Patented RTO Technology for fugitive methane emission abatement
Background

• Centennial Coal and Corky’s have been working on VAM abatement for the previous 5 years
• There is a pilot and a demonstration scale plant, including safety duct already built
• CMATSP is a $70m 50:50 fund over next 5 years
• Administered by Dept Resources, Energy and Tourism (DRET)
• Advised by Technical Advisory Committee (TAC)
• Round 1 Application submitted September 2012
• Round 2 Proposal submitted in Feb 2013
• Centennial is the Applicant, Corky’s is a technology consultant
Perceived Barriers to VAM Abatement

- Safety
  “It will be a candle at one end of the mine”
- Fluxing
  “Mine dusts react with brick”
- Temperature control
  “VAM is highly variable. A 600% upswing is likely at times”
- Cost and footprint of new technology
  “No safe mine connection yet proven”
- Design Assurance Process
  “There are no mine accepted standards for this technology”

Technical problems
Easy to solve if there is a design assurance path

Political problem
Difficult to solve
Establishing the Development Path (stage A)

V-model of complex design process

- Demonstration
  - Year: 2008
  - Concept of Operations
- Project definition
- Detailed Design
  - Requirements and Architecture
  - Implementation
  - Integration Test, and Verification
  - System Verification and Validation
  - Verification and Validation
- Time

- Scale Up
  - Year: 2012
  - Operation and Maintenance
  - Year: 2016
  - Integration Test, and Verification
  - Year: 2018
  - System Verification and Validation

- VAM RAB
  - March 2013
Strengths and Risks of Proposed Project

**Strengths**

- Test case on similar project already on site
- Site Management understand VAM RAB
- Consultation with workforce already started
- Consultation with NSW Mines Regulators started
- **Safety Requirements Specification** already developed for smaller scale
- Pit falls of past project mostly understood
- Concept can be physically viewed at smaller scale
- Unilateral design assurance of non-safety functions developed
- **Technology licence model so benefits can be spread quickly**

**Risk**

- Potential to unsettle work force
- Budget at prefeasibility stage only
- The schedule is dependant on DA approval
- The schedule requires goodwill to come to a consensus quickly
- The budget and schedule assume the conceptual design is very close to final design
Connection to Mine – LOPA

<table>
<thead>
<tr>
<th>LOP</th>
<th>VAMRAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILP1</td>
<td>SIL rated bypass</td>
</tr>
<tr>
<td>ILP2</td>
<td>SIL rated dilution doors</td>
</tr>
<tr>
<td>ILP3</td>
<td>Intrinsically safe by design</td>
</tr>
<tr>
<td>ILP4</td>
<td>SIL rated isolation</td>
</tr>
<tr>
<td>ILP 5</td>
<td>SIL rated frangible design</td>
</tr>
</tbody>
</table>
Safeguards .... with a probability of failure appropriate to the degree of risk posed by the hazard.

How do you define appropriate?  How do you get agreement?
Design Assurance Barriers

1. Without political certainty about the quantum and duration of a carbon price the logical financial strategy for Australian coal mines is to do the minimum and wait for certainty.

2. Expensive test work by miners and OEM’s has not moved the industry forward due to lack of agreement on the test framework and written feedback from the mining industry.

3. There was no group from the mining industry tasked to receive and comment on data and VAM abatement tests.

4. Individual company effort has not been coordinated.

5. The technology is new to miners and takes time to understand. Miners have in the past changed roles often.
Proposal for first safe, direct coupling of a commercial scale RTO to a working coal mine ventilation fan

CMATSP Grant Proposal
Stage A - Test case - Establishing the development path, for both safety and function, for new complex technologies on coal mines using aerospace standards.

Centennial Coal

The aerospace industry has systems that allow an aircraft that has never flown below to be safely tested. Let us use those systems.
Unilaterally Requirements Assumed in Grant Proposal

- 100 to 150 m³/s of variable flow ventilation air capacity
  212000 to 318000 cfm

- Demonstrable Tolerable risk less than $10^{-8}$ events per year
  Assuming one 8% methane outburst every two years and 40 miners exposed

- 98% capture and abatement of methane from one fan
  Averaged over a year

- less than 50 Pa ventilation fan back pressure
  5 mm water gauge
A proposed commercial scale design has been developed, and described, to illustrate concepts and facilitate discussion. However, amendments to the design will be required as a result of the design assurance program which must be run in consultation with the mining industry. No one knows what those amendments will be.
Physical Concept

Proposed commercial scale direct coupled safety duct and VAM RAB

Current demonstration scale VAM RAB
Physical Concept
De-Risking the Project

Ultimately, at this stage no one knows if the concept will be acceptable to regulators and if it will ever be allowed to operate.

Key to the success of the proposed project is:

a. Building on lessons learnt (case study)

b. Avoiding Miner and OEM unilateral problem solving through scheduled consultation and demonstration

Completing the Design Assurance path (stage A) similar to DO254 and MIL STD 1521B before any serious money is committed

c. Staging the project progress into sub-projects.
De-Risking the Project

Some of the sub projects are:

- Independent repetition of deflagration and venting experiments
- Design, test and exhibition of full scale safety duct off-site
- Move, test and exhibition of full scale safety duct on-site
- Design, test and exhibition of full scale RTO on site
- Close working relationship with University of Newcastle Safety Flagship Programme and the mine regulators. The results of all aspects of the design process accessible to wider industry.
Stage A: Design Assurance Case Study

A well defined Development Path has a planning phase before the design phase. The planning phase will:

a. Define the lifecycle processes used for hardware and software design

b. Select and document any standards to be used in the project and any deviation before the design

c. Define and document the development and verification environment including the tools to be used

d. Define the team responsible for sign off at the various stages and commit those people to the risk assessments and meetings

e. Define and document the design assurance strategy. Agree the Strategy
What Development Path?

Safety sits above process

AS 61508
AS 61511

Concepts of Operation

Functional Requirements

Risk Assessments

Definition and documentation of Requirements
Traceability Matrix

Detailed Design

Risk Assessments

March 2013
What Development Path?

Concepts of Operation

AS 61508 AS 61511 Safety Program

Safety Requirements

Risk Assessments

Operating concept

Operating requirements

Specifications and Data Requirements List

Functional Requirements

• Functional Requirements Document
• System Test Plan

Detailed Design

Meeting

Preliminary Design Review by wider mining industry
What Development Path?

Meeting

Preliminary Design Review by wider mining industry

Purpose:
Have we identified the requirements sufficiently well to show understanding of what is required and how will it be Verified and Validated?
What Development Path?

- **Functional Requirements**
  - AS 61508
  - AS 61511
- **Detailed Design**
  - Risk Assessments
  - Amend Requirements
  - Traceability Matrix
- **System / Subsystem Design Doc**
  - Hardware Detailed Design
  - Software Detailed Design
  - Drawings
  - System Test Plan
- **Meeting**
  - Critical Design review by specialist acceptable to mining industry

March 2013
What Development Path?

Meeting

Critical Design review by specialist acceptable to mining industry

Purpose:
Have we shown how we will implement each function and sub function, are all functions allocated, with relationships and interfaces identified?
What Development Path?

Detailed Design

Meeting

Integration test and Verification (physical plant)

Implementation

Test Readiness Review by specialists acceptable to mining industry

Risk Assessments

Commission sub systems SIL Tests Factory Acceptance Test Environment Assessments

Software Design Doc SIL Plan

March 2013

VAM RAB
What Development Path?

Purpose:
Have we scoped enough testing? Are all verifications in place for requirements. Were all requirements tested? Are all status recorded? Are all failure Identified and fixed?

Meeting
Test Readiness Review by specialist acceptable to mining industry
What Development Path?

Meeting
Systems Verification Review
by specialist acceptable to mining industry
Risk Assessments

Meeting
Test Readiness review by specialist acceptable to mining industry
Risk Assessments

Integration test and Verification (physical plant)

Operations and Maintenance
Operating results
Maintenance results
Project Close report
What Development Path?

Meeting
Systems Verification Review by specialist acceptable to mining industry

Integration test and Verification (physical plant)

Verification and Validation

Operations and Maintenance
Operating results
Maintenance results
Project Close report

Verification and Validation

Systems Verification and Validation (physical plant)
Stage B – Functional requirements and detailed design for direct coupling of a commercial scale RTO to a working coal mine ventilation fan. Repeating test with U of N supervision. (First half of V model)

Stage C – Implement full scale safety duct offsite including integration testing, verification and validation, operations and maintenance (second half of V model for duct only but not integrated with RTO)

Stage D – Implement full scale safety duct connected to RTO onsite including integration testing, verification and validation, operations and maintenance (second half of V model working as demonstrator on coal mine)
# Proposed Project Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Budget $M</th>
<th>Timing</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.8</td>
<td>First 6 to 9 months</td>
<td>Case Study using existing Mandalong Plant Establish if design assurance path is workable</td>
</tr>
<tr>
<td>B</td>
<td>2.1</td>
<td>Years 2</td>
<td>Scale up and system functional requirement definition</td>
</tr>
<tr>
<td>C</td>
<td>6.2</td>
<td>Years 3 and 4</td>
<td>Safety duct test and exhibition</td>
</tr>
<tr>
<td>D</td>
<td>20.7</td>
<td>Years 4 and 5</td>
<td>Integration, demonstration Operations and maintenance</td>
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</table>
Australian Context Stake Holders

The following are considered key stakeholders

- ACALET VAM Taskforce
- Department Of Resources Energy and Tourism
- Mine Management
- Mine Regulator
- Workforce
- Mandalong Community
- NSW Clean Coal Fund (past funder and scope setter)
- Process Designers (Corky’s) and other RTO manufactures
- Newcastle University
- Overseas regulators

It is expected that the panel of experts, committed to the project, would come from a subset of the above groups. Overseas input is welcome.
Conclusion

We believe that:

• The V model, which is mandated for safety on NSW coal mines, needs to be extended to VAM abatement functional requirements
• The V model must have mandated meetings and milestones as is done in the aerospace industry.
• The regulators and third party miners need to be engaged through the process not just at the end
• Full scale VAM abatement is possible and affordable
• Direct coupling is safe and does not necessarily impede ventilation fan operation

Cooperation, consultation and agreement is the key to creating certainty and reducing cost of developing VAM abatement projects.

Let us, as an industry, be coordinated and collaborative.