or turbine rooms. It includes a range of design options that facilitate development of complex excavation geometries for a wide variety of design conditions.

Interactive 3D design tools

- **Background displays** of any combination of geoscience and/or engineering data structures in a wide range of display formats for design reference purposes
- Interactive 3D editing of excavation boundaries into complex irregular shapes
- **Assembly facilities** for replicating and positioning standard excavation units
- **Interactive sectioning** at any view plane orientation through defined excavation volumes
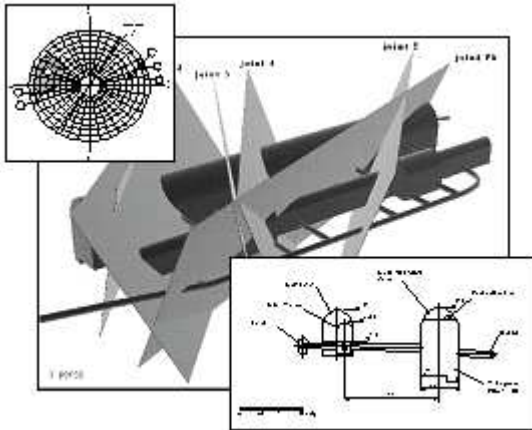
Excavation analysis

- **Excavation intersection reporting** of characteristic and variable values intersected by any selection of excavations and their associated volumes

### Surface excavation and dump design

- Excavation design of slopes, cuts and berms by conical expansion using excavation sectors and elevation limits
- Top-down or bottom-up design flexibility to allow either optimal excavation or excavations based on surface limits or boundaries.
- Automatic creation of excavation crests.
- Dump / fill design by **conical expansion with Automatic generation of toe line.**
- TIN surface modeling for representation of both topography and pit / dump surfaces. Draping of aerial photos onto TIN surfaces.
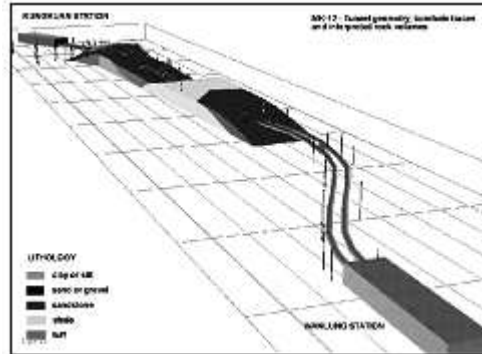
A range of interactive centerline-based design tools simplifies tunnel and ramp design with variable grade, elevation and profile. All design tools incorporate the full LYNX interactive graphics functionality including point-and-click selection, snap-to functions, and zoom, scale and refresh functions.

Excavation design tools

- **Centerline definition** for tunnels, ramps and other excavations with elevation or grade alignment
- Curve, straight and figure tools for generation of excavations with specified geometries
- **Profile definition** for rectangular, arched and circular excavation profiles
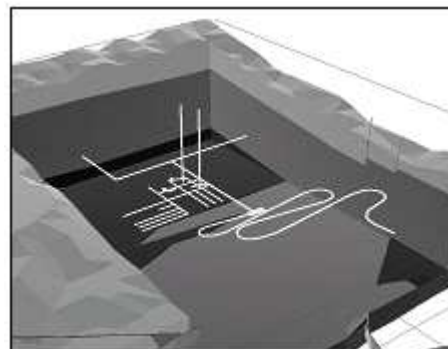
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Surface Mine Design & Planning

LYNX Surface Engineering provides a 3D platform for interactive design and planning of surface mining excavation limits with reference to geological and geostatical models of a deposit. LYNX design methods include Lerchs-Grossmann 3D Pit Optimization and the Conical Expansion techniques. A range of design options allows application to strip and open pit mines. Conical expansion dump design tools are also included.

Interactive 3D design tools

- **Background displays** for any combination of hole geological, geostatistical, excavation data in a wide variety of formats
- Interactive definition of excavation boundaries and assignment of engineering parameters for planning
- **3-D perspective views** in any orientation to assist in rapid visual appreciation of the spatial relationships of mine geometry
- **Interaction sectioning** at any view plane, including excavation profiles

Lerchs-Grossmann pit optimisation

3D pit optimization provides a method for generating preliminary open pit limits based on economic criteria. Using a 3D grid of net $ values generated from geostatistical models of relevant grades; taking into account key variables such as recoverable commodity values, mining and processing costs, haulage costs, depth, metal recovery and other operating costs. The method optimizes the total net profit from the mining operation, constrained by wall slopes in different pit sectors, to obtain the excavation limits, which contain the largest possible profit. Profit constraints allow definition of staged pits based on profitability.

Conical expansion design

- **Interactive definition** and editing of surface excavations or surface dumps
- Slope and berm control by sector and elevation limits.
- **Geological and topographical control** of profile projections
- **Top-down or bottom-up design** to allow excavation or dump/fill design based on surface boundary constraints
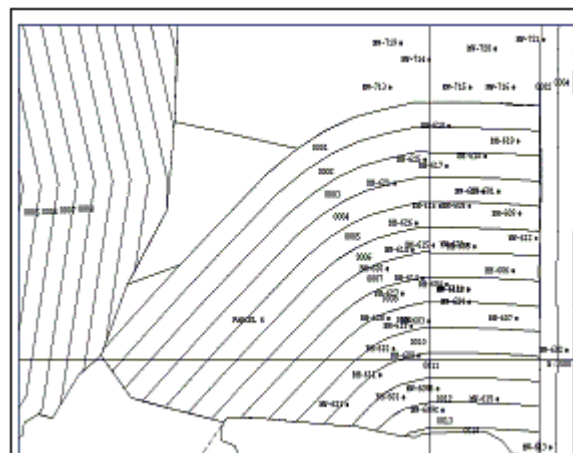

Grade control options

- **Excavation volume reporting** of any volume or planning unit
- **Analysis** of grade variance & distribution
- **Direct volume estimation** of production workings

Strip mine design tools

- **Design** of panel, strip or block layouts
- Design of box cuts or special excavation shapes
- **Automatic clipping** of cut boundaries

MineWorks Collection

Survey Office

Survey Office provides the user with all types of survey functions required for both underground and surface mining operations. Comprehensive database tools for the customising, management and security of the data is the foundation of the package. Survey data can be entered via the keyboard or downloaded from total-station electronic instruments.

Emphasis is placed on the seamless transfer of measurement data through the survey functions database to the 3D draughting package StopeCAD. Together these two packages provide the user with a complete practical and productive solution for the Survey Department.

Database Features

- Storage of historical and current survey field data, calculated results, audit trails, errors found etc.
- Easy querying and customizeable reporting
- User security levels protect the data integrity
- Backup and restore functions
- User defined error limit setting
- Statutory defined error limit setting

Survey Data Input & Output

- Download from electronic instruments and loggers
- - Leica, Topcon, Nikon, Sokkia
- Keyboard entry via generic forms
- Output via user-defined report formats
- Output directly to graphical plans in StopeCAD

Utilities

- Join and Polar calculations
- Intersections by bearings or distances
- Database Peg control and Base Control
- Traverse Tree Builder - graphical visualisation
- Base Builder to facilitate Gyro and Control surveys
- Baseline & Traverse Management Check Surveys
- Database administration

Surface Survey Functions

- Levelling 'Rise & Fall' or 'Collimation' methods
- Resection (Least Squares) & trigonometrical heighting
- Tacheometry 'Staff' or 'EDM' methods
- Surface bore-hole collar position, dip and direction

Underground Survey Functions

- Levelling 'Rise & Fall' or 'Collimation' methods
- Peg traversing, line-pegs, double-elevating options
- Supervisory control to mark sub standard results as temporary until checked.
- Limits of error settings to comply with on-mine standards as well as statutory compliance
- Underground bore-hole collar position, dip and direction
- 2 Point Resections (Weissbach/Free Station)
- Side grades (electronic & manual)
- Geological Features (faults, dykes etc.) location
- Excavation profiles using radial offsets
- Offsets - normal or 3D wireframe, electronic or taped

- When exported to StopeCAD the above offsets will be shown as follows:
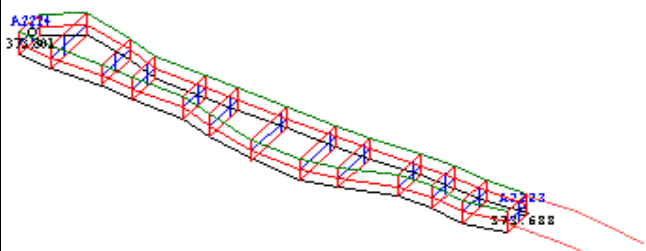
- Gyro calculations (Transit and Turning Point methods)
- Underground tache for profiling (electronic transfer)
- Multiple end offsetting (electronic) from one setup
- Multiple borehole (ringdrill) survey from one setup
- Check and control surveys (ex Gyro bearing)

Traverse Management

- - One click traverse recalculation
- - Compare traverses closure results
- - Balancing of closure errors by using Arithmetic Mean,
- - Compass Rule, Bowditch, Least Squares

MineWorks Collection

Designer

MineWorks Designer is a 3D modelling, designing and scheduling package that allows dynamic modelling, active designing and immediate updating of scheduling. The system converts center line layouts to 3 dimensional designs and draws information from StopeCAD drawings, Survey Office center line calculations and schedules the modelled layouts.

Emphasis is placed on the transfer of planning data for excavations from Geolog database to Designer. Together these two packages provide the user with a complete practical and productive solution for the Planning department.

Modelling

- Construction of plane views
- Scaling and setting of rotating points
- Selection and deletion of layers or features
- Changing feature colours and coordinates
- Adding new nodes and edges in layouts
- Ability to freeze points at a certain elevation using planes.
- Change curvature and steepness of lines in seconds using vertical and horizontal curving
- Design tools ensure the accuracy of the distance, area and volume of modelled designs.

Plane Construction, setting the Rotation point and 3D visualization in Designer.
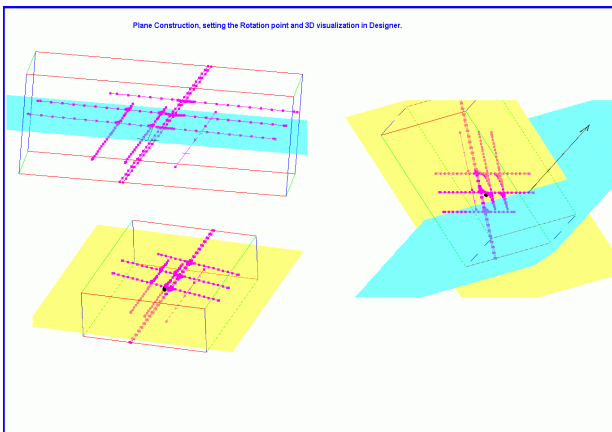
3D Visualization
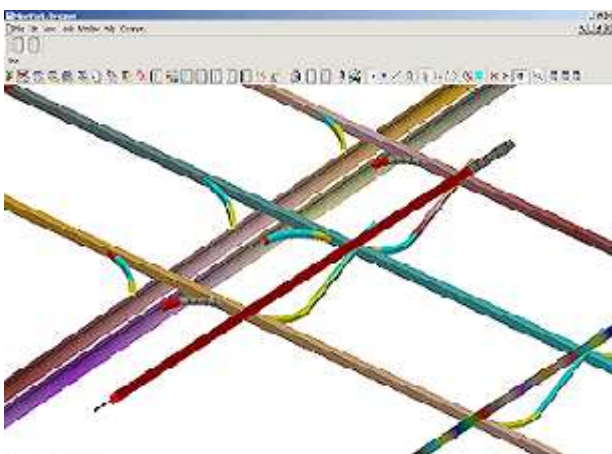
- Geology, survey and planning data displayed in full 3D
- Displayed information is dynamic, any changes made to the scheduling are reflected graphically, instantly

Scheduling

- Interactive scheduling, using well established project management techniques
- Simple, easy to use interface for changing durations, start dates and rates of scheduled activities
- Activity duration may be specified in terms of time or rates
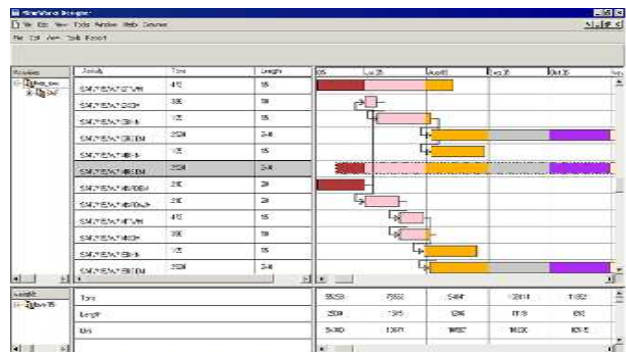
- Allow an activity to be defined by its predecessors start or finish date.
- Allows a working calendar to be associated with individual activities

Reporting

- Production figures regarding activities may be displayed next to each task on the bar chart.
- Crosstab values can be used to display activity attributes over a specific period
- Colour periods used for scheduling and visualization may be adjusted for various levels of details
- Production below merit is clearly highlighted
- Detailed Reports may be generated using Geolog

Database integration

- Designer's data handling structure allows a one to one mapping with Geolog.
- Changes made in Geolog are reflected in Designer schedules and graphics
- Network database functionality allows multiple users to simultaneously make changes to a single project

Data Import

- Supports the data formats of other MineWorks drafting and modelling packages such as StopeCAD and Lynx
- Supports the import of Lynx Drillhole, Lynx Volumes and Lynx map information

MineWorks Collection

Drilling Performance Monitor

Drilling Performance Monitoring System is an integrated database system designed for monitoring drilling performance as related to drillers' performance and machine performance in terms of production time and productivity information; and drill bits performance. It can be used for drillers' and drillers assistants' bonus calculations as well as integrated with SAP to generate financial costing reports.

Database Features
- User-friendly data capturing.
- Customisable database.
- Database administration.
- Total data storage: historical and current.
- Import of historical data from ASCII format.
- User security access levels to protect data integrity.
- Database backup and restore functions.
- Centralised database combining daily production information with geological borehole data as geology or core losses logging.
- Consistency checks on entered data, e.g. erroneous duplication of drillers/assistants on the same date, maximum of 8 hours per shift per driller.
- Pick lists for uniformity of entered data.

Utilities
- Similar database merging made easy.
- Easy user-defined database field calculation, e.g. calculation of core losses per drilled interval from core loss log.
- User definable interface.
- Easy and extensive data querying.
- Mailing of data and/or reports.

Data Entry
- Meters drilled per shift per driller/machine.
- Time break-down per shift per driller/machine (categorised as time in production, production time losses or mining delays).
- Personnel info (drillers, drillers' assistants).
- Core recovery logging.
- Drill bit register (bits issued, meters drilled with a bit, on which machine used, etc.).
- Year planning for meters to be drilled per machine.

Reporting
- Use of a Professional Independent Report Writer.
- Data availability in user defined format, customisable reports.
- Flexibility of time period being reported: running reports on daily, weekly or monthly basis.
- Daily monitoring of cumulatively drilled meters against planned figures, machine availability, cumulative calls and deviations from calls, dynamic reallocation of resources.
- Break-down of time allocation per driller/machine on daily or monthly basis.
- Range of graphical representation tools: linear, bar or pie charts; regression curves.
- Correct bonus calculation based on production time, core retrieved, bits usage.
- Comparison of performance figures between machines, drillers, across time span, against planned figures.
- Monthly drill bit utilisation, bit performance of each producer per area, per machine, per driller, per rock type, etc.
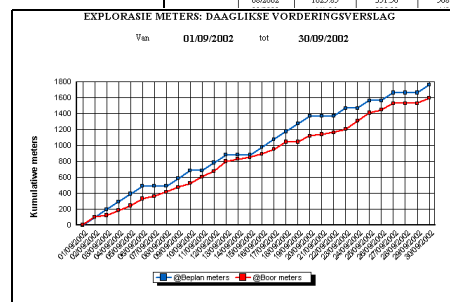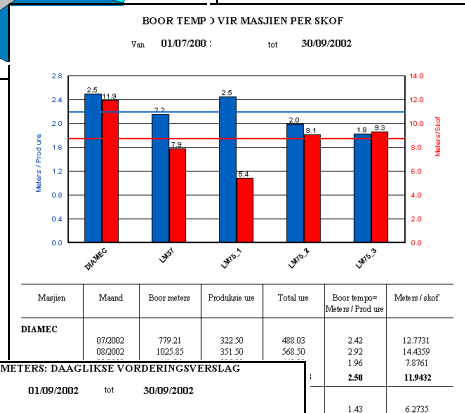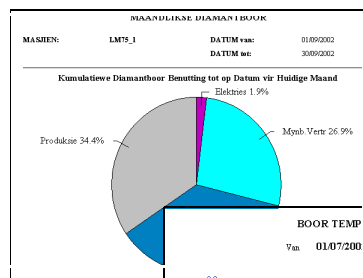
MineWorks Collection

Geolog

Geolog enables user efficient and user friendly capture and storage of data originating from borehole logging, channel or grab sampling, geotechnical logging, ore reserve management, claims management etc. The data can be displayed graphically in **StopeCAD** and incorporated in the geological model. The functionality of **Geolog** extends to calculation of washtables which makes it ideal for coal mining.

Database Features

- User friendly interactive data capturing operation.
- Generic administration setup, user security levels.
- Data management.
- User customisable interface.
- Pick lists for uniformity of entered data.
- Easy compositing of assay results over any required interval.
- Direct link between **StopeCAD** and **Geolog** database.

Utilities

- Honours known logging conventions.
- Similar database merging made easy.
- Import of digital assay data.
- Exporting of data setup in various formats.
- Interactive coordinates retrieval from **StopeCAD**.
- Effective database querying.

Reporting

- Use of a Professional Independent Report Writer.
- Data availability in user defined format, easy user-defined reporting.
- Error reporting.
- Audit trail.
- Dynamic printing as well as historical printing.

Borehole Logging

- Storage of all borehole information: survey, geology, assay results including coal wash tables, geotechnical logging, downhole geophysical measurements, etc.
- Printing a user-definable log sheet.
- Spatial reproduction of boreholes in **StopeCAD** as straight boreholes, traces or fence-diagrams.
- User defined borehole graphics options: variety of patterns for lithology, stratigraphy, structure or alteration display, value display as histogram or linear graph, etc.

Underground Sampling

- Storage of any sampling information originating from channel or grab sampling.
- Incorporating of check samples in average calculations.
- Calculation of averages weighted by selected interval width (current and progressive).
- Printing a customisable sampling sheet.
- Spatial reproduction of samples in **StopeCAD.** Direct link between **StopeCAD** and **Geolog** database.
- User defined graphics display.
- Storing an image from **StopeCAD** with the position of the sample underground.

Development Sampling Sheet Report

Washability Calculations

- Interactive point-and-click selection of the mining seam interval.
- Washtable adjustments for core & sample loss.
- Weighted compositing of the washtable for a mining seam which takes into consideration unproductive intervals.
- Multiple productisation.
- Validity and trend checks.
- Display of seam product values on the log.
- Calculation of a washtable for a set of boreholes comprising a mining block
- User definable graph display.

DrillHole Logging Sheet

DrillHole No:	MDA17	X Collar:	179205.8	Core Type:	
Geologist:	Bombile	Y Collar:	302704.5	Laboratory:	
Final Depth:	106	Z Collar:	1364.7		
Start Date:	11/28/2005	End Date:		Geologist Signature :	
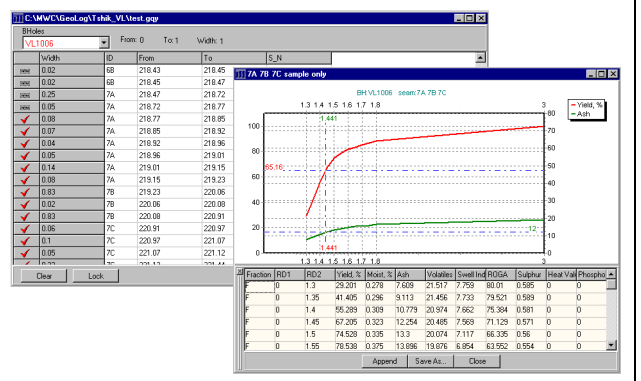
MineWorks Collection

MineWorks Monitor

MineWorks Monitor is an integrated database system catering for the interactive capturing of **ore reserves**, **ore reserve depletion**, **LOM** and **short term planning** detail, real-time activity logging, audit measurements and all graphical- and text reporting.

Features
- User-friendly interactive data capturing operation.
- Designed for capturing of planning, real-time activity logging and audit measurements.
- User definable data mapping for easy ASCII data import.
- Easy user definable and maintenance of reports.
- Data querying on a field selection base.
- Data management.
- Effective data security per department per user.

MineWorks Monitor Functionality
- Single screen standardised data capturing.
- Spatial reproduction of all graphics supported data in **StopeCAD** (GIS).
- Interactive Bi-directional communication between **StopeCAD** and **MineWorks Monitor** database.
- User defined graphics reproduction.
- Bi-directional link between **Visual Planner** and **MineWorks Monitor** database.

Utilities
- Database verification with exception reporting.
- Similar database merging made easy.
- Easy user-defined database field calculation.
- Mailing of data and/or reports.

Other Options
- Import of digital data.
- Generic Administration Setup.
- User definable interface.
- Exporting of Data setup in various formats.
- Application activity log.

Reporting
- Use of a Professional Independent Report Writer.
- Total data storage (historical and current).
- Data availability in user defined format.
- Error reporting.
- Dynamic- or scheduled printing of current as well as historical reports.

MineWorks Collection

MineWorks Planner

Based on **project management tools and techniques**, **MineWorks Planner** enables project members and production staff at all levels to do **contingency** planning quickly and easily. The intuitive graphical interface and powerful data management tools ease the task of reporting complex relationships between scheduled production rates and the many variables and resources associated with mining activities.

The ability to track the project status against a **baseline** schedule and to report on actual vs. planned values is used to monitor and control capital projects as well as monthly production in both surface and underground mining environments.

Flexible project definition
- Up to 200 base **properties** can be assigned to each activity.
- Track planned / actual values for selected properties.
- Define property values using **formulae.**
- **Structure** activity names to filter, group & sort activities.
- Up to 200 report properties can be defined to report on the **aggregate** of base properties.
- Multiple **user-defined calendars** can be created and assigned to individual or grouped activities.

Interactive scheduling
- **Define** the activity duration by specifying a **production rate** in terms of any of the activity base properties or by specifying a fixed duration.
- Define geometrical **constraints** by graphically linking activities.
- Allow an activity to start when all or any predecessor is complete.
- **Drag** the activity bar to the start date or to change the rate.
- **Allocate** a working calendar to individual activities.
- **Sort** and **filter** activities on any field or combination of conditions and fields.
- **Build** a **work breakdown structure** by using the structured naming convention and the indent / outdent facilities.
- **Split** activities into smaller sections for detailed schedulling.
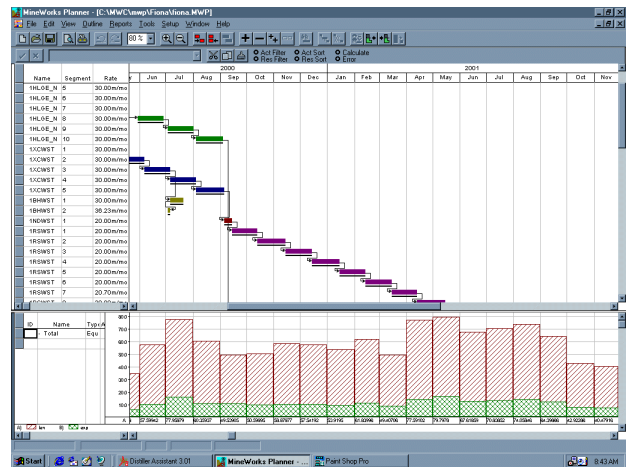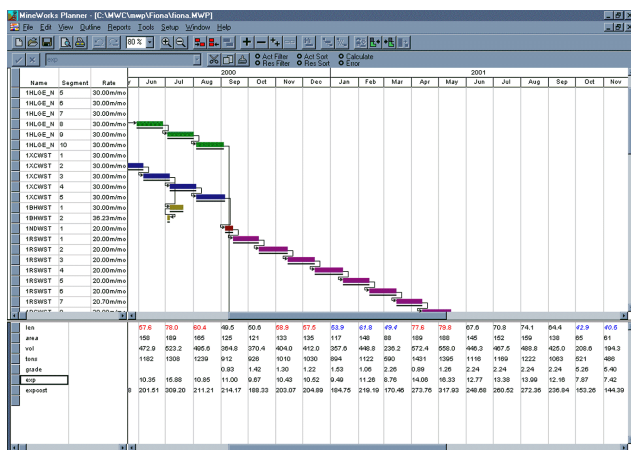
Manage equipment and labour resources
- Create a **common resource pool** which can be shared by a number of projects.
- Assign resources to activities through drag-and-drop.
- Resource assignments can be rate driven, duration driven or effort driven.
- **Build a resource breakdown structure.**
- **Summarize** resource usage for single or multiple schedules.
- **Show** resource effort or number on **histograms** or crosstab.
- Vary resource costs and availability over time.

Customisable reporting
- **Show** crosstab **indent** of bar for each task on bar chart.
- Production below **merit** is highlighted clearly.
- Split activities into smaller sections which can be scheduled individually for finer **blending.**
- **Change** the quantity scheduled for an activity during a specific period by entering the desired value.
- **Plan/revise** production with expected grades/costs on any basis including **earned value.**

Powerful data import / export
- **Copy and paste** data to and from text-based applications via the Windows clipboard.
- Use ODBC drivers to import data from relational databases.
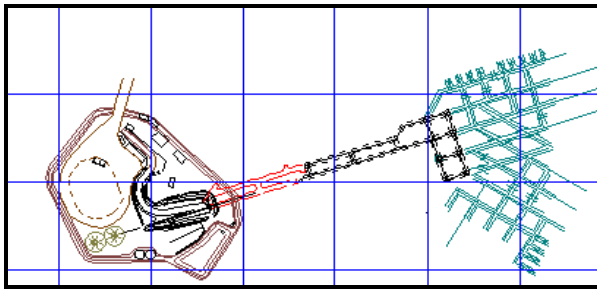
MineWorks Collection

StopeCAD

StopeCAD is a user friendly 2D – 3D draughting and graphical data base package, designed to cater for all possible requirements in the mining industry. Drawings can be updated on a daily basis and when used in conjunction with the other **MineWorks Collection** modules, information from the **survey, sampling, geological** and **planning** departments can easily be incorporated.

Drawings are stored under different user departments and can be merged to allow for the **easy access** of information. Multiple, networked users can work or look at the same plan. Log-on user levels and departments ensure security of plans. A large selection of draughting **features** is available. These can be edited by the user to suite specific needs.
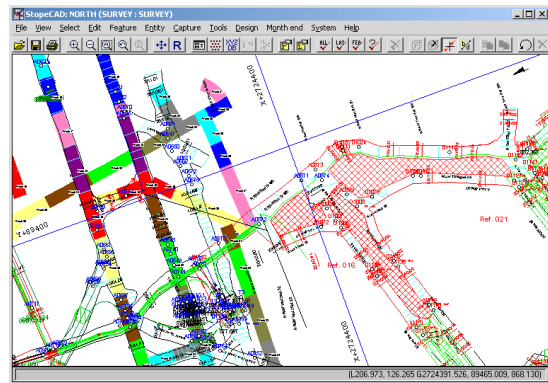
Draughting

- A **professional** layout and finish to statutory drawings.
- Topographical **drawings** can amongst others, show rivers, roads and farm boundaries in 2-D and 3-D.
- Grid lines spacing can be adjusted to any **scale.**
- Any portion of a drawing can be **printed** to any desired scale.
- Custom **title blocks** can be designed and placed as required.
- The dip and bearing of any area in **3-D** can be selected.
- Photographs & scanned images can be displayed.

Geology

- Access to Survey plans as **overlays** allows for up-to-date plans on which to work on a daily basis.
- Geological **mapping** done on **elevation.**
- Sections can be viewed from any desired viewpoint.
- **Contouring** of assay results.
- **Boreholes** with **values** and **lithologies** from the **GeoLog** module displayed as straight, traces or fence-diagrams.
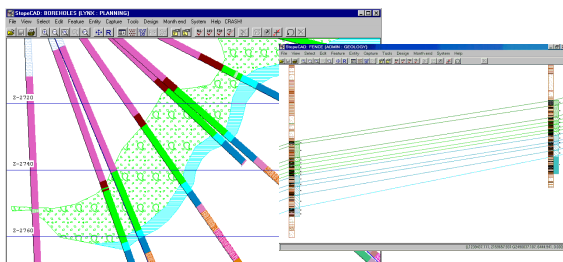
Ventilation

- Relevant information such as rescue bays, ventilation doors, fans etc. can be drawn on the plans.
- Temperature measurements can be contoured to indicate problem areas.
- Access to Survey plans as **overlays** in order to plot air flows, temperature measurements, dust content.

Planning

- Graphical **ore** resource **management** system.
- Short and long term planning blocks can be laid out.
- Variables are used to store information which can then be used to run **queries** or be exported to spreadsheets.
- Block names, dates, volumes and values are typical **variables.**
- Mining blocks can be **linked** by means of a network and exported into the **MineWorks Planner** to update the information contained therein.
- **Scripts** can be setup, stored and run to assess different queries.

Survey

- Pegs can be **plotted** directly or imported from a database.
- All relevant survey features, for example pegs, drives, raises, stopes, offsets and sample points can be imported from **Survey Office.**
- **Multiple queries** on variables and properties can be performed.
- **Advanced contouring** routines are incorporated.
- **Areas** and **averages** can be saved and exported
- **Volume** calculations of dumps.
- **Profiles** can be imported or drawn with ease.
- **GIS** capabilities where data may be attached to and stored with the graphical image.

Sampling

- Sample values using **GeoLog** are displayed in their correct locations.
- Averages and ranges of assay results, stoping widths etc., in any selected block are easily computed for ore reserve management purposes.
- Sample values can be selected according to their value and defined by colour.