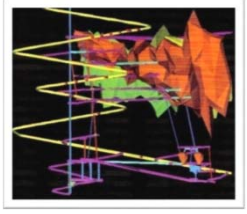
Optimized Mine Ventilation on Demand

Mark Anderson and Mark Laine
Simsmart Technologies
MDEC 2009

Mining Diesel Emissions Conference 2009 –Toronto Ontario

Optimized Mine Ventilation-On-Demand "OMVOD"



- ✓ Underground Mine Ventilation Design / Planning Tool
- ✓ Health and Safety Regulatory Compliance
- ✓ Personnel & Machinery Tracking
- ✓ Controls
  - Manual and Automatic Air Flow Controls
  - Air Distribution Optimization for Production Enhancement
- ✓ Energy Optimization

OMVOD

ABB/Simsmart Combined Solution Background

•ABB and Simsmart Technologies have entered into a formal contractual relationship to provide underground mining customers with a complete mine automation solution.

•Simsmart has over 23 years of ventilation experience with very demanding customers including the US Navy and governments of over 12 countries.

•ABB is a multinational corporation providing Total Mine Electrification and Automation with a proven track record of delivering full scope projects successfully by working directly with customers to jointly determine the system requirements, scope and design. ABB is the partner from design, through project execution, commissioning, start up and long term support.

- ***The patent pending, proprietary ABB/Simsmart OMVOD solution is Military tested and approved for surface and undersea naval applications***
- ***The OMVOD system 'mass balance' ventilation calculations are suited for real-time control.***
- ***The solution is "off the shelf" therefore no need for in house development.***
- ***The solution is* being deployed at Vale Inco Totten and Xstrata Nickel (NRS Mine) in Sudbury and other mines outside Sudbury.**

OMVOD Project Phases

Inputs	Phase	Outputs
• Mine development plan • Mine ventilation layout (plan view and detailed level and draw point views) • Equipment list for fans, regulators and machinery and personnel count • Energy costs • Interviews with operations and ventilation engineering	**Phase 1** **Preliminary engineering**	Comprehensive preliminary assessment of the business opportunity, savings, scope and costs of implementing the full OMVOD solution with the following deliverables • System Requirements Specification (SRS) and project scope • Savings Rough Order of Magnitude (ROM) • Fixed cost for project phases 2a and b • ROM for project cost
• Phase 1 deliverables • All equipment detailed parametric and behavioral information • Operating scenarios (machinery, shifts, pre-blast, post-blast, scheduling, ...) • Interviews with operations and ventilation engineering	**Phase 2a** **OMVOD production detailed engineering**	• System Requirements Review (SRR) and acceptance • Critical Design Review (CDR) and acceptance • Test Plan and Factory Acceptance Testing (FAT) procedures review and acceptance • FAT and system acceptance • OMVOD ventilation model, controls, optimization, scheduling, configuration, HMIs and performance analysis capability
• Phases 1 and 2a deliverables • Physical mine survey • Interviews with operations and ventilation engineering	**Phase 2b** **Equipment procurement & installation detailed engineering**	• Confirmation of the expected costs of the complete system including installation costs • Detailed cost estimate and fixed procurement and installation cost for Phase 3
• Phases 1 and 2a and 2b deliverables	**Phase 3** **System installation and startup**	• Procurement, installation, commissioning and training for the VFDs, instrumentation, automation air flow regulators , ABB DCS and integration of OMVOD model to ABB control system • OMVOD integration to the ABB control system • System installation, set to work, startup and model adjustments as per ventilation surveys • Site Acceptance Testing (SAT) and final system acceptance
• Installed system • Support contract	**Phase 4** **System support**	• Remote and/or on-site support for maintenance and support • Troubleshooting assistance • Problem resolution • Upgrades & enhancements • Bug fixes

OMVOD

Mine Ventilation Dynamic Design Validation Tool

Support full life cycle from system engineering to operations:

- **Challenge existing and new ventilation design and performance**
- **Evaluate ventilation design alternatives**
- **Validate mine expansion plans**
- **Advanced real-time transient calculations:**
  - ✓ **Mass flow and energy balance**
  - ✓ **Compressible air flow**
  - ✓ **Density corrected for depth**
  - ✓ **Resistance and friction corrected for density change**
  - ✓ **Fan curves corrected for density change**
  - ✓ **Temperature corrected for depth**
  - ✓ **Natural ventilation flow from pressure difference due to temperature change**

OMVOD Architecture

General Process Control Hierarchy

OMVOD integrated HMI

- Integrates tracking, monitoring, controls and optimization
- Surface, Underground and Web
- Autoconfigures on mine evolution

OMVOD configuration interface:

- Ventilation layout
- Fans and regulators
- Control parameters
- Machinery
- Personnel
- Configuration reports

Dynamic economic control
Surface fan energy, scheduling

Supervisory control
Level air flow distribution, scheduling

Optimizing loop control
Air flow demand calculation, scheduling

Single loop control
Fan air flow, regulator air flow, scheduling, Field safety, field interlocks, permissives

Measure / Manipulate
Air quality, air flow, personnel location, machinery location and operating status, fan speed, regulator position or flow

OMVOD real-time engine

- Tracking integration
- Air demand calculation
- High fidelity ventilation model
- Controls and optimization
- Scheduling

Dynamic Tracking System

ABB DCS and PLCs

Fans, Regulators, Air flow sensors, Air quality sensors

Ventilation process

Complete OPC Client-Server communication architecture

Mine Ventilation Optimization
Functional Architecture

All information interchange

OPC Server

Open Architecture

Mine Ventilation Optimization
Functional Architecture

Dynamic tracking of machinery location and operating status with dynamic connection to any third party SQL compliant tracking system

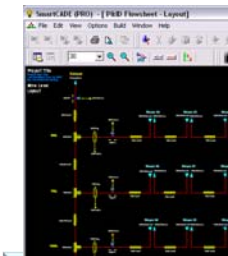
OPC Server

Mine Ventilation Optimization
Functional Architecture

A control system comprising:

- **Dynamic ventilation demand calculation**
- **Physics based high fidelity ventilation network model**
- **Regulatory analog and logic controls**
- **Air flow optimizer**
- **Energy optimizer**

Mine Ventilation Optimization
Functional Architecture

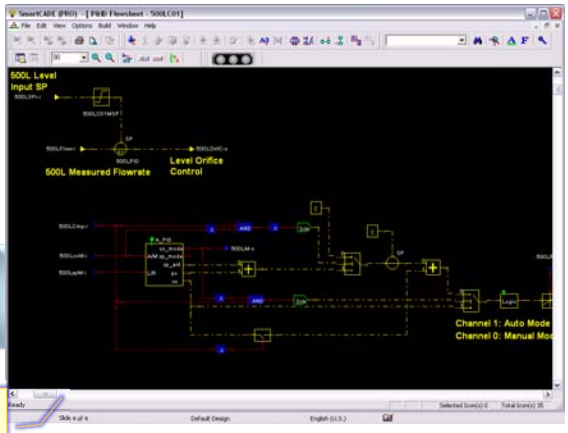


Smart P&IDs

- **Model performs a real time air mass balance**
- **Real-time results for flow, pressure, velocity and temperature**

Proven Military Grade M&S

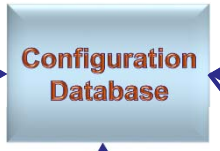
Mine Ventilation Optimization
Functional Architecture



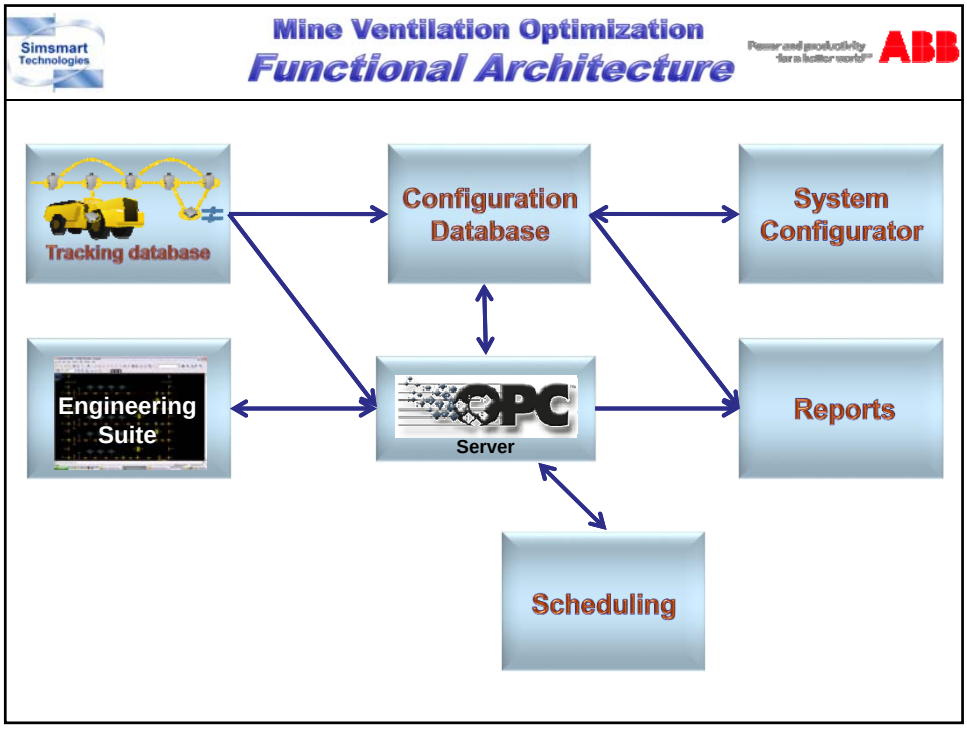
Control Schematics

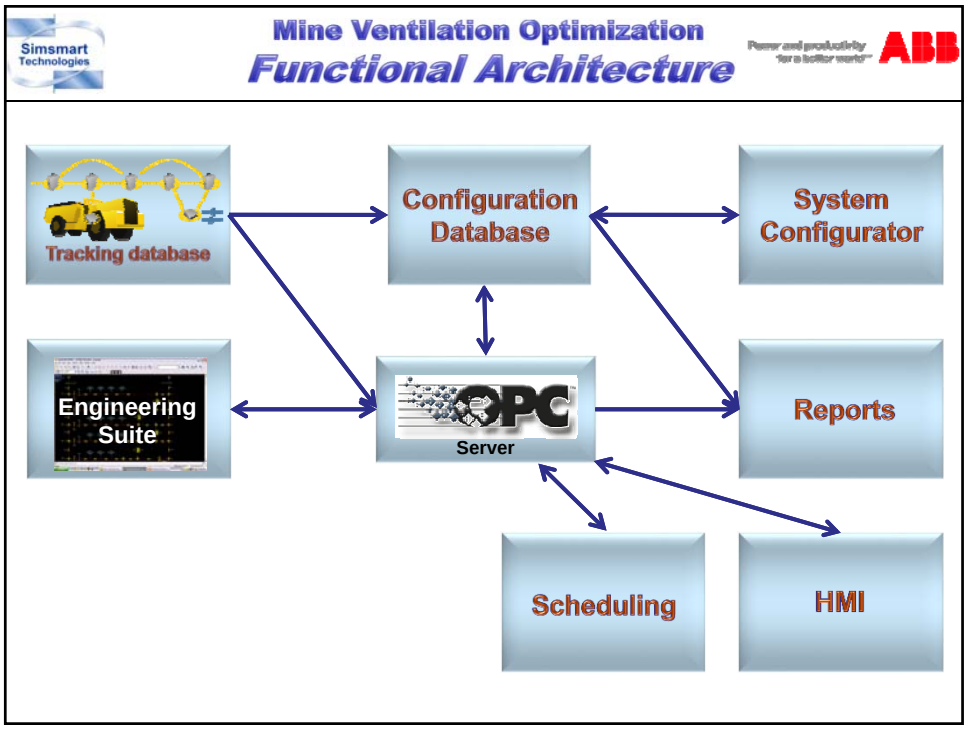
- Real-time analog and logic control
- Air flow and energy optimization
- Fans and air flow setpoints sent to PLCs via OPC

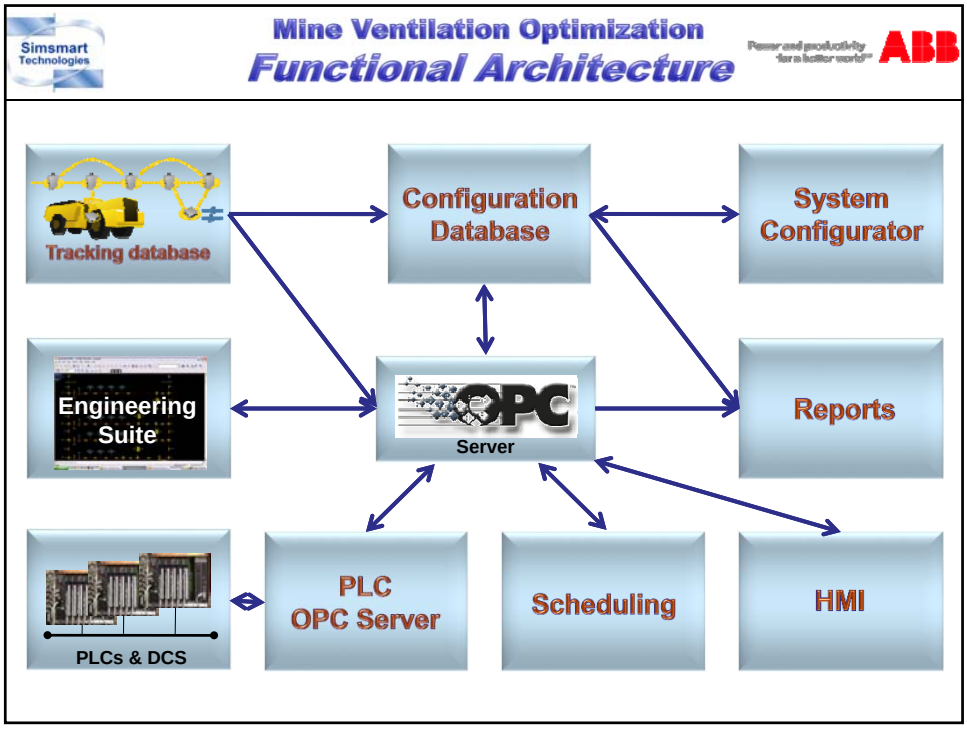
Mine Ventilation Optimization
Functional Architecture

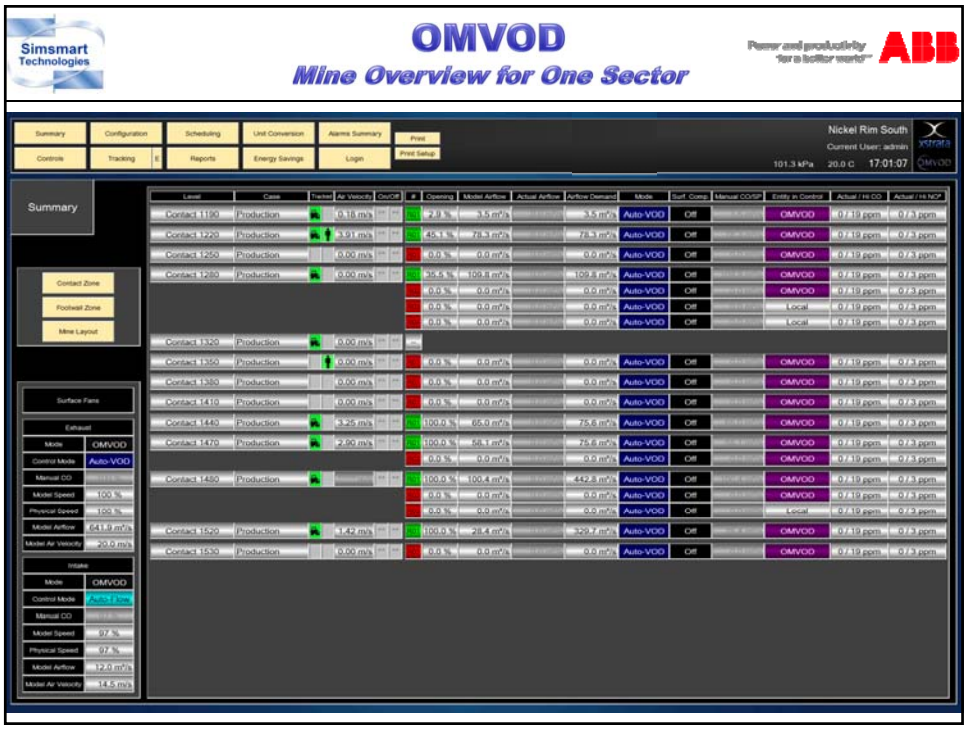


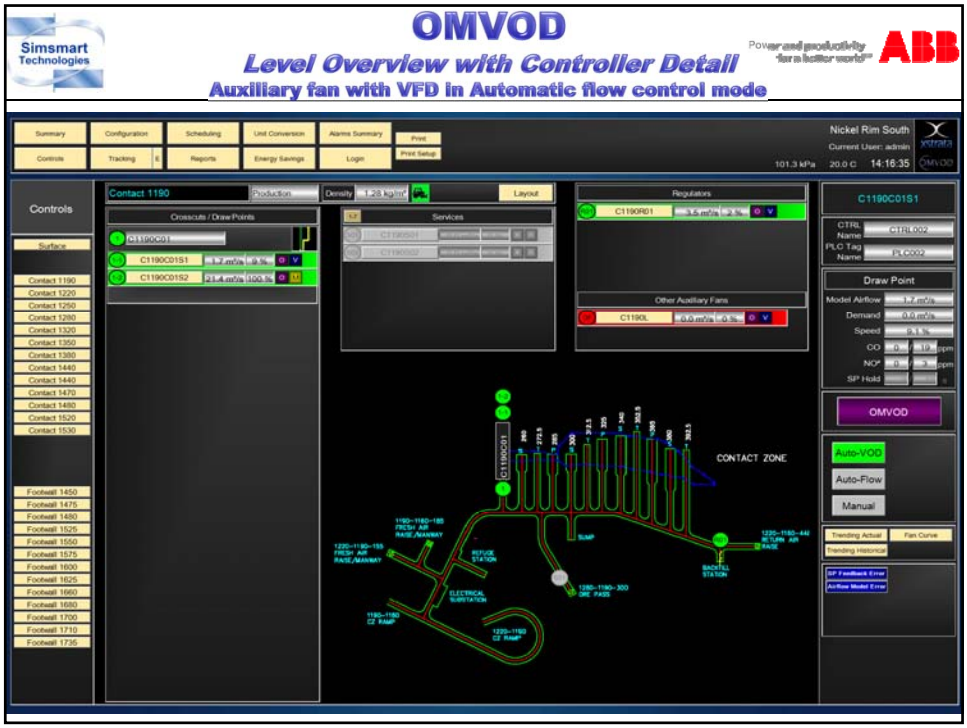
A configuration tool enables mine personnel to adjust the model, controls and HMIs electronically as the mine layout evolves in time

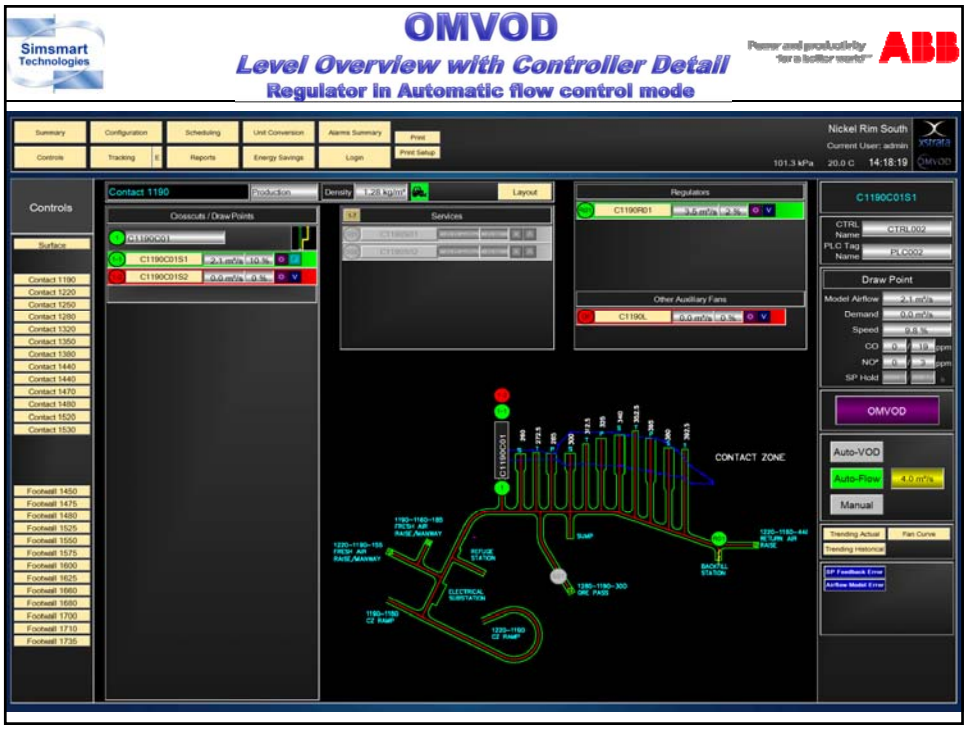

Simsmart Technologies
Mine Ventilation Optimization
Functional Architecture
ABB
Tracking database
Configuration Database
System Configurator
Engineering Suite
OPC
Server
Reports
Scheduling


Simsmart Technologies
Mine Ventilation Optimization
Functional Architecture
ABB
Tracking database
Configuration Database
System Configurator
Engineering Suite
OPC
Server
Reports
Scheduling
HMI


Simsmart Technologies
Mine Ventilation Optimization
Functional Architecture
ABB
Tracking database
Configuration Database
System Configurator
Engineering Suite
OPC
Server
Reports
PLCs & DCS
PLC OPC Server
Scheduling
HMI


Simsmart Technologies
OMVOD
Mine Overview for One Sector
ABB
Nickel Rim South
Summary


OMVOD
Level Overview with Controller Detail
Auxiliary fan with VFD in Automatic flow control mode
Simsmart Technologies
ABB
Nickel Rim South
Controls
Contact 1190
Regulators
C1190C01S1
Draw Point
OMVOD
Auto-VOD
Auto-Flow
Manual
CONTACT ZONE


OMVOD
Level Overview with Controller Detail
Regulator in Automatic flow control mode
Simsmart Technologies
ABB
Nickel Rim South
Controls
Contact 1190
Regulators
C1190C01S1
Draw Point
OMVOD
Auto-VOD
Auto-Flow
4.0 m³/s
Manual
CONTACT ZONE

OMVOD

Live Energy Consumption Report

Power and productivity for a better world™ ABB

Simsmart Technologies

Electricity Cost Report

$/kWh: 0.07

Cost per year: $3,286,516 Savings: $2,004,019

Rated: $5,290,535 in %: 38%

Configuration

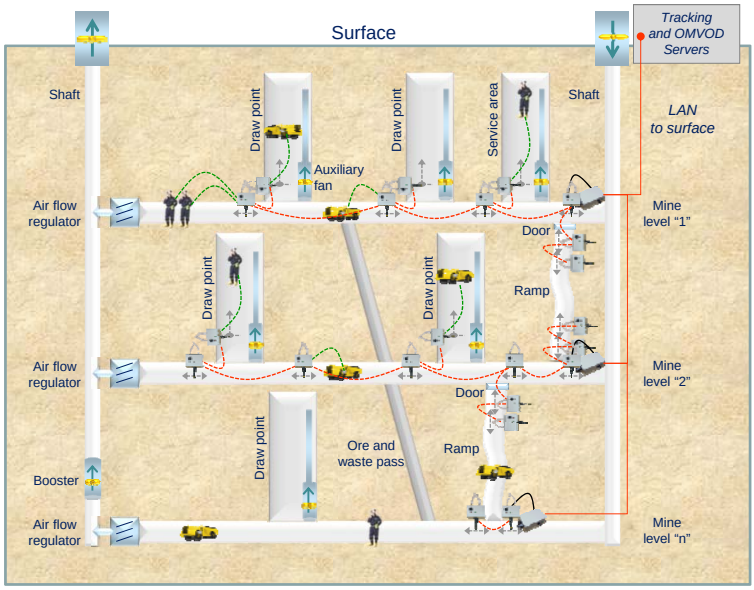
Physical Fan	Tag	Level	Crosscut	Stope	Nominal HP	Auto/Man	VOD/ Flow	Actual CO	Actual HP	Actual kW	Annual Energy Cost Current	Annual Energy Cost Rated	Sav.
ExhaustFan1	Exhaust1	Surface	N/A	N/A	4000.0	Automatic	VOD	85.1	2462.0	1835.9	$1,125,775	$1,829,053	38%
ExhaustFan2	Exhaust2	Surface	N/A	N/A	4000.0	Automatic	VOD	85.1	2462.0	1835.9	$1,125,775	$1,829,053	38%
Fan001	Tag001	Contact 1220	C1220C01	C1220C0151	30.0	Automatic	VOD	13.9	0.1	0.1	$37	$13,718	100%
Fan002	Tag002	Contact 1250	C1250C01	C1250C0151	30.0	Automatic	VOD	32.4	1.0	0.8	$467	$13,718	97%
Fan003	Tag003	Contact 1280	C1280C01	C1280C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan004	Tag004	Contact 1320	C1320C01	C1320C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan005	Tag005	Contact 1440	C1440C01	C1440C0151	30.0	Automatic	VOD	32.4	1.0	0.8	$466	$13,718	97%
Fan006	Tag006	Contact 1470	C1470C01	C1470C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan007	Tag007	Contact 1480	C1480C01	C1480C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan008	Tag008	Footwall 1375	F1375C01	F1375C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan009	Tag009	Footwall 1450	F1450C01	F1450C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan010	Tag010	Footwall 1475	F1475C01	F1475C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan011	Tag011	Footwall 1525	F1525C01	F1525C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan012	Tag012	Footwall 1550	F1550C01	F1550C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan013	Tag013	Footwall 1600	F1600C01	F1600C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan014	Tag014	Footwall 1625	F1625C01	F1625C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan015	Tag015	Footwall 1660	F1660C01	F1660C0151	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan016	Tag016	Footwall 1680	F1680C01	F1680C0151	30.0	Automatic	VOD	0.0	0.0	0.0	$0	$13,718	100%
Fan017	Tag017	Footwall 1660	F1660512	N/A	30.0	Automatic	VOD	100.0	30.0	22.4	$13,718	$13,718	0%
Fan018	Tag018	Contact 1220	C1220C02	C1220C0251	30.0	Automatic	VOD	93.8	24.8	18.5	$11,332	$13,718	17%
Fan023	Tag023	Contact 1280	C1280S01	N/A	30.0	Manual		0.0	0.0	0.0	$0	$13,718	100%
SupplyFan1	Intake1	Surface	N/A	N/A	1000.0	Automatic	VOD	85.1	615.5	459.0	$281,444	$457,263	38%
SupplyFan2	Intake2	Surface	N/A	N/A	1000.0	Automatic	VOD	85.1	615.5	459.0	$281,444	$457,263	38%
SupplyFan3	Intake3	Surface	N/A	N/A	1000.0	Automatic	VOD	85.1	615.5	459.0	$281,444	$457,263	38%

2009-02-06 09:54:33 Page 1 of 1

Tracking & Mobile Data

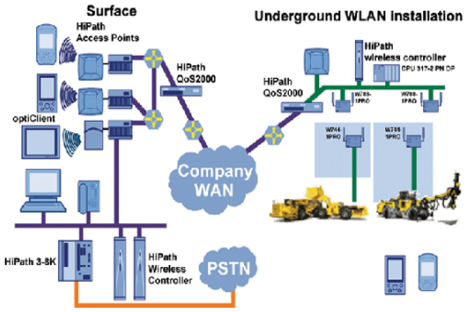
Power and productivity for a better world™ ABB

Simsmart Technologies



OMVOD

Integrated dynamic tracking for machinery and personnel



OMVOD

Integrated dynamic tracking for machinery and personnel

Mach001	Production Drill 1	Production Drill	--	Contact 1160 - Crosscut 01 - Stope 1	Yes	No	No
Mach002	Production Drill 2	Production Drill	--	Contact 1280 - Crosscut 01 - Stope 1	Yes	No	No
Mach003	Production Drill 3	Production Drill	--	Contact 1320 - Crosscut 01 - Stope 1	Yes	Yes	No
Mach004	Jumbo 1	Jumbo	E2C	Contact 1440 - Crosscut 01 - Stope 1	Yes	Yes	No
Mach005	Jumbo 2	Jumbo	E2C	Contact 1470 - Crosscut 01 - Stope 1	Yes	Yes	No
Mach006	Jumbo 3	Jumbo	E2C	Footwall 1680 - Crosscut 01 - Stope 1	Yes	No	No
Mach007	Jumbo 4	Jumbo	E2C	Footwall 1680 - On Level	Yes	No	No
Mach008	Jumbo 5	Jumbo	E2C	Footwall 1680 - On Level	Yes	No	No
Mach009	Development LHD 1	Development LHD	1700 8Y	Footwall 1660 - Service 12	Yes	Yes	No
Mach010	Development LHD 2	Development LHD	1700 8Y	Contact 1280 - Ventilation Zone 1	Yes	Yes	No
Mach011	Development LHD 3	Development LHD	1700 8Y	Contact 1280 - Ventilation Zone 1	Yes	Yes	No
Mach012	Development LHD 4	Development LHD	1700 8Y	Contact 1440 - On Level	Yes	Yes	No
Mach013	Development LHD 5	Development LHD	1700 8Y	Contact 1470 - Ventilation Zone 1	Yes	Yes	No
Mach014	Development LHD 6	Development LHD	1700 8Y	Footwall 1625 - Crosscut 01 - Stope 1	Yes	Yes	No
Mach015	Development LHD 7	Development LHD	1700 8Y	Footwall 1625 - On Level	Yes	Yes	No
Mach016	Production LHD 1	Production LHD	2900 10Y	Contact 1220 - Idle On Ramp	Yes	Yes	No
Mach017	Production LHD 2	Production LHD	2900 10Y	Contact 1220 - Crosscut 02 - Stope 1	Yes	Yes	No
Mach018	Production LHD 3	Production LHD	2900 10Y	Contact 1320 - On Level	Yes	Yes	No
Mach019	Transfert LHD 1	Transfert LHD	2900 10Y	Contact 1520 - On Level	Yes	Yes	No
Mach020	Haulage Truck 1	Haulage Truck	AD 45B	Contact 1480 - Ventilation Zone 1	Yes	Yes	No
Mach021	Haulage Truck 2	Haulage Truck	AD 45B	Footwall 1375 - On Level	Yes	Yes	No
Mach022	Haulage Truck 3	Haulage Truck	AD 45B	Footwall 1475 - On Level	No	No	No
Mach023	Scissorlift 1	Scissorlift	Marcotte	Footwall 1475 - On Level	Yes	Yes	No
Mach024	Scissorlift 2	Scissorlift	Marcotte	Footwall 1680 - On Level	Yes	No	No
Mach025	Scissorlift 3	Scissorlift	Marcotte	Footwall 1735 - Ramp Access	No	No	No

OMVOD
Airflow Equipment & Monitoring Stations

ABB / Simsmart / Accutron Instruments

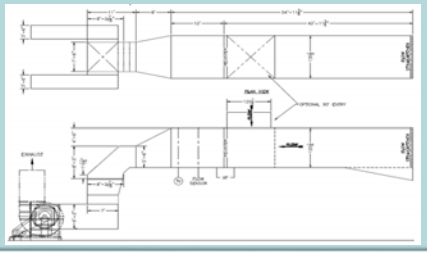
An integrated team approach, challenging existing and new ventilation control and monitoring strategies.

- ABB/Simsmart / Accutron design reviews:
  - ➢ Wind Tunnel Testing of:
    - Ventilation Regulators
    - Accutron Drift Monitors
  - ➢ Evaluation of Mine Atmosphere Instrumentation:
    - Underground Gas Monitors (Carbon Monoxide, Nitrogen Dioxide)
    - Real time Diesel Particulate Monitors (personnel and area monitoring)

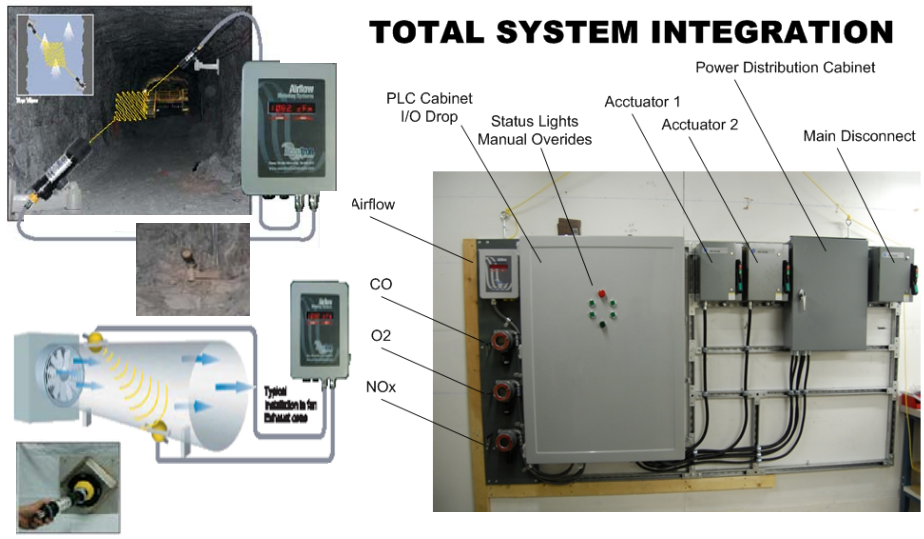
OMVOD
Airflow Regulators

ABB / Simsmart / Accutron – Regulator Wind Tunnel Testing Objectives:

- •Obtain the resistance coefficient (k factor) for the complete range of opening positions [0 to 90 degrees]
- •Analyze the relationship between k factor, pressure drop and velocity
- •Analyze the effect of different flow rates on the k factor
- •Analyze leakage through the regulator
- •Test the Accutron air flow measuring device
- •Compare test empirical data with equivalent Engineering Suite model
- •Adjust the Engineering Suite model to comply with reality



OMVOD
Mine Atmosphere Monitoring



Airflow sensor works like a "virtual pitot tube", averaging the airflow throughout the full path, maintaining a high measurement accuracy"

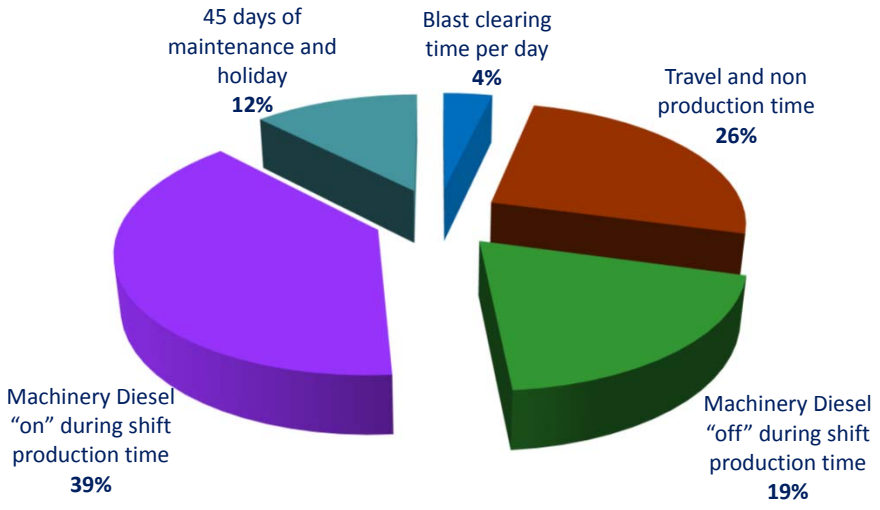
OMVOD
Underground Mine Monitoring

OMVOD process control / ventilation model dynamically modulates primary surface Fresh Air and Return Air Fans Variable Frequency Drives, underground booster fan Variable Frequency Drives and air flow Regulators.

OMVOD utilizes these following key elements to manage underground ventilation as a resource:

- **Equipment Tracking**
  - **Equipment Status**
  - **Equipment location**
- **Personnel Tracking**
  - **Personnel location**
- **Mine atmosphere data**
  - **Airflows,**
  - **Contaminant levels (CO, N02, DPM),**
  - **Temperature and relative humidity**

Opportunities for Savings



320 days of production with 2x11.5 hours shifts and 1 hour blast clearing per day
45 days of maintenance and/or holidays
(Chart is expressed as year time percentage)

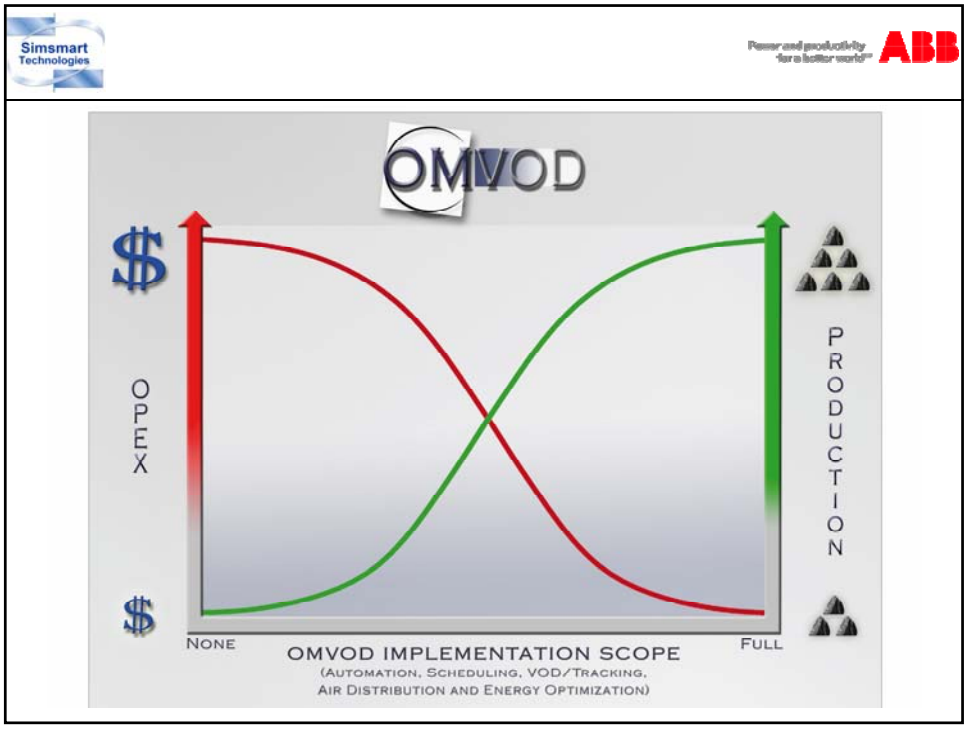
27

OMVOD
Energy Savings Examples

Surface fans operation analysis under OMVOD

			Case #2
1	Ventilation cost at 100% speed	[illegible]257,797	$ 4,257,797
2	Yearly operating cost at optimize[illegible]	$ 1,732,820	$ 1,911,601
3	Obtained flow in m³/s[illegible]	465.4	482.8
4	Obtained flo[illegible]	986,126	1,022,995
5	Su[illegible] operating speed	81%	84%
6	[illegible]uivalent yearly optimization savings from 100% speed on surface fans	$ 2,524,977	
7	Operation penalty on one fixed opening bulkhead		$ 178,781

Millions of Dollars per year in OPEX savings at each Mine


Simsmart Technologies
Power and productivity for a better world
ABB
OMVOD
$
$
OPEX
PRODUCTION
None
Full
OMVOD IMPLEMENTATION SCOPE
(Automation, Scheduling, VOD/Tracking,
Air Distribution and Energy Optimization)