Real-time optimized ventilation-on-demand
Alexandre Cervinka and Michel Massé
MDEC 2007

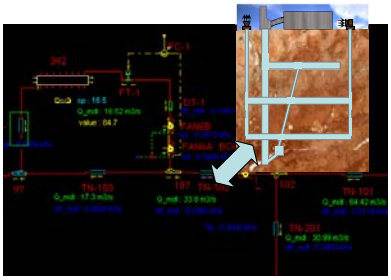
Two Technologies Produce an Unprecedented Mine Ventilation Optimization Capability

- ✓ *Energy savings*
- ✓ *Enhanced safety*
- ✓ *Emissions reduction*

Rev. 1 Page 1

Mine Ventilation Optimization
The system components

1. A battery-powered wireless mesh network that tracks the operating machinery.
2. A virtual mine ventilation network dynamic model and fan speed optimizer.
3. An OPC server for information interchange
4. A Human Machine Interface (HMI) that bridges optimized fan setpoints to the physical world. The HMI also provides data archiving, trending and reporting.
5. The battery-powered network mesh also provides SCADA functionality to route optimized setpoints to the fans and automated regulators.



Page 2

Mine Ventilation Optimization
How it works !

1. A ventilation demand is calculated as a function of machinery and people presence in each workspace.
2. From the calculated demand, a high fidelity complete mine simulation establishes a real time dynamic balance, regulates and optimizes energy consumption for all fans and/or regulators to meet the demand.
3. Fans and/or automated air flow regulators setpoints are sent to the physical control devices via a wireless battery-powered network.
4. All ventilation system control and measurement information is available on a human machine interface. Complete information data collection also provides detailed reports on system operation and performance.


Diesel driven mining machinery

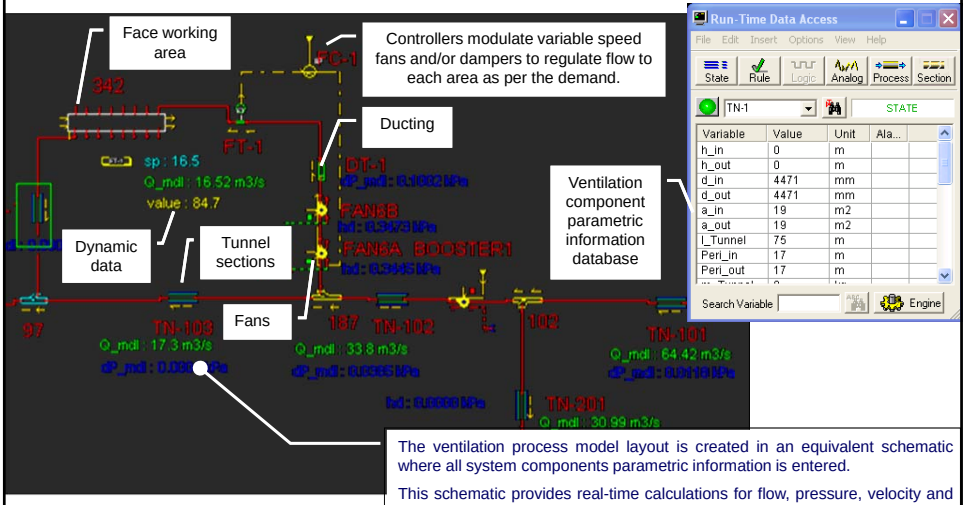

Auxiliary and booster fans


Intake and exhaust fans


Optimizer control panel

Page 3

Mine Ventilation Optimization
Modeling & Simulation Technology
(Originally developed for the military industry)



The ventilation process model layout is created in an equivalent schematic where all system components parametric information is entered.

This schematic provides real-time calculations for flow, pressure, velocity and temperature for each component. This information can be displayed dynamically and modified directly on the schematic.

The simulation performs a real time balance of the entire system.

Page 4

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Mine Ventilation Optimization
Modeling and Information Access

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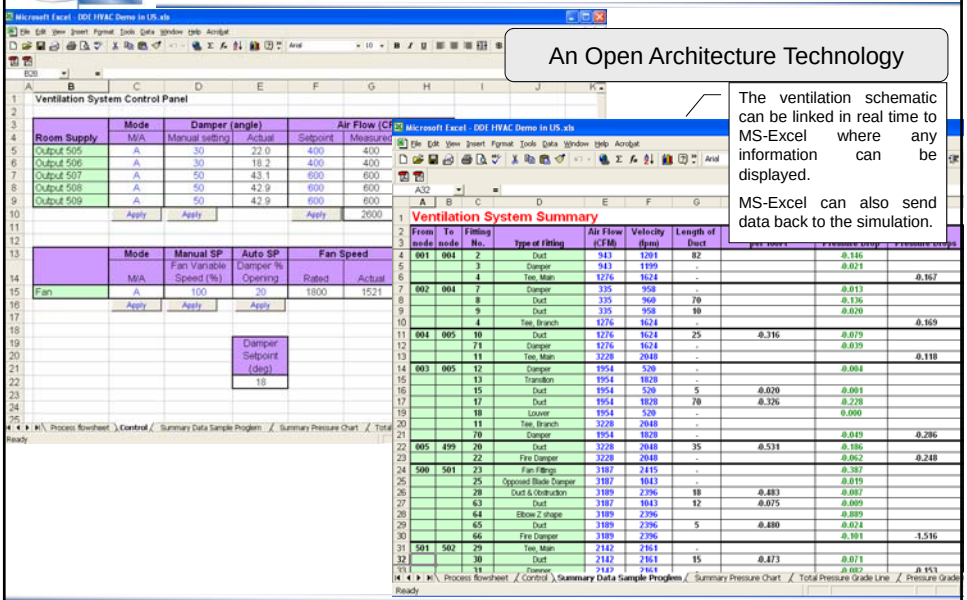

An Open Architecture Technology

The ventilation schematic can be linked in real time to MS-Excel where any information can be displayed.

MS-Excel can also send data back to the simulation.

Page 5

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Modeling and Information Access

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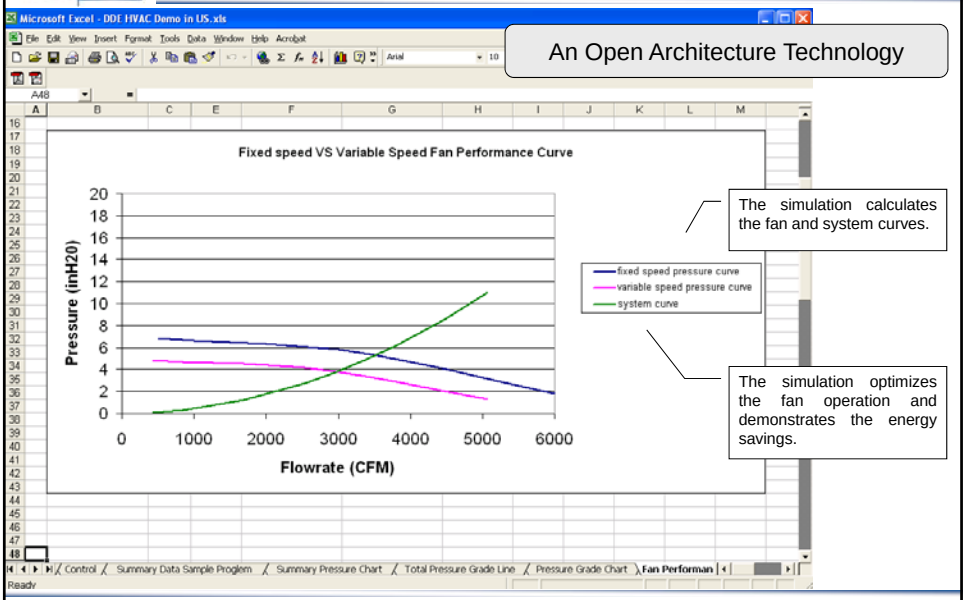


An Open Architecture Technology

The simulation calculates the fan and system curves.

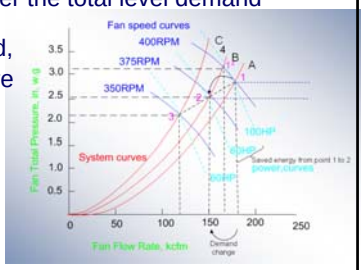
The simulation optimizes the fan operation and demonstrates the energy savings.

Page 6

Mine Ventilation Optimization
The Capabilities

Three levels of control:

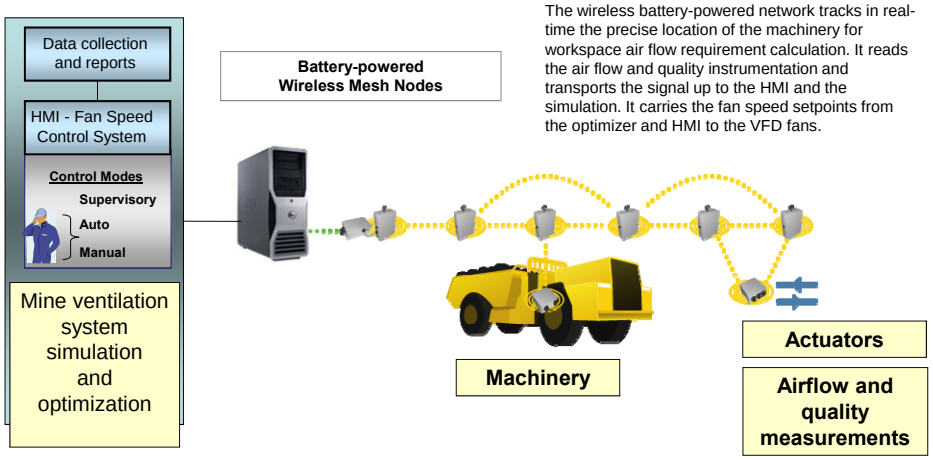
1. Auxiliary fan regulation for work areas (stopes) as a function of diesel HP active
2. Total level flow requirement as a function of all related stopes demand and "flow through" ratio
3. Regulate the mine intake and exhaust fans as per the total level demand
   - ✓ Exhaust fan speed = f(stopes total demand, "level flow through" ratio and global pressure losses)
   - ✓ Intake fan speed = f(exhaust fan speed)



- The systems balances itself for all pressure losses, all fan curves are calculated in real-time
- Fan energy global energy consumption is optimized

Mine Ventilation Optimization
Tracking & Networking

Real-time tracking and communication between the simulation, optimizer, HMI, data collection, Variable Frequency Drives and PLCs is accomplished by a wireless battery-powered network deployed in the mine



The wireless battery-powered network tracks in real-time the precise location of the machinery for workspace air flow requirement calculation. It reads the air flow and quality instrumentation and transports the signal up to the HMI and the simulation. It carries the fan speed setpoints from the optimizer and HMI to the VFD fans.

Mine Ventilation Optimization
Tracking & Networking Requirements

- The Newtrax extension fills the gap between the capabilities of standard leaky-feeder, Ethernet or fiber networks, and the requirements of VOD.
- This gap includes:
  1. Cost-effective real-time monitoring and control of hundreds of I/Os
  2. Reliable, real-time and mine-wide pervasive tracking of both vehicles and personnel

Page 9

Mine Ventilation Optimization
Tracking & Networking Requirements

Tracking issues:

A. Mainstream tracking technologies are not designed to support **safety-critical process control**, and their reliability is further deteriorated by the harsh and confined environment of underground mines

B. Most production applications can tolerate deferred location updates, e.g. when machinery *exits* drawpoints, but VOD requires **immediate location updates**, i.e. when machinery *enters* drawpoints

C. Installation and maintenance of wired, grid-powered or RF-fingerprinting **infrastructure for mine-wide pervasive tracking** is expensive and a burden to skilled labor

Page 10

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Mine Ventilation Optimization
Tracking & Networking Requirements

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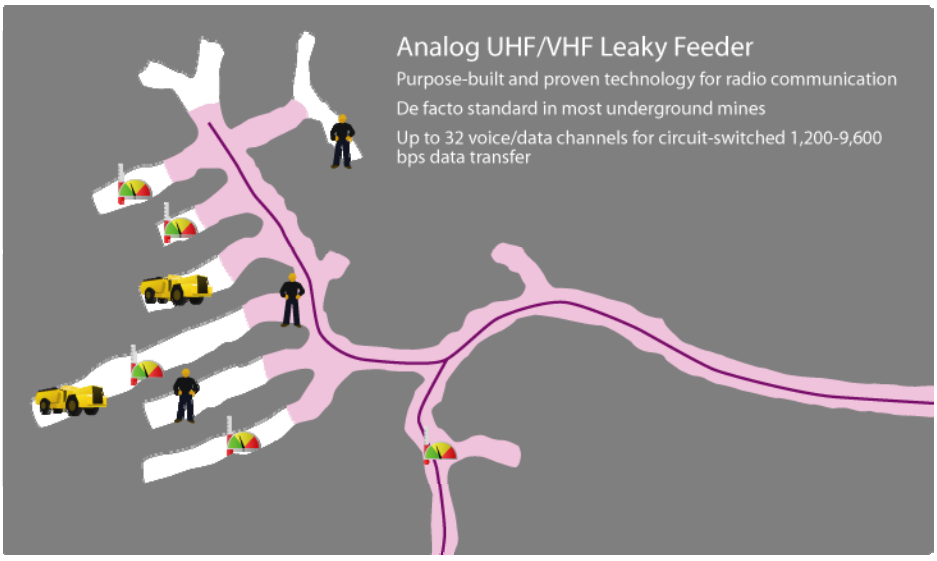

Page 11

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Mine Ventilation Optimization
Tracking & Networking Requirements

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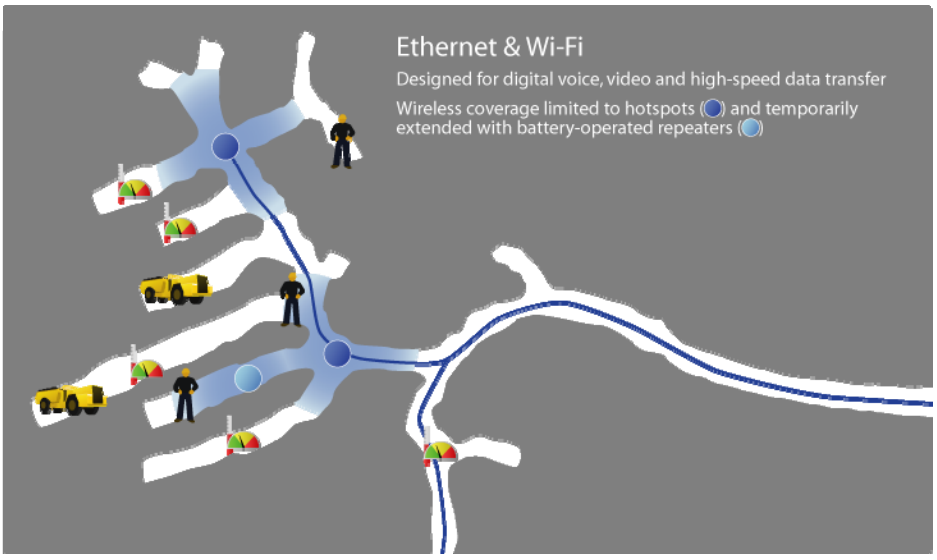

Page 12

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Mine Ventilation Optimization
Tracking & Networking Requirements

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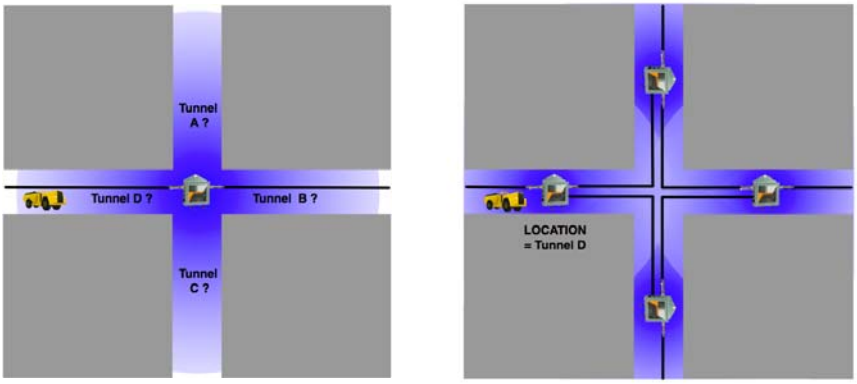
100% coverage for
Wi-Fi communications
($)

≠

Enough access points for
Wi-Fi tracking
($$$$)



Page 13

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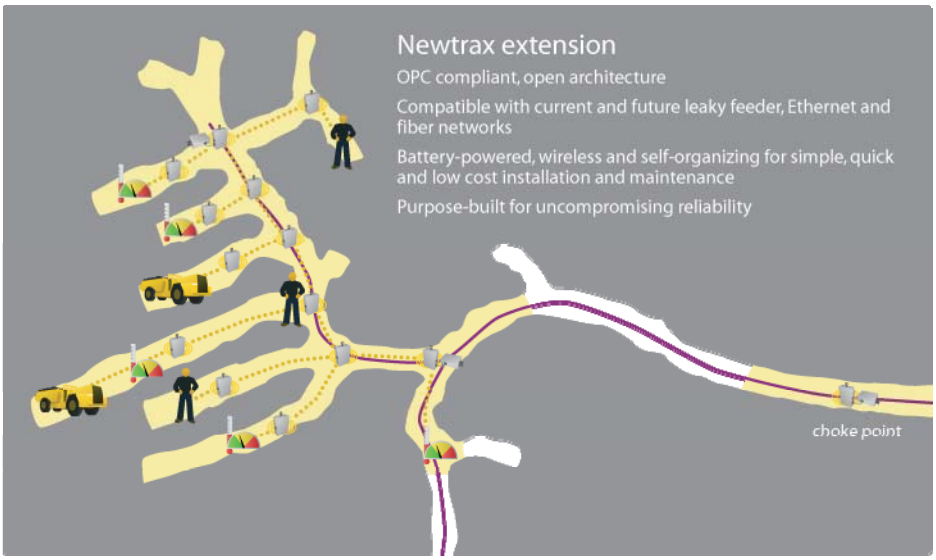


Page 14

Mine Ventilation Optimization
Implementation Steps

8 Steps
to a Fully Implemented
Mine Ventilation Optimization System

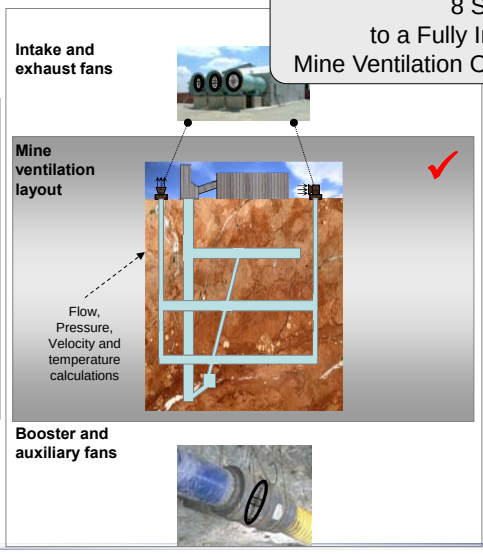
Step 1:

Gather information on ventilation system operation and parametric information for each system component.

Model the system.

Test for validity against mine data.

Make necessary adjustments to obtain desired fidelity.

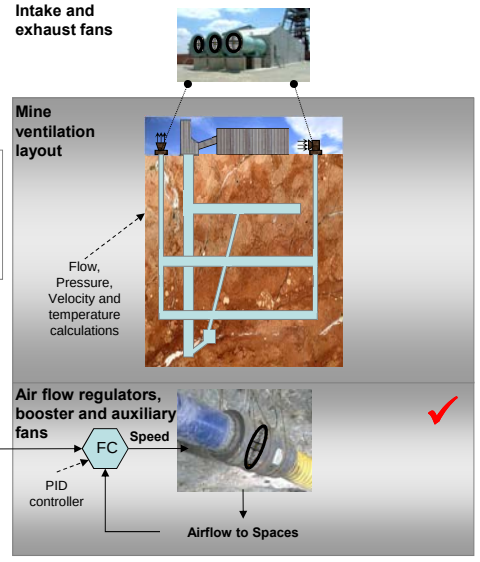


Page 15

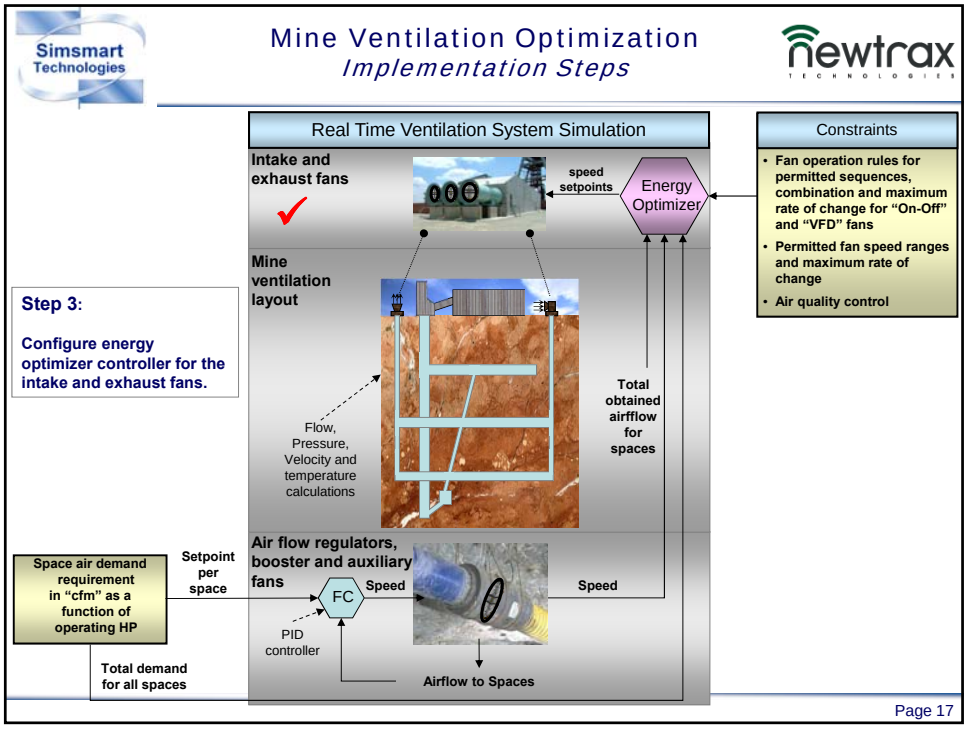
Mine Ventilation Optimization
Implementation Steps

Step 2:

Configure controllers for each workspace booster and auxiliary fan and/or air flow regulators.



Page 16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Mine Ventilation Optimization
Implementation Steps
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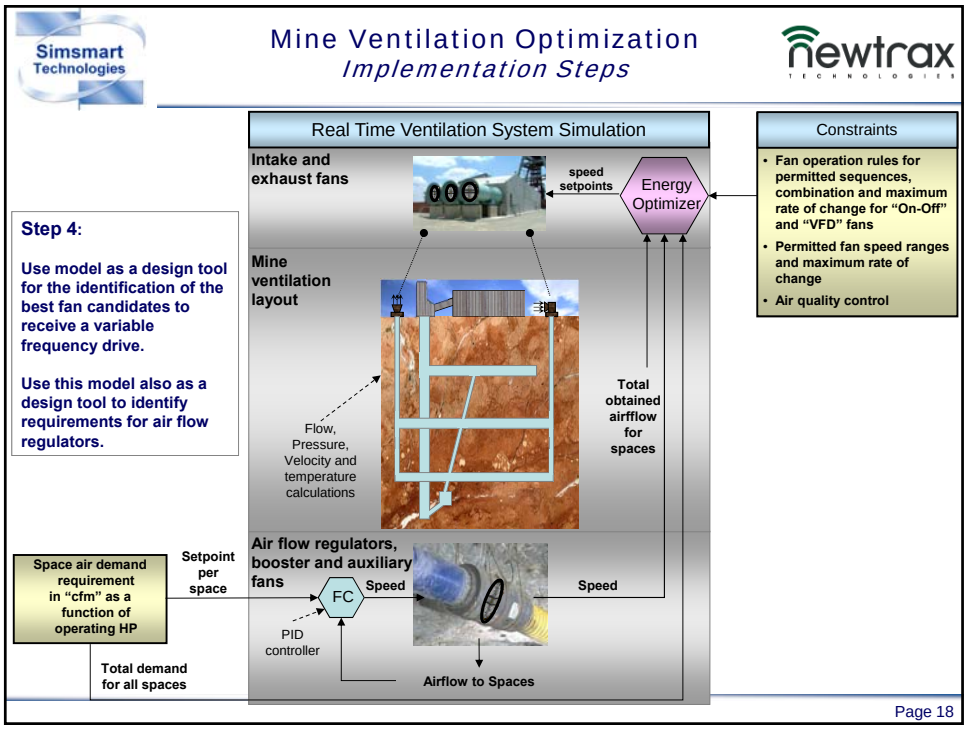
Real Time Ventilation System Simulation
Intake and exhaust fans
speed setpoints
Energy Optimizer
Mine ventilation layout
Total obtained airfflow for spaces
Flow, Pressure, Velocity and temperature calculations
Air flow regulators, booster and auxiliary fans
Speed
FC
PID controller
Airflow to Spaces
Space air demand requirement in "cfm" as a function of operating HP
Setpoint per space
Total demand for all spaces
Constraints
• Fan operation rules for permitted sequences, combination and maximum rate of change for "On-Off" and "VFD" fans
• Permitted fan speed ranges and maximum rate of change
• Air quality control
Step 3:
Configure energy optimizer controller for the intake and exhaust fans.
Page 17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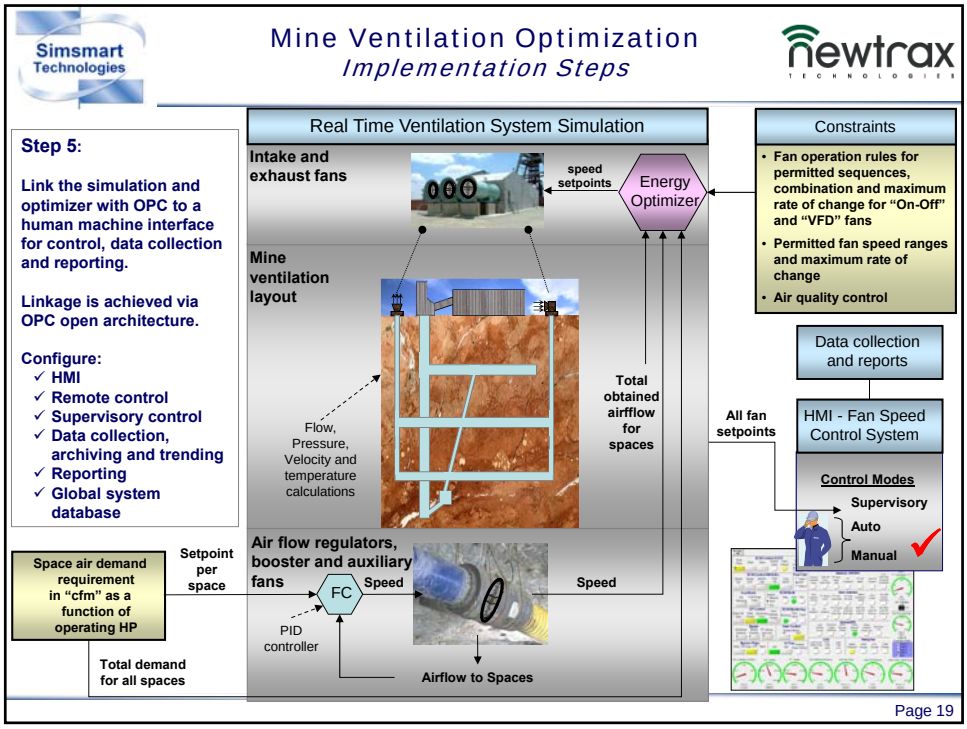
Step 4:
Use model as a design tool for the identification of the best fan candidates to receive a variable frequency drive.
Use this model also as a design tool to identify requirements for air flow regulators.
Page 18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Implementation Steps
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Step 5:
Link the simulation and optimizer with OPC to a human machine interface for control, data collection and reporting.
Linkage is achieved via OPC open architecture.
Configure:
✓ HMI
✓ Remote control
✓ Supervisory control
✓ Data collection, archiving and trending
✓ Reporting
✓ Global system database
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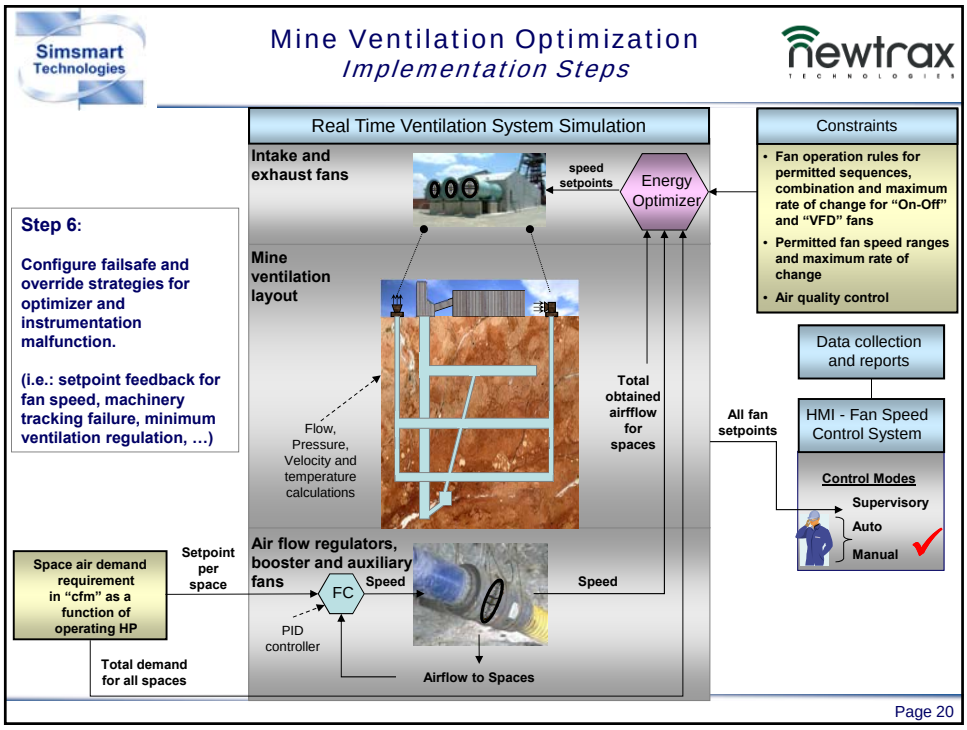
Data collection and reports
All fan setpoints
HMI - Fan Speed Control System
Control Modes
Supervisory
Auto
Manual
Page 19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Mine Ventilation Optimization
Implementation Steps
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Step 6:
Configure failsafe and override strategies for optimizer and instrumentation malfunction.
(i.e.: setpoint feedback for fan speed, machinery tracking failure, minimum ventilation regulation, ...)
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Page 20

Mine Ventilation Optimization
Implementation Steps

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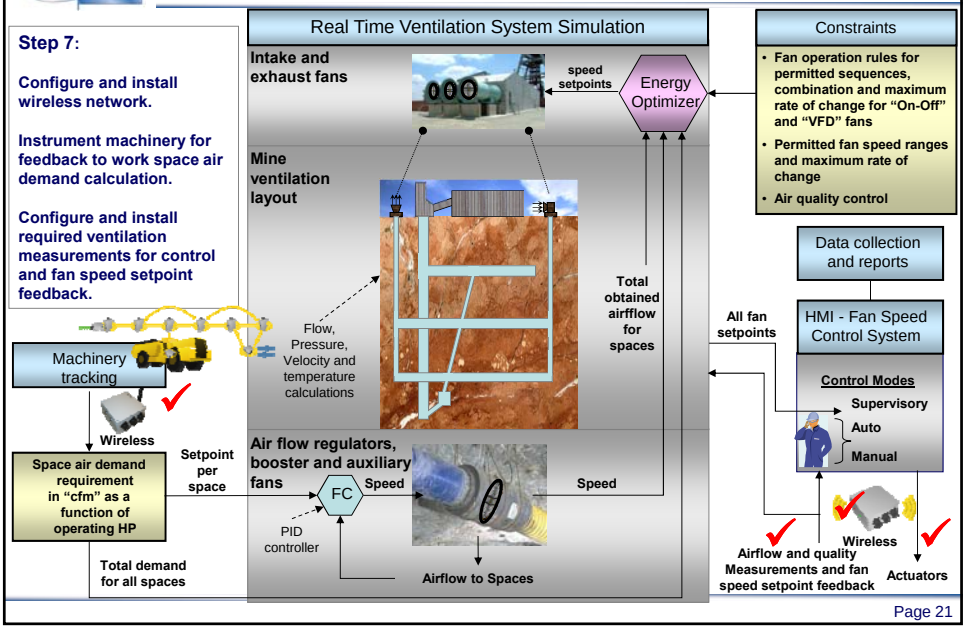
Step 7:

Configure and install wireless network.

Instrument machinery for feedback to work space air demand calculation.

Configure and install required ventilation measurements for control and fan speed setpoint feedback.



Mine Ventilation Optimization
Implementation Steps

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Step 8:

1) Install air flow regulators where required.

2) Motor starters or Variable Frequency Drives and network connections

a) Upgrade selected booster and auxiliary fans with motor starters or variable frequency drives and connect to the wireless network

b) If required, upgrade selected intake and/or exhaust fans with variable frequency drives and connect new drives to either, the wireless network or existing PLCs

c) If required, connect existing PLCs to wireless network

d) If required, configure OPC and HMI addressing to existing PLCs