Moranbah North underground coal mine is situated deep in the coal belt of central Queensland. The site was a greenfield site for Shell Coal Australia, and comprised a number of innovations in its automation system.

At the outset of the project, Moranbah North had a vision of their control system. This system would allow more flexibility in their operational staff and increased mobility of personnel. It would allow fast access to maintenance documentation from anywhere, including the Longwall Maingate.

This vision required the use of technologies more commonly used in business environments than in mining environments, however the final product has been found to be extremely well adapted to the adverse conditions found in underground mining.

**SOLUTION**

Citect Professional Services engineered the project over the course of 12 months.

Responsibilities included:
- Initial design of GE Fanuc PLC and CitectSCADA system.
- Proving of the design prior to commencement of the project.
- Technical Management
- High level design
- Ethernet network design
- Functional Specification
- CitectSCADA configuration
- SQL configuration
- WEB Interface
- Testing and FAT
- Commissioning
- CitectSCADA and SQL licenses
- CitectSCADA computers
- SQL computers
- File Server computers
- Network hardware

**NETWORK ARCHITECTURE**

The entire underground control system communicates via an ethernet local area network (LAN), utilizing both fibre optic cables and unshielded twisted pair copper cables. Standard off-the-shelf products were used for the network including switching hubs, transceivers and ethernet network cards. The GE Fanuc 9030 PLCs allow direct connection to the ethernet via their ethernet communications.
modules, which also allow for redundant connections to a single processor.

The CitectSCADA stations have dual network cards which allow redundant connections to each computer. Two redundant CitectSCADA servers reside on the surface which facilitate I/O, Alarms, Trends and Reports.

Two subnets are used on the single LAN to differentiate redundant paths to the various computers.

**RISK ANALYSIS**

Since there is only a single path for the network to run from the surface to the underground, it was not considered advantageous to run redundant cables. Instead a single network link is used, and localised redundancy is used to overcome reliability issues associated with failure of this link.

Citect Professional Services was involved in the risk assessment which determined the best use of technology to solve the problems associated with running an ethernet network in an underground environment. It was found that the highest risk to the reliability of the network was the Switching Hub which connects the surface to the underground.

As a result of this risk analysis, Localised Redundancy was conceived and implemented.

**LOCALISED REDUNDANCY**

Each CitectSCADA computer underground is a standby IO server for its local PLCs. In the event that the communications link to the two surface CitectSCADA servers fail, the underground CitectSCADA instantly takes over data acquisition tasks for their local PLCs.

When the underground CitectSCADA detects that surface communications have been absent for a period of three minutes, it prompts the operators to choose whether to take over data logging tasks locally also. If the operators select ‘Yes’, the underground CitectSCADA will take over Trend and Alarm tasks for its local PLCs. This is called Local Mode operation.

When the surface communications are restored, the underground CitectSCADA prompts the operator to choose whether to halt local Trend and Alarm servicing, and use the surface servers instead. If the operators select ‘Yes’, the underground CitectSCADA turns itself into a client again.

**STORE AND FORWARD**

All historical data is stored on the surface File Server, and is logged from the surface CitectSCADA servers. The SQL server on the surface retrieves historical data from the File Server for long term archival and data publication.

When in Local Mode, historical data is stored to the underground CitectSCADA hard drives. Once surface communications are restored, the SQL server automatically retrieves that data from the underground CitectSCADA before returning to the surface CitectSCADA as its main source of historical data.

**CONFIGURATION MAINTENANCE**

Each underground CitectSCADA has a copy of the latest CitectSCADA configuration project stored on its own hard drive. A CitectSCADA page allows the system administrator on the surface to update this project and remotely shut down each CitectSCADA station and restart it with the latest project.
CONFIGURABILITY

The underground mine has an initial development plan for ten years. Accordingly, the control system has been designed to require zero engineering modifications for the first 10 years of operation.

This is achieved by building a high level of configurability into the system. That is, all processes which will require modification during the first ten years of operation, are built to accept new configurations in run time from process personnel, rather than engineering personnel.

Configuration changes are made locally and distributed across the entire network to each CitectSCADA station. CitectSCADA does not need to be recompiled or shutdown to use the new configurations.

Drift belts have Dupline bugs which report to the PLC system. Each bug can be reconfigured from CitectSCADA to reside in different locations, on different conveyors and service different data.

Maingate and Tailgate conveyors have nine starter drives which can be used as head or tripper drives on any conveyor. These can be dynamically reallocated with new locations, purposes and descriptions as required. All graphical mimics, Alarms and Trend information is automatically updated in runtime.

Mine Development machinery at each development substation is automatically detected by the CitectSCADA system. Using super-genies which drill down from the substations to the machinery, information specific to each machine can be monitored by the operators.

AMR gas monitoring has four sensors in each of thirty two locations with four analog inputs on each sensor. Sensor locations, descriptions and types of measurement can be dynamically modified as they are relocated around the underground. Graphical mimics, Alarms and Trends are automatically updated in runtime.

Tube Bundle gas monitoring allows modification of tube locations and descriptions. This is achieved graphically by clicking and dragging sensor symbols over a CAD diagram of the mine layout. Graphical mimics, Alarms and Trends are automatically updated in runtime.

Phone List which contains both the phone numbers and locations of phones throughout the underground are configurable in runtime.

Figures 2-5: Some of the machinery used in the Moranbah north coal mine in Queensland
User Passwords are able to be modified by each individual user on the CitectSCADA system, and are distributed across the entire network such that all CitectSCADA stations are updated with the latest user passwords.

Passwords are encrypted for additional security.

CONFIGURATION METHODS

All configuration described above is stored in database files externally to the CitectSCADA configuration. Each CitectSCADA computer retains a local copy of these database files for Local Mode operation if required (configuration modification cannot be performed when in Local Mode).

A database distribution system is then utilized to ensure that all computers are using the most recent database files. The file distribution occurs in the background of the CitectSCADA operation.

SQL SERVER

A single SQL Server resides on the surface. This server retrieves historical data from the CitectSCADA historical databases for Alarms, events, operator actions and Trends including all gas monitoring values which are sampled every 30 seconds.

For gas Alarms, when the operator acknowledges the Alarm, a ‘response’ form is presented on CitectSCADA. The form contains suggestions for the operator regarding the most appropriate response for each particular Alarm. These suggestions are stored on the SQL server and retrieved by CitectSCADA for display purposes.

The operator is required to select their response from the list of suggestions. If the list does not have an appropriate response, a typed response may be entered instead.

Multiple responses are available on each Alarm. For instance, if the operator later finds out that there was a problem with the gas sensor, that information can be added to the previous response to the Alarm.

All responses are logged to the SQL server along with the identity of the operator who responded. The information is published such that the mine ventilation officer can review the information, and filter it based on Alarms, areas, sensors, operators, time and date.

WEB INTERFACE

The information stored on the SQL Server is published via a WEB interface. This allows access to production and downtime information by any authorised personnel on the Shell intranet, anywhere from the longwall itself at Moranbah North to Shell's Brisbane office, to Shell's Melbourne office.

Site information available on the web includes:

- Alarms (and operator responses)
- Operator control actions
- Production statistics
- Graphs of variables

A user friendly graphical interface has been manufactured for the WEB interface which allows point-and-click selection of information and filters.

DOCUMENT DISTRIBUTION

The WEB interface is also used to publish maintenance and operational information to the field personnel. From any CitectSCADA station both above ground and underground, personnel have access to:
• Functional Specifications
• Operator manuals
• Maintenance manuals
• Electrical drawings
• Maintenance drawings
• Mine managers notes
• Safety notes

All documents are stored in their native formats on the surface (eg. Microsoft Office, AutoCAD), and access is directly to the source documents, rather than via converted documentation. This means modifications to the source documents are available instantly over the WEB, and removes the costly exercise of maintaining multiple sets of documentation.

POWER DISTRIBUTION

The GE Fanuc 9030 PLCs communicate with the PM2000 protection relays used in the development substations. Each development substation has 6 intelligent outlets into which the mining equipment is plugged.

A module in the mining equipment identifies the equipment to the substation over a pilot carrier and the PM2000 changes the protection settings of the outlet to suit the equipment. GE Fanuc Micro PLCs with RTU communications capability are used in the DCBs to relay information from remote PM2000 modules back to the development substation.

The entire network of development substations and DCBs is displayed in the control room showing the location and status of all the major equipment in the mine.

BENEFITS

Configurability ensures minimal modifications for all foreseeable process changes over the first 10 years of operation. Maintenance can be performed from any location and is distributed across the entire system automatically.

WEB documentation available at any CitectSCADA station greatly reduces the time consuming task of travelling between underground and the surface for maintenance documentation.

Since the documentation is available to everyone, the delineation of roles between operations and maintenance has been blurred, allowing more efficient work practices to exist. This was the intention of the mine and the goal has been achieved.

Information everywhere allows personnel to view the status of the entire site at any location, and in some instances perform control from remote locations. For example, a mine electrician can see (and reset some), circuit breaker faults from any location. This greatly reduces the requirement for travel between locations, and increases the mobility of existing personnel.

Accurate logging of Alarms, responses, operator actions and production statistics directly to the surface SQL server greatly reduces managements reliance on interpreted data since they are presented with information directly from the control system.

The publishing of this data on the WEB increases the mobility of management personnel.
### Statistics

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contract Sum</strong></td>
<td>AUS$1.5m</td>
</tr>
<tr>
<td><strong>CitectSCADA Version</strong></td>
<td>5.01</td>
</tr>
<tr>
<td><strong>Operating System</strong></td>
<td>Windows NT4.0</td>
</tr>
<tr>
<td><strong>Network Equipment</strong></td>
<td>3COM and Cisco</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA Tags</strong></td>
<td>26,050¹,²</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA Digital Alarms</strong></td>
<td>7,310¹,³</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA Trend Tags</strong></td>
<td>1,814¹,³</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA Graphics Pages</strong></td>
<td>426¹,³</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA Display Nodes</strong></td>
<td>34¹,³</td>
</tr>
<tr>
<td><strong>Number of CitectSCADA IO, Trend and Alarm Servers</strong></td>
<td>25¹,²</td>
</tr>
<tr>
<td><strong>Number of Windows NT File Servers</strong></td>
<td>2¹</td>
</tr>
<tr>
<td><strong>Number of Windows SQL File Servers (Dual Pentium 200, 128MB RAM)</strong></td>
<td>1¹</td>
</tr>
<tr>
<td><strong>Number of IO Devices</strong></td>
<td>48¹,³</td>
</tr>
<tr>
<td><strong>Average response time as measured by CitectSCADA</strong></td>
<td>0.063 seconds¹</td>
</tr>
<tr>
<td><strong>Observed response time</strong></td>
<td>Sub 1 seconds¹</td>
</tr>
<tr>
<td><strong>Observed time to call up a graphic page (with all display data)</strong></td>
<td>Sub 1 seconds¹</td>
</tr>
<tr>
<td><strong>Observed time to call up an historical trend page (with all display data)</strong></td>
<td>Up to 6 seconds¹</td>
</tr>
<tr>
<td><strong>IO, Trend, Alarm and Report Server CPU Usage</strong></td>
<td>7% to 8%¹</td>
</tr>
<tr>
<td><strong>Network Utilisation</strong></td>
<td>3% to 4%¹</td>
</tr>
<tr>
<td><strong>Display client CPU Usage</strong></td>
<td>1% to 2%¹</td>
</tr>
<tr>
<td><strong>Other systems connected to the control system</strong></td>
<td>PM2000MultiLin protection relays; GEC protection relays; Dupline conveyor monitoring system; AMR environmental monitoring system; Sepam power monitors; GE Fanuc 9030</td>
</tr>
</tbody>
</table>

**Notes:**
1. Statistics measured by Citect on the commissioned system as of 15/06/98.
2. 23 CitectSCADA display nodes can switch to IO/Trend/Alarm/Report servers.
3. Longwall yet to be added.