Key Learning's from the CAF VOD Project
MDEC Conference

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Outline

- What was the CAF VOD Project
- Who are our partners
- What work was conducted
- What were the Outcomes
- Where should the industry head next

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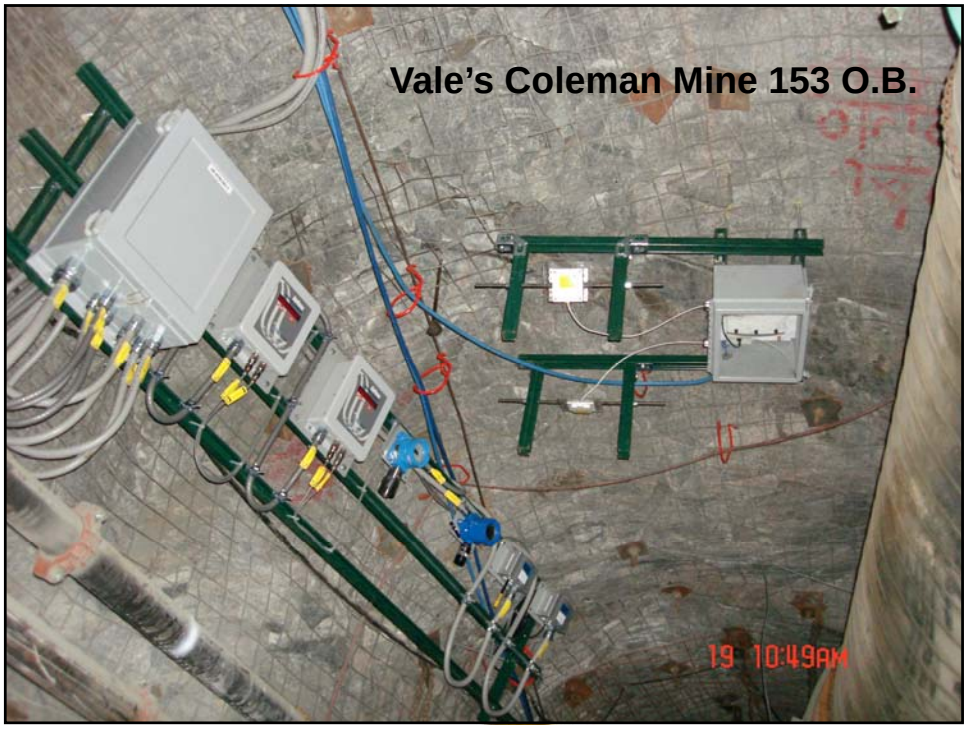
CAF VOD Partners Project 8.5 M

Canada FedNor VALE xstrata nickel BESTECH Simsmart Technologies TOROMONT Mining Products CAT objectivity Natural Resources Canada Ressources naturelles Canada Canada symboticware CEMI Centre for Excellence in Mining Innovation

Nickel Rim South – Surface Plant

xstrata nickel



Results, what was done

- Installed extra sensors to augment existing system
- Undertook the field studies at both mines
- Built VREX
- Began analysis of the data

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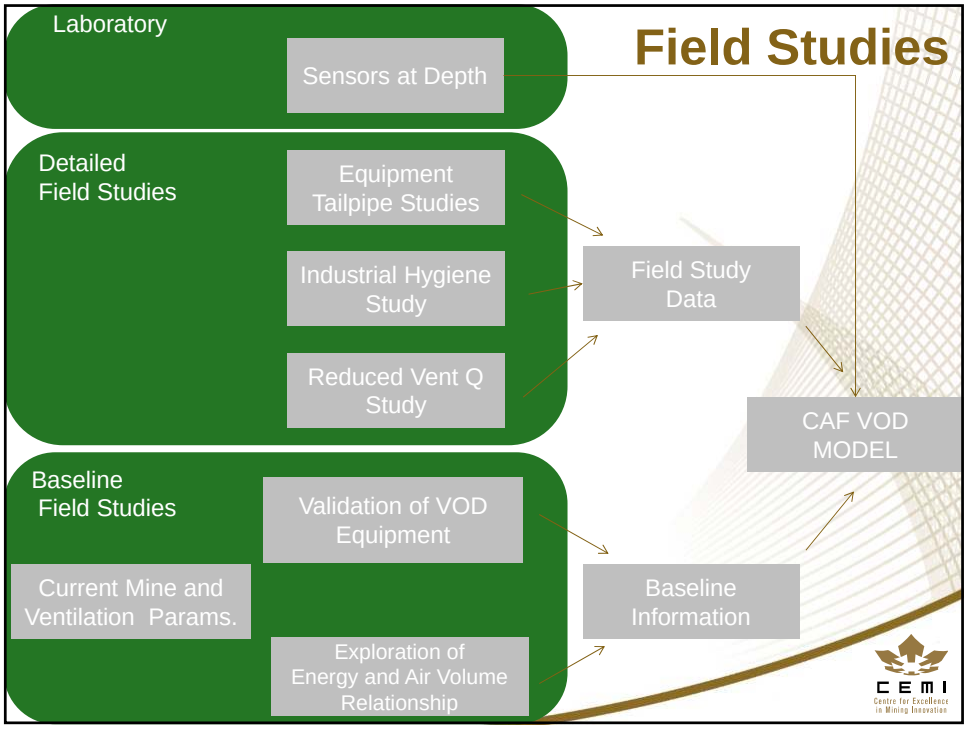
Field Studies
Laboratory
Sensors at Depth
Detailed
Field Studies
Equipment
Tailpipe Studies
Industrial Hygiene
Study
Reduced Vent Q
Study
Field Study
Data
CAF VOD
MODEL
Baseline
Field Studies
Validation of VOD
Equipment
Current Mine and
Ventilation Params.
Baseline
Information
Exploration of
Energy and Air Volume
Relationship
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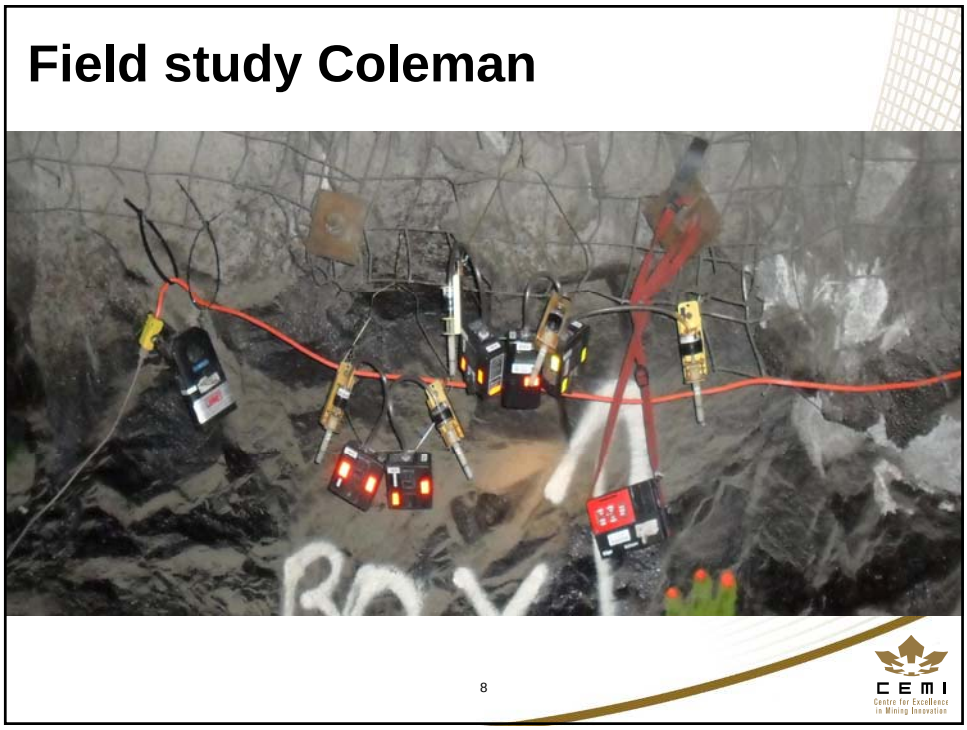
Field study Coleman
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What was Learned

- Sensors
- Modeling
- Quality vs. quantity
- Engines

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Sensors

- Sensor calibration
  - Impacted by depth
  - Varies with manufacturer
  - Can suffer from cross-contamination
- Process needs to be followed
  - Placement, installation, maintenance, accuracy check
- Signal to noise is high, presents challenges for control with increased levels of noise
- Sensor heads need to be protected
- Equipment can't be left blocking sensors if used for control

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Sensors

- Need to review data storage policies, compression removes important details
- Temperature probes and relative humidity can be used in conjunction with RFID to determine scoop location
- RFID tracking is not yet fully mature
- Using sensors to control instead of monitor will require more robust sensors
  - Self-diagnostic ability
  - Self calibration
  - Require re-evaluation of location
  - Defined maintenance program

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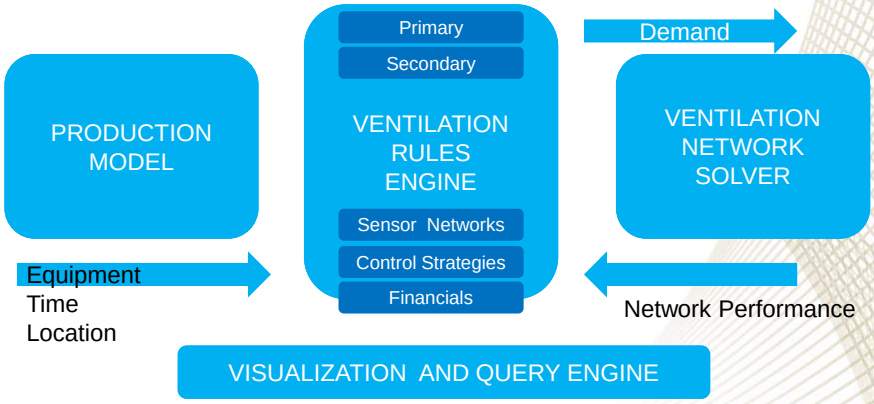
Modeling Components



- Excel cannot capture dynamic nature of mining
- Allows scenarios that we have not thought of yet

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Modeling

- Complimentary tool to current evaluation techniques
- Allows detailed “what if” evaluation to aid in making the most efficient choices
  - Where should the investment be made
  - Determine cost benefit

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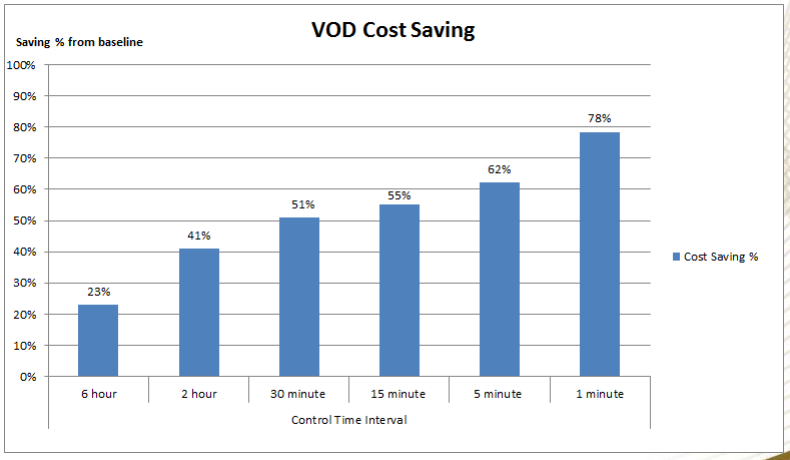
Evaluate VOD value through the model



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VOD Value

- Will result in reductions in energy demands or “Energy Intensity”
- Ability for shift to shift control of air will result in increased productive capacity
- Will require some changes to our “Mine Design” process

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Quality vs Quantity

- Will not be a short term goal
- Will require better predictive models
- Currently can't reliably measure all contaminants in real time (DPM)
- Will need to measure exposure closer to the source

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Engines

- Largest single source of contamination (heat aside), driving air volume requirements
- Can show the link between laboratory and field measurements
  - Monitoring performance
  - Allow predication of contaminate levels
- Need to keep aware of alternative engine options

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Future of On-Board Monitoring

- Value in the link between the laboratory and the field
- Value in capturing engine operating parameters
- Ability to add environmental as well as tailpipe sensors
- Can be serviced during vehicle service
- Opportunity to capture maintenance information
- Operational data can be logged

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Engine Monitoring

- The field studies showed that tailpipe sensors designed for continuous operation can be related to laboratory testing.
- We believe further work will show that emissions from a diesel engine in operation can be reliably predicted.
- The following slides were produced by Brent Rubeli (CANMET Ottawa lab)

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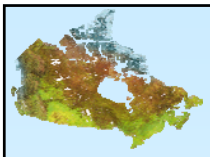

VOD- Diesel

On-Board Diesel Emissions
Measurement – Preliminary Data

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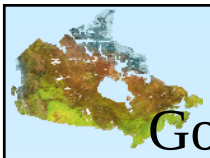

Goals for On-Board Sensing

- On-vehicle measurement of tailpipe emissions may be useful as a predictor of future ambient air quality.
- Load-based ventilation (engine out NOx).
- Faults and engine tune (fuel/air ratio O_2)
- Linkage to certification test values with in-use / deterioration factor.

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Sensor Technology

- NGK NOx/O2 Sensor
- Zirconia-type
- Continuous monitoring

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Lab Testing

- Baseline NGK sensor against CANMET-MMSL certification gas bench.

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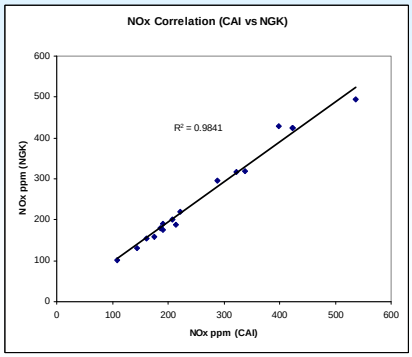
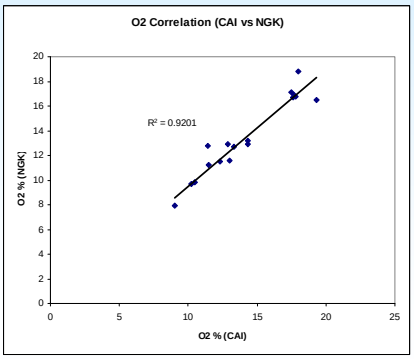
Lab Correlation

- NGK vs CAI gas bench
- Very good preliminary results – dry to wet correction still needed





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Mine Tests

- In-Mine testing of NGK sensor at Nickel Rim South on R1700 LHD loader.
- Baseline against SEMTECH-DS gas analyzer.

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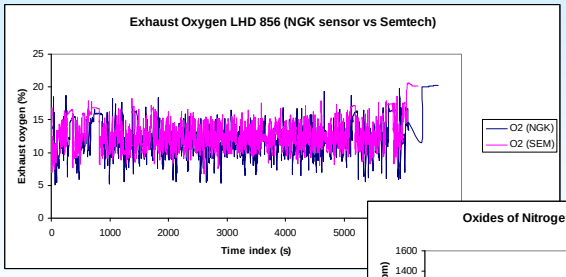
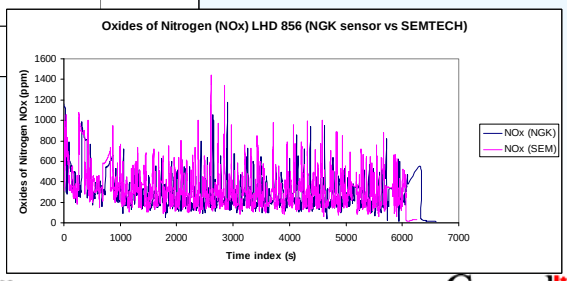
Mine Results

- Simultaneous measurement of NOx and O_2 over typical production cycles.





Average Cycle	NOx (ppm)	O2 (%)
NGK	295	12.2
SEM	315	12.94
Error (%):	-6.3	-5.7

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Conclusions

- On-board tailpipe sensing of load-based emissions (NOx) and fuel/air ratio (O2) is feasible for integration into VOD systems.
- Expert applications may be able to use the data for pollutant prediction, maintenance, and certification-based ventilation.
- Further work is required to develop linkages with certification data and engine manufacturer data.

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Future

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Vision

- Create industry wide knowledge with respect to Ventilation on Demand:
  - Backed by Scientific Rigour
  - Evaluates the latest technology
  - Is focused on creating value
  - Strong collaborative participation

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Project Themes

- Opportunities for the advancement of VOD include

1. Technology Transfer
2. Monitoring, controls and data reporting
3. Developing a quality based ventilation system
4. Operating a VOD system
5. Management of Diesel engines
6. Development of design guidelines

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CEMI is developing VOD Next Steps

- Form a consortium of companies interested in the research and development (initiated)
- Goals:
  - Not system design – how the system is used
  - Address industry wide issues identified in CAF VOD
  - Evaluate possible solutions
  - Validate data with scientific integrity
  - Evolve the next generation of engineering tools, (VREX)
  - Create value:
    - Beyond energy savings (energy intensity)
    - Higher production
    - Better use of air
- $1-2 M /year for 3 years (total project budget)

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- Questions?