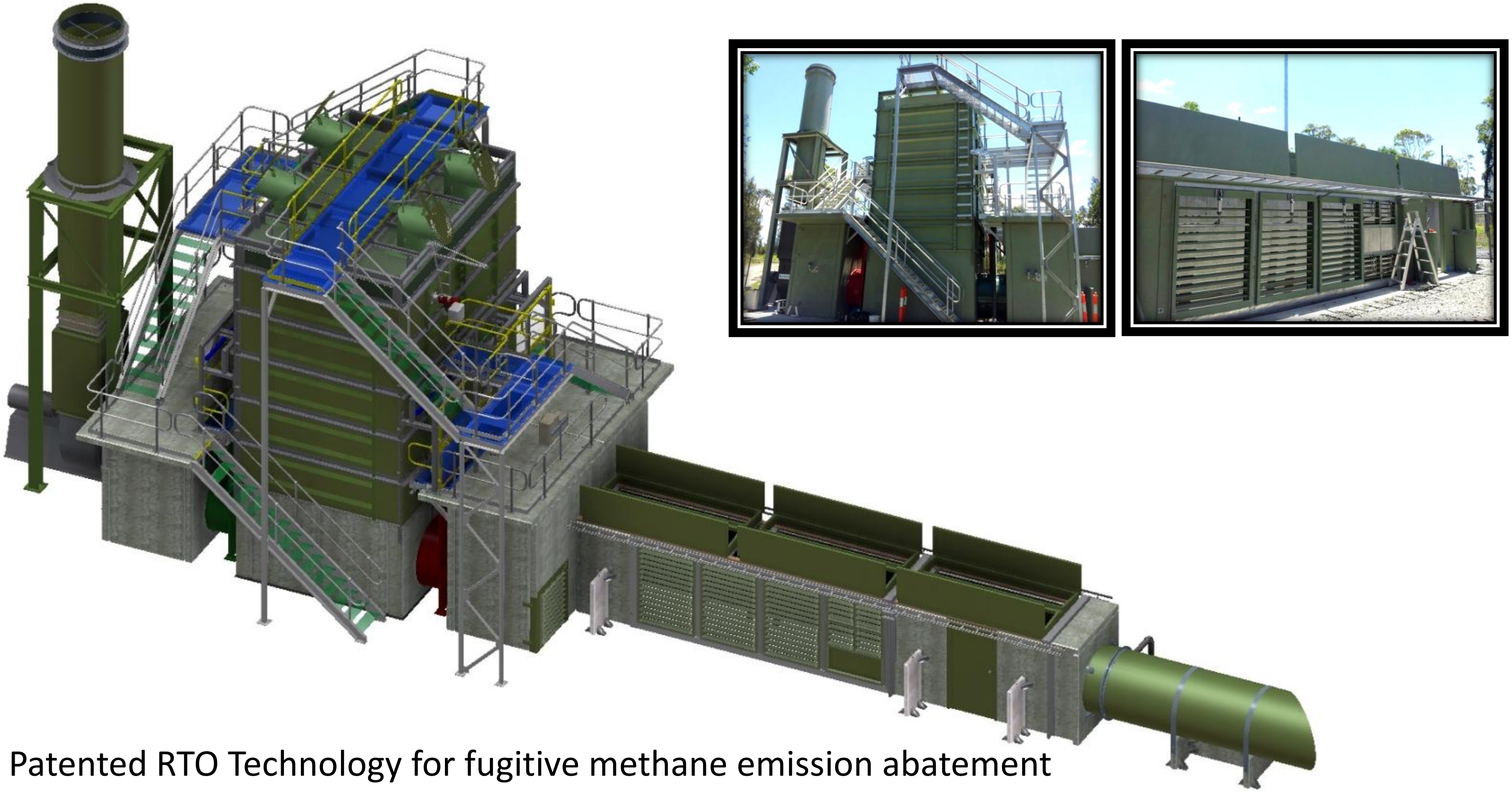
VAM RAB Scale-up and Design Assurance Path

Rod Peet and David Cork



Patented RTO Technology for fugitive methane emission abatement

Background

- Centennial Coal and Corky's have been working on VAM abatement for the pervious 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"

Technical problems

Easy to solve if there is a design assurance path

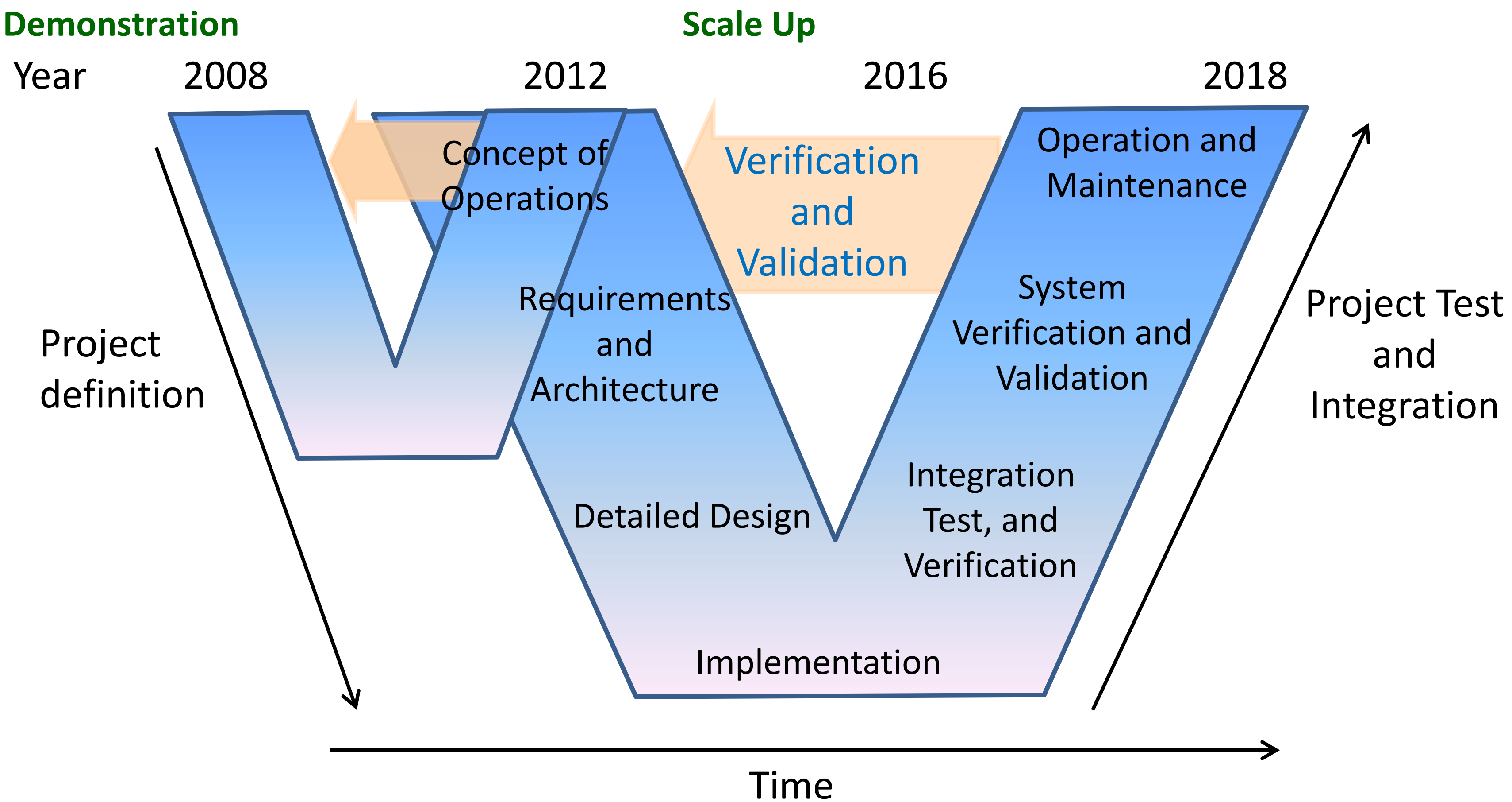
- Design Assurance Process

"There are no mine accepted standards for this technology"

Political problem

Difficult to solve

Establishing the Development Path (stage A)



V-model of complex design process

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

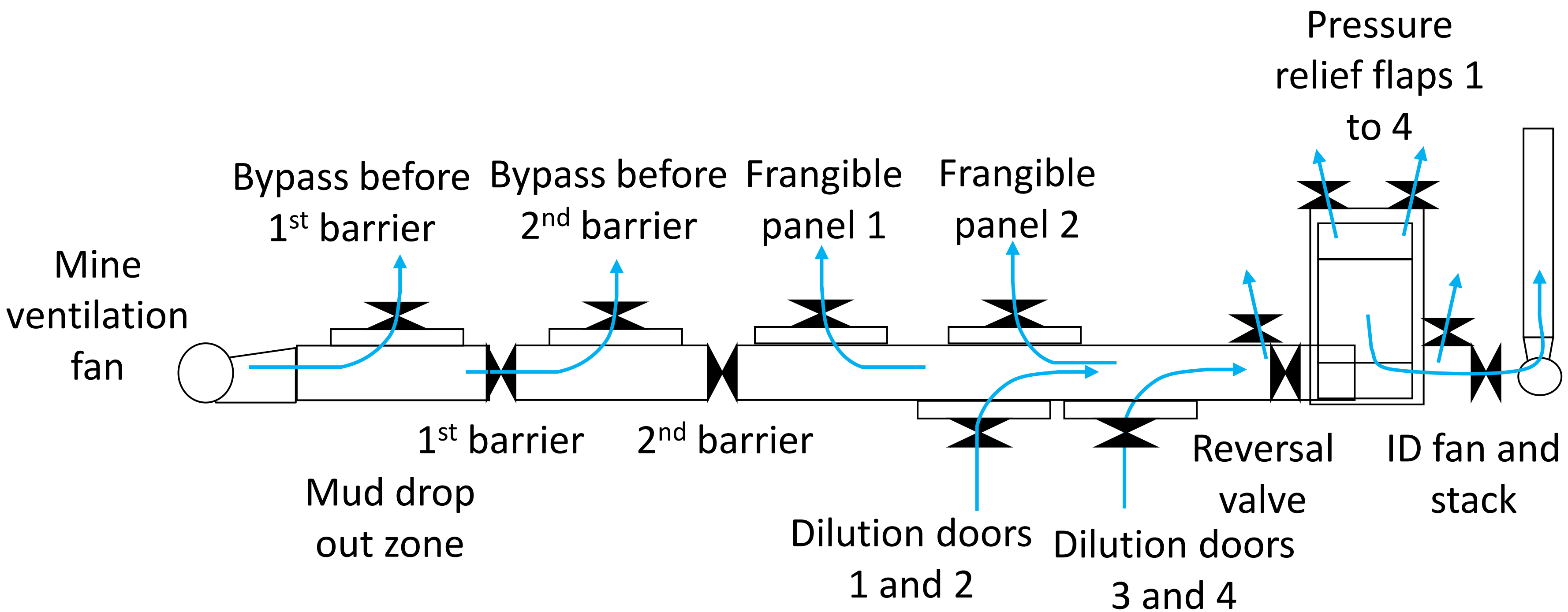
Connection to Mine – LOPA

LOP	VAMRAB
ILP1	SIL rated bypass
ILP2	SIL rated dilution doors
ILP3	Intrinsically safe by design
ILP4	SIL rated isolation
ILP 5	SIL rated frangible design

Connection to Mine – Safety Systems

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

Centennial Coal

- 100 to 150 m^3/s of variable flow ventilation air capacity
  212000 to 318000 cfpm

- 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

Physical Concept

Centennial Coal

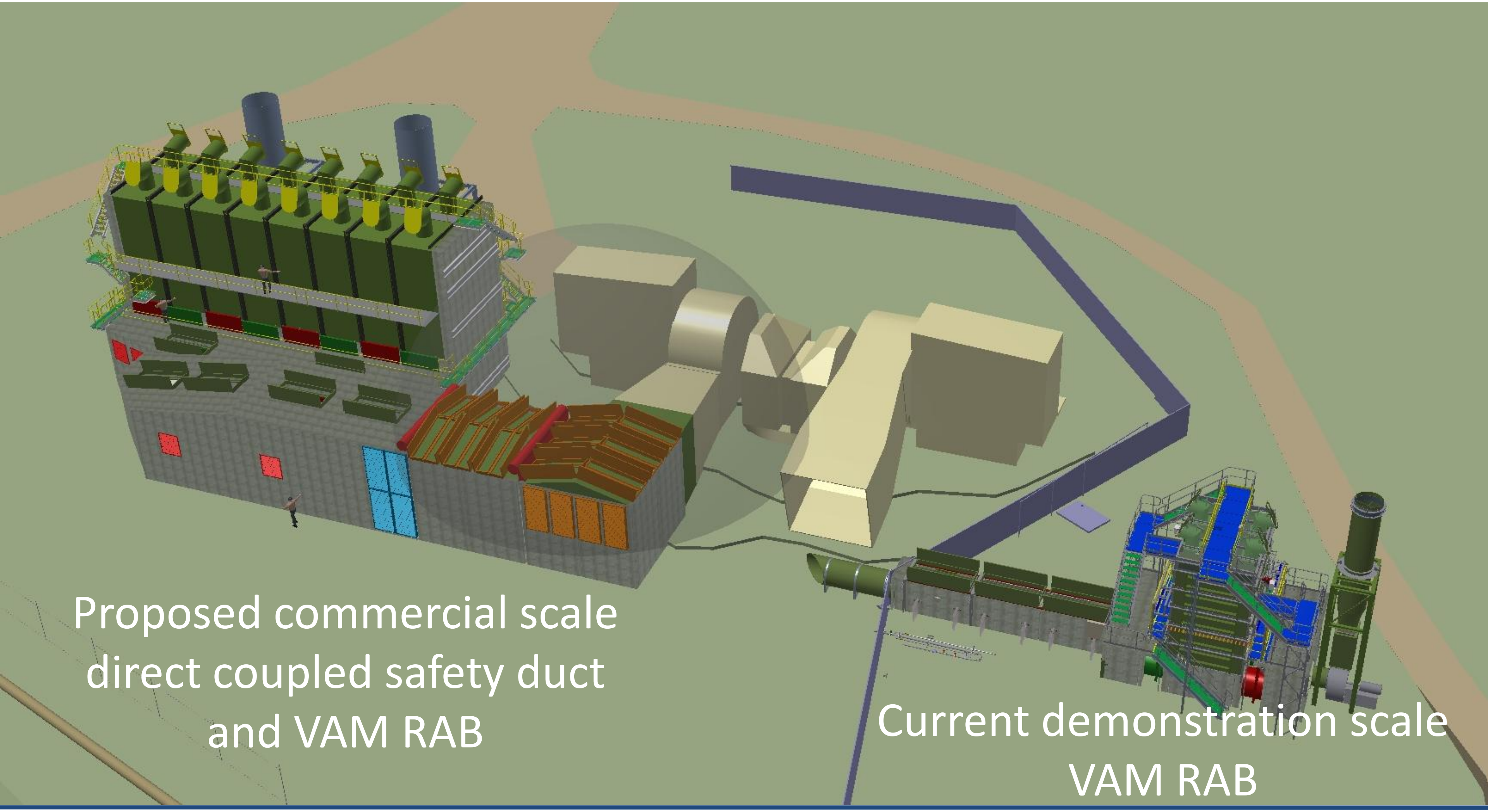
A proposed commercial scale design has been developed, and described, to illustrate concepts and facilitate discussion. However, amendments to the design will be required as a result of the design assurance program which must be run in consultation with the mining industry. No one knows what those amendments will be.

Proposed commercial scale direct coupled safety duct and VAM RAB

Current demonstration scale VAM RAB

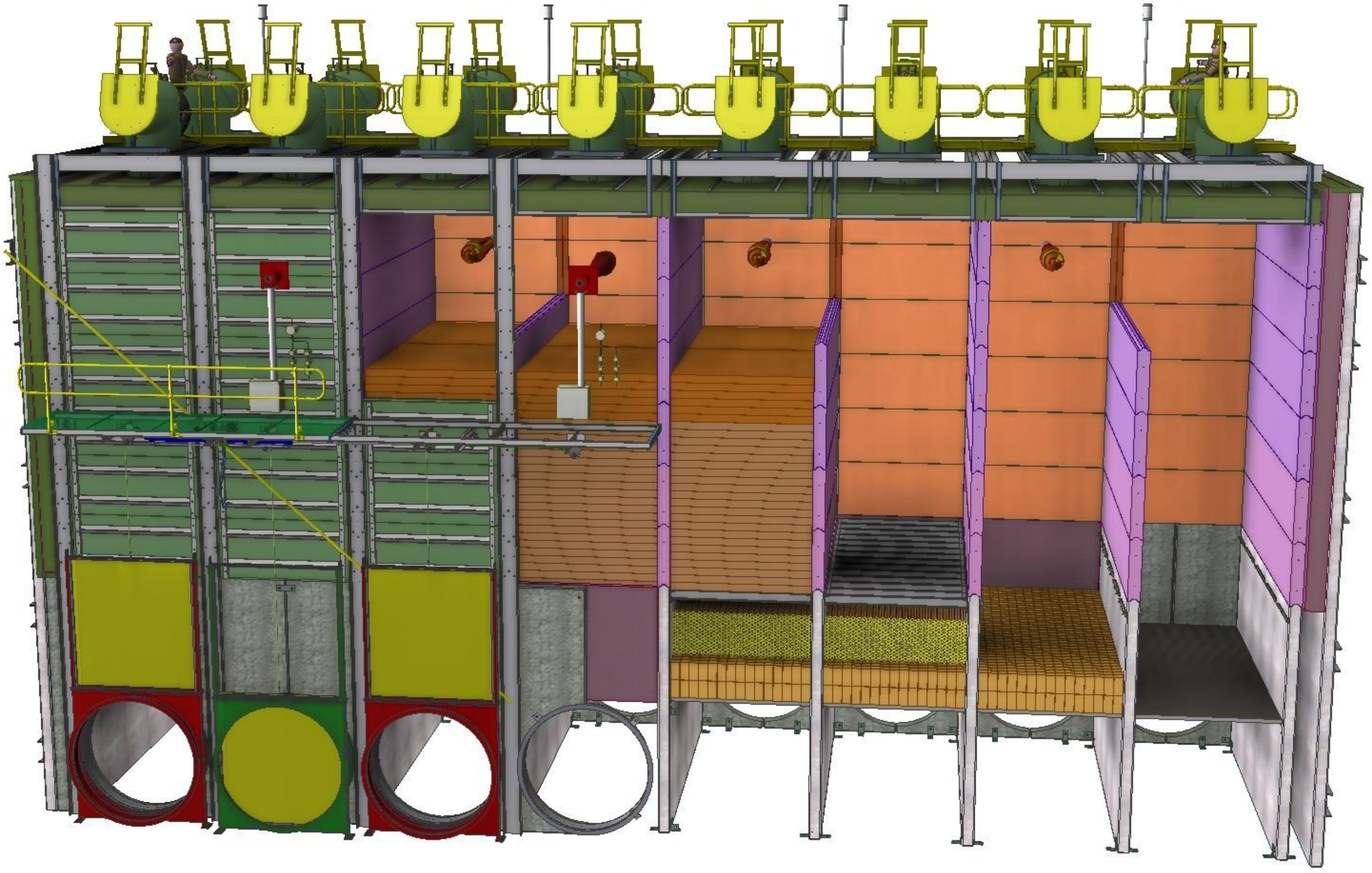
Physical Concept

Centennial Coal



Physical Concept

Centennial Coal



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:

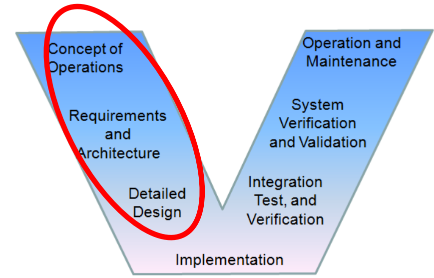
- Independent repetition of deflagration and venting experiments
- Design, test and exhibition of full scale safety duct off-site
- Move, test and exhibition of full scale safety duct on-site
- Design, test and exhibition of full scale RTO on site
- Close working relationship with University of Newcastle 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

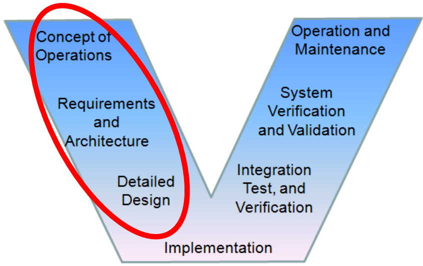
Risk Assessments

Detailed Design

Risk Assessments

Definition and documentation of Requirements Traceability Matrix

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

Meeting

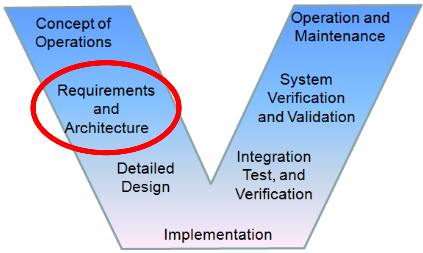
Preliminary Design Review by wider mining industry

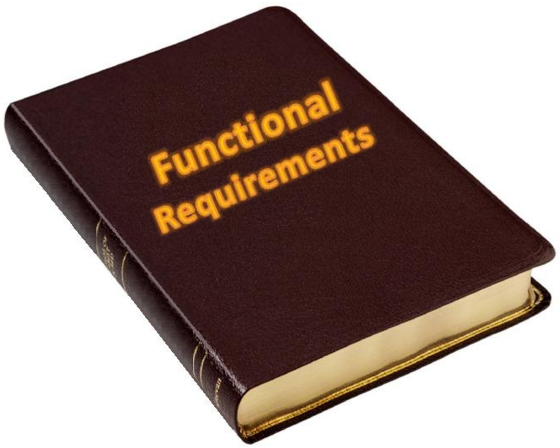
Functional Requirements

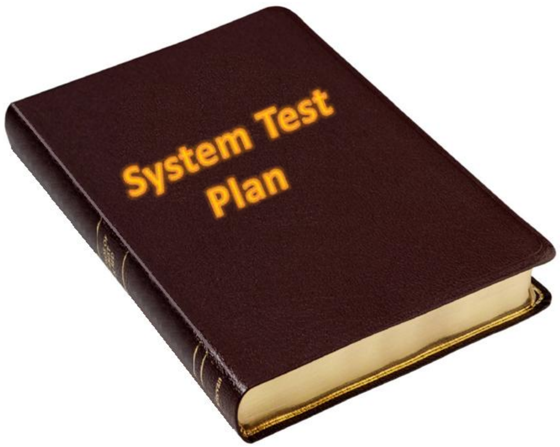
- Functional Requirements Document
- System Test Plan

Detailed Design

What Development Path?







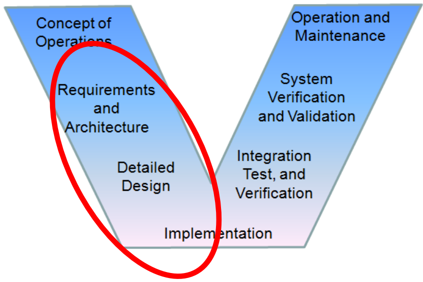
Meeting

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?



AS 61508
AS 61511

Functional Requirements

Meeting

Critical Design review by specialist acceptable to mining industry

Detailed Design

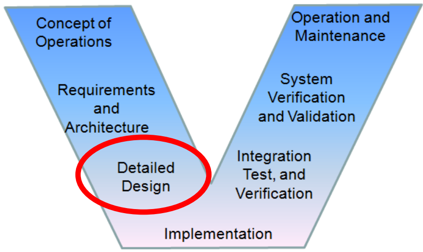
Risk Assessments

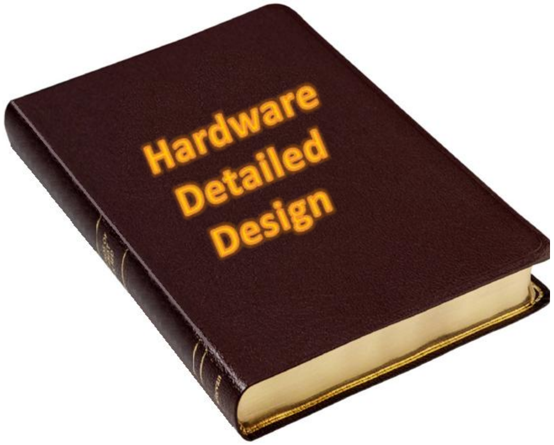
System / Subsystem Design Doc
- Hardware Detailed Design
- Software Detailed Design
- Drawings
- System Test Plan

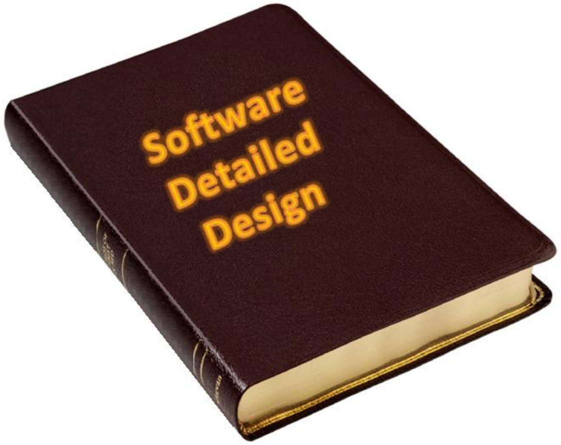
Amend Requirements Traceability Matrix

Implementation

What Development Path?



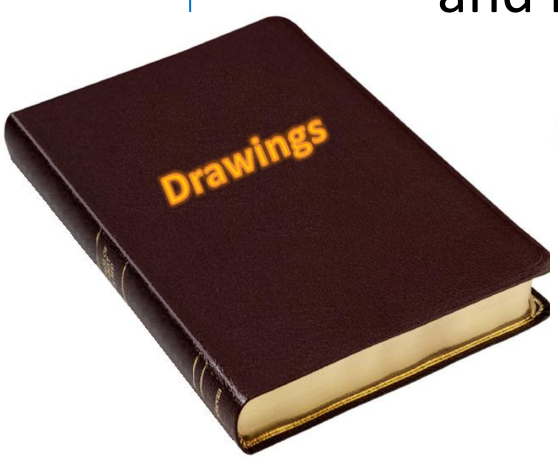


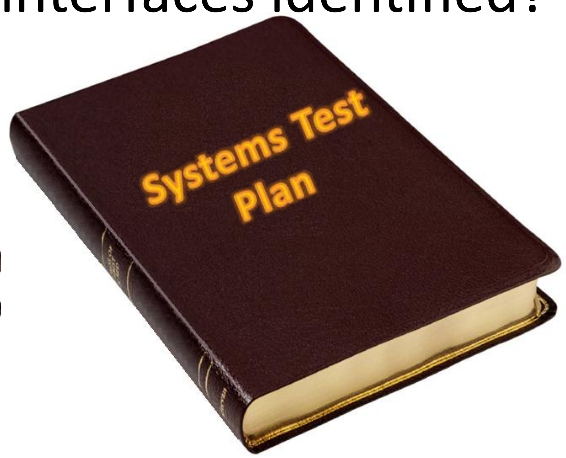


Purpose:
Have we shown how we will implement each function and sub function, are all functions allocated, with relationships and interfaces identified?

Meeting

Critical Design review by specialist acceptable to mining industry





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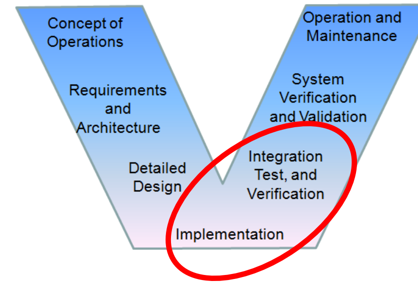


Detailed Design

Meeting

Test Readiness Review by specialists acceptable to mining industry

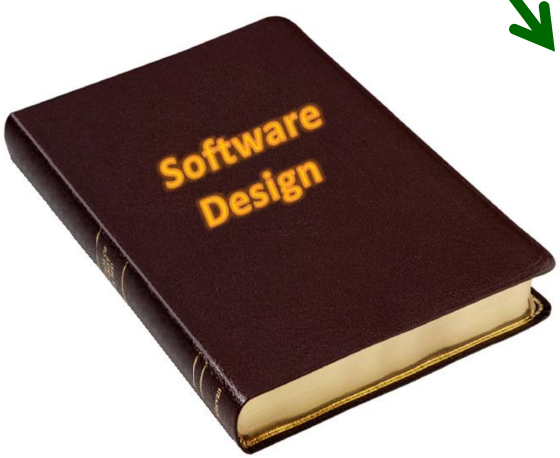
Risk Assessments

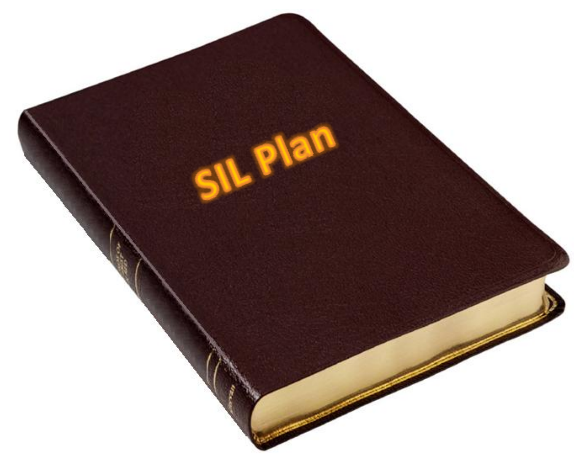
Integration test and Verification (physical plant)

Commission sub systems
SIL Tests
Factory Acceptance Test
Environment Assessments

Implementation

Software Design Doc
SIL Plan





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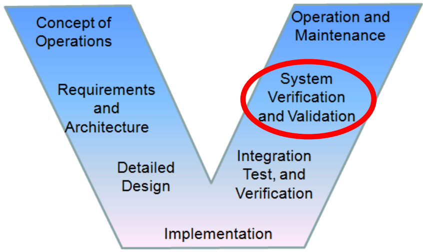
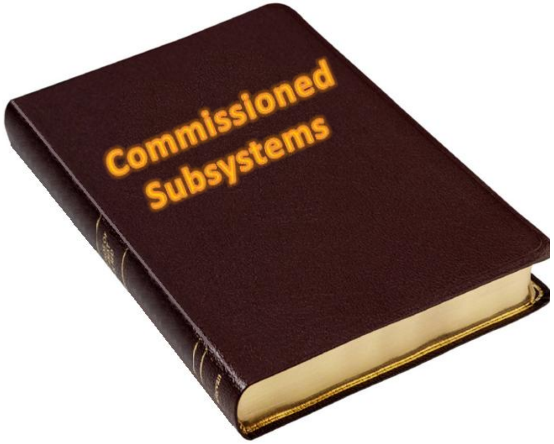
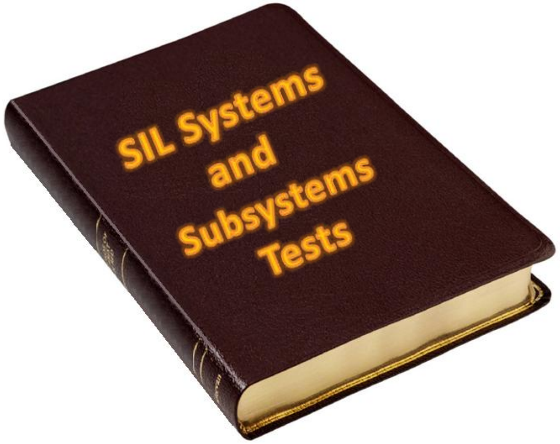




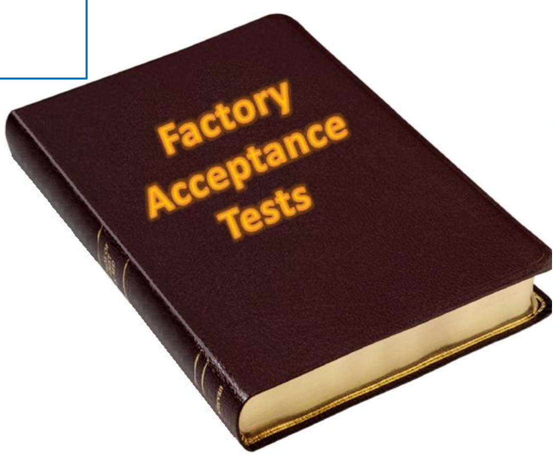


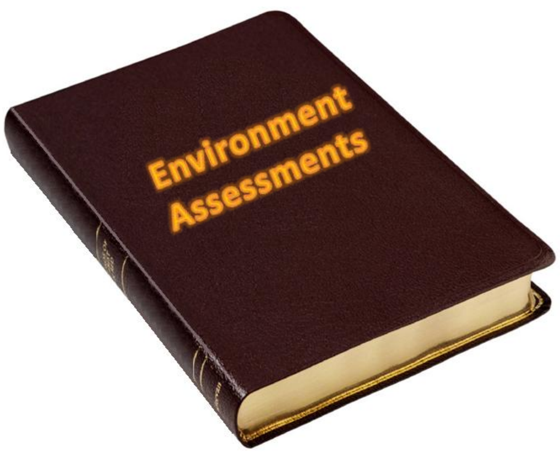
Purpose:

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

Operations and Maintenance

Operating results
Maintenance results
Project Close report

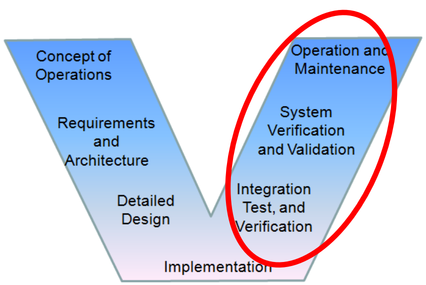
Meeting

Test Readiness review by specialist acceptable to mining industry

Risk Assessments

Systems Verification and Validation (physical plant)

Integration test and Verification (physical plant)



What Development Path?

Verification and Validation

Meeting

Systems Verification Review by specialist acceptable to mining industry

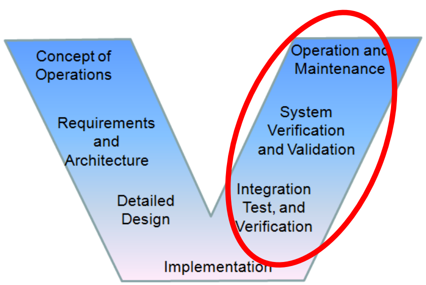
Operations and Maintenance

Operating results
Maintenance results
Project Close report

Verification and Validation

Systems Verification and Validation (physical plant)

Integration test and Verification (physical plant)



Other Stages

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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

Centennial Coal

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

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.