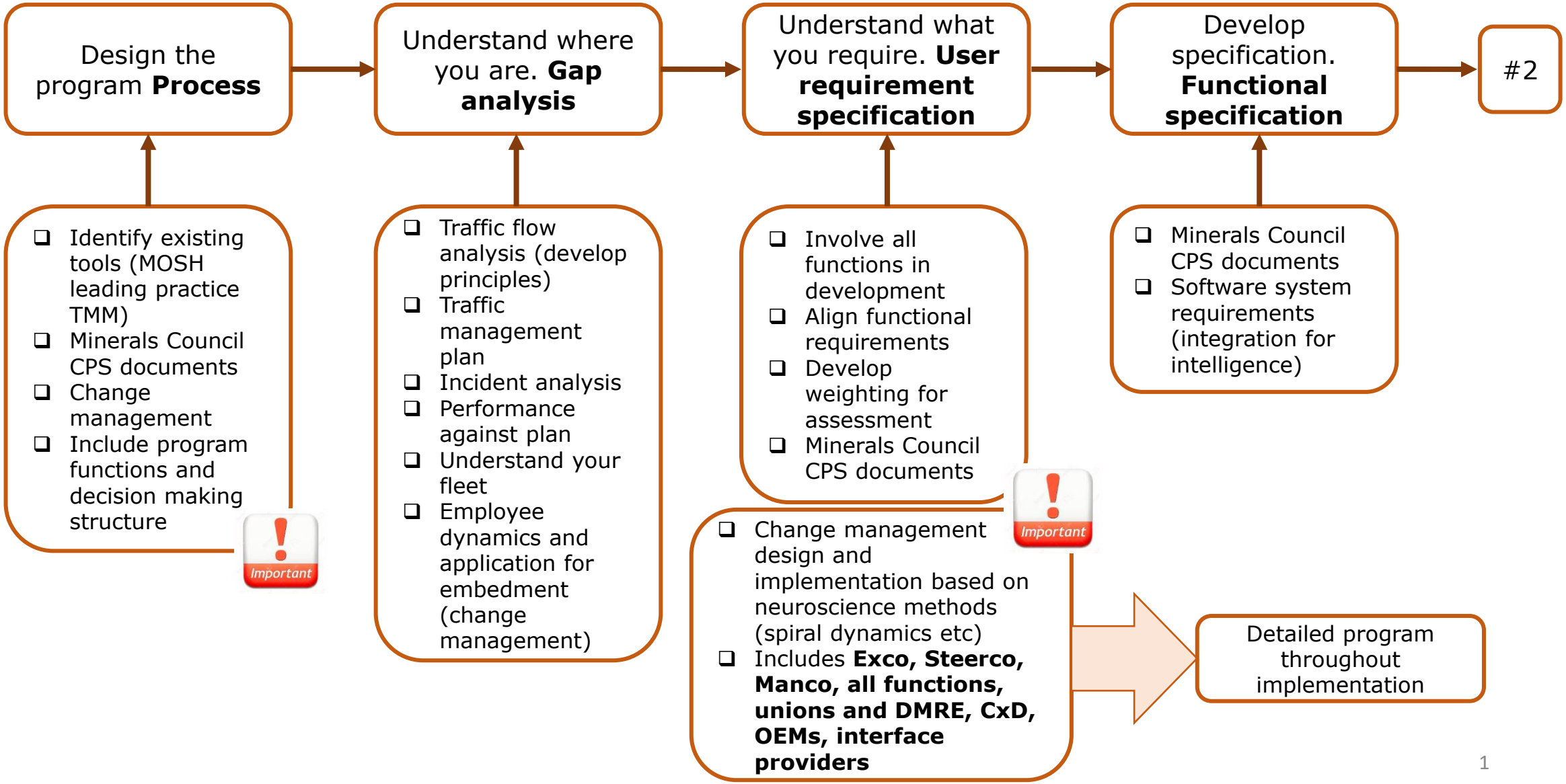
Case study lessons learnt: Get the basic process right #1



Case study lessons learnt: Get the basic process right #2

Understand the cost and timeframes. **Order of magnitude costs**

- ❑ Identify potential CxD providers
- ❑ Perform desk top study
- ❑ Issue Enquiry to CxD providers (Including SLA)
- ❑ Visit each CxD provider
- ❑ Check references and visit reference mines
- ❑ Issue enquiry to OEMs (including SLA)
- ❑ Testing costs
- ❑ Upgrade of lamp rooms etc

Create Exco (board) understanding . **CAPEX & OPEX**

- ❑ CAPEX and OPEX requirement and awareness
- ❑ Apply for test funding
- ❑ Process optimisation and plan finalisation

- ❑ Change management also includes the Board, Steerco, Manco etc
- ❑ Change management also includes OEMs, CxD providers and interface technology providers

Test against requirements. **Develop test procedure and test**

- ❑ Involve all functions in testing
- ❑ Minerals Council CPS documents
- ❑ Develop reports
- ❑ Selection of appropriate CxD technology and others (weighting, intelligent lamp room etc)

Final costing and implementation planning. Issue **RFQ (CAPEX and OPEX)**

- ❑ Award contracts and prepare for implementation

#3

- ❑ Changing technologies

Case study lessons learnt: Changing technologies #1

GOVERNMENT GAZETTE, 27 FEBRUARY 2015; DEPARTMENT OF MINERAL RESOURCES (No. R. 125); MINE HEALTH AND SAFETY ACT, 1996 (ACT NO 29 OF 1996) - REGULATIONS RELATING TO MACHINERY AND EQUIPMENT; Amendment of Chapter 8 of the regulations

8.10.1 The employer must take reasonably practicable measures to ensure that pedestrian are prevented from being injured as a result of collisions between trackless mobile machines and pedestrian. At any mine where there is a significant risk of such collisions, such measures must include at least the following:

8.10.1.1 **All electrically or battery powered trackless mobile machines**, excluding shovels, bucket wheel excavators and overburden drills, must be provided with means to automatically detect the presence of any pedestrian within its vicinity. Upon detecting the presence of a pedestrian, the operator of the trackless mobile machine and the pedestrian must be warned of each other's presence by means of an effective warning. In the event where no action is taken to prevent potential collision, further means must be provided to retard the trackless mobile machine to a safe speed where after the brakes of the trackless mobile machine are automatically applied without human intervention.

8.10.1.2 **All underground diesel powered trackless mobile machines** must be provided with means:

8.10.1.2(a) to automatically detect the presence of any pedestrian within its vicinity. Upon detecting the presence of a pedestrian, the operator of the diesel powered trackless mobile machine and the pedestrian shall be warned of each other's presence by means of an **effective warning**; and

8.10.1.2(b) in the event where no action is taken to prevent potential collision, further means shall be provided to retard the diesel powered trackless mobile machine to a safe speed where after the brakes of the diesel powered trackless mobile machine are automatically applied. The prevent potential collision system on the diesel powered trackless mobile machine must fail to safe without human intervention. Collisions between diesel powered trackless mobile machines

8.10.2 The employer must take reasonably practicable measures to ensure that persons are prevented from being injured as a result of collisions between diesel powered trackless mobile machines. At any opencast or open pit mine where there is a significant risk of such collisions, such measures must include:

8.10.2.1 **Every diesel powered trackless mobile machine** must be provided with means to automatically detect the presence of any other diesel powered trackless mobile machine within its vicinity

8.10.2.1(a) upon detecting the presence of another diesel powered trackless mobile machine, the operators of both diesel powered trackless mobile machines shall be warned of each other's presence by means of an **effective warning**; and

8.10.2.1(b) in the event where no action is taken to prevent potential collision, further means shall be provided to retard the diesel powered trackless mobile machine to a safe speed where after the brakes of the diesel powered trackless mobile machine are automatically applied. The prevent potential collision system on the diesel powered trackless mobile machine must "fail to safe" without human intervention

Currently partly on hold as per the below

The Regulations shall come into operation 3 months after the date of publication in the government gazette, with the exception of sub-regulations 8.10.1.2(b) and 8.10.2.1(b).

ADV N.A RAMATLHODI, MP
MINISTER OF MINERAL RESOURCES

Case study lessons learnt: Changing technologies #2

Understanding what the change entails

Always comply

No – Develop specific controls for changeover period

Application for exemption from Regulations

How do you comply with Regulations 8.10.1.2(a) and 8.10.2.1(a) during the changeover? (note: this includes legacy to new of same technologies)

Yes – carry on with implementation

- ❑ Risk assessment
- ❑ Hot spot analysis
- ❑ Pedestrian and vehicle tracking
- ❑ TMP updates
- ❑ Live risk management
- ❑ Extensive and intensive change management
- ❑ Extensive DMRE engagement

Important

Time

Important

Change management design and implementation based on neuroscience methods (spiral dynamics etc)

- ❑ Includes **Exco, Steerco, Manco, all functions, unions and DMRE, CxD, OEMs, interface providers**

Detailed program throughout implementation

Case study lessons learnt: Summary

- ❑ Follow a defined process
- ❑ Have you basics in place and working as intended
- ❑ Use available material (Minerals Council CPS documents)
- ❑ Implement a comprehensive change management program through all program phases based on proper neuroscience principles
- ❑ Know where you are and what you must do to fill the gaps
- ❑ Involve all functions throughout the implementation process (including DMRE, unions, CxD providers, OEMs)
- ❑ Each TMM is different – know what you have and the details of your fleet (auto retard, braking, safety features
- ❑ Allow sufficient time for company processes, CxD delivery and OEM upgrade times
- ❑ If you decide to change CxD technologies, beware you don't breach regulations
- ❑ This is a costly exercise.

Case study lessons learnt: Mine B visit to Mine A - Summary

Important background:

- CAS ecosystem (safe people, safe roads, safe vehicles)
- Human change management (limited)
- Mine engineering induced problems (VSD induced harmonics)
- TMM composition, health and investment approach (unintelligent fleet, non OEM alignment)
- Lamp room cap lamp management (access control with healthy lamp for shift)
- Effective warning (zone sizes)

Learnings from Mine B

- Ultra slow speed testing
- Emergency override
- Ultra slow speed up to crawl
- Dead spot analysis
- Testing RCA anomaly analysis (incidents have highlighted issues)
  - **Action from learnings:** Instituted urgent inclusion in testing

Mine B risks

- Effective warning compliance (zone sizes)
- Relay system (log keeping, fail to safe etc)
- Work methods
- CPS to solve engineering induced problems (lamp interference)
- Human change management

We learnt a lot from one another. We are immediately applying what we have learnt

Case study lessons learnt: Mine B visit to Mine A – Summary
Anomalies analysed

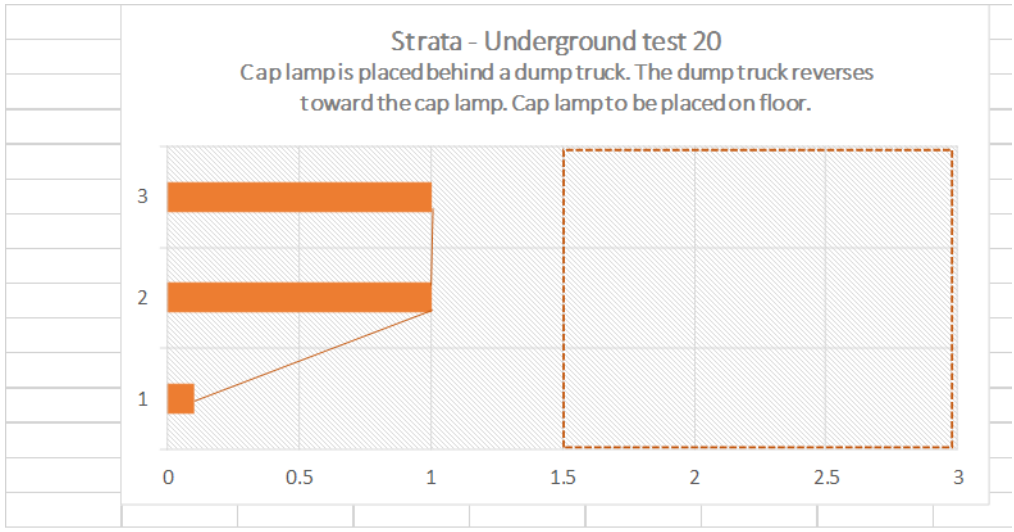
Good morning Z and X

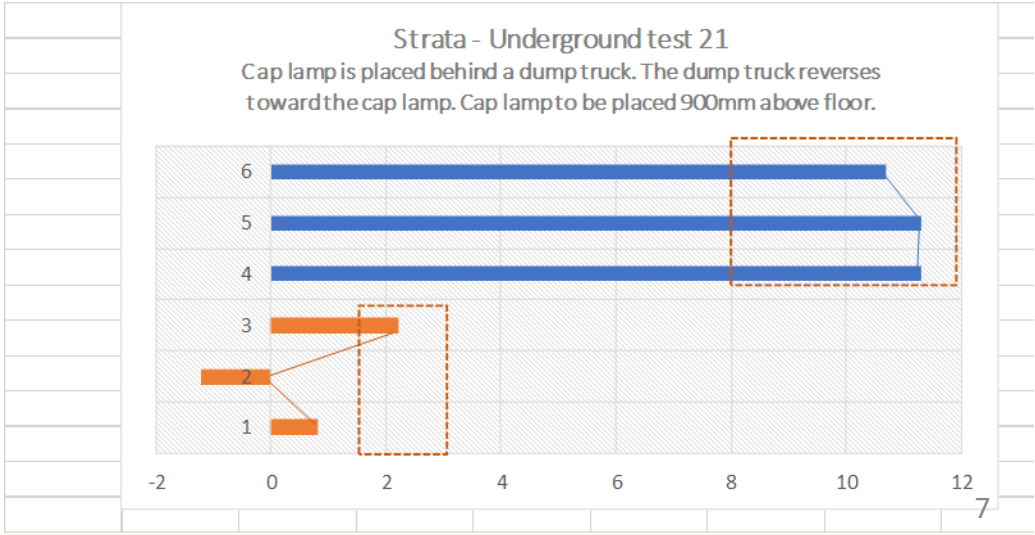
We went back and examined all the tests conducted during the CAS evaluation process in the last quarter of 2020. We focussed only on the underground testing and investigated all anomalies again.

Findings:

1. **Anomalies definition:** Something that deviates from what is standard, normal, or expected. In this instance, anomaly means a measurement that had a large variation from other measurements taken for the same test. (inconsistency, irregularity, deviation)
2. **Percentage anomalies:**
   a. **V-V:** of the 126 tests conducted, 6 tests had anomalies: **4,7%**
   b. **V-P:** of the 216 tests conducted: 5 tests had anomalies: **2,3%**
3. **CxD test score:** Actual test score was 90,2% pass against test criteria and adjusted to 82% when Mine A adjustment criteria was applied.
4. **Anomaly analysis:** of the 11 tests where anomalies occurred, the following was observed:
   a. All 11 involved a dump truck (Epiroc MT 42 - intelligent):
      i. **V-V:** Dump truck reverses to crawl pass LHD, Dump truck head on to Fermel crawl pass
      ii. **V-P:** Dump truck reverses to cap lamp on floor and at 900mm above floor. (note: this was exactly the same as what we observed during the Mine B visit) (see diagrams in 4. Below. Note: Test 21 blue lines indicate the auto retard zone)

5.





Case study lessons learnt: Mine B visit to Mine A - Summary Anomalies analysed

1. **Reasons for anomalies:**
   a. **V-V:** When field settings were adjusted, crawl was fairly consistent (note: we tested extensively after the tests and it was very difficult to gauge the exact distances at which the vehicle started to crawl. It was also very difficult to get the vehicles to run at consistent speeds prior to crawl)
   b. **V-P:** The placement of the proximity modules was changed and consistent stopping distances were achieved – we couldn't replicate the above anomalies (until the Mine B visit in the morning)
2. **Follow up actions:**
   a. 5 b. above is of particular concern to us. We have repeatedly tested the BEVs since the Mine Bvisit and we haven't driven over a cap lamp at all speeds (including <1km/hr) in reverse.
   b. We have instituted dead spot analysis as you do at Mine Band we have picked up some very small dead spots on some TMMs. This has been corrected.
   c. We have instituted a CxD provider technical team (USA, RSA, Europe and Australia) sharing meeting monthly to go through our issues log and share with other CxD provider clients our issues for resolution.
   d. CxD provider cap lamp interference: We are performing extensive tests with CxD provider in their laboratory in this regard and will give feedback.
   e. Engineering Change management: Rigorous Engineering Change Management procedure is being enforced and included in SLA contracts etc.

Case study lessons learnt: Mine B visit to Mine A – Notes to support slides #1

Important background:

- ❑ CAS ecosystem (safe people, safe roads, safe vehicles)
  - CAS is an ecosystem. Tackling any one of the ecosystem silos and not focussing on the entire ecosystem will result in a partial implementation and expose mines to increased risks: safety, production, financial)
  - Building blocks of the ecosystem include effective upskilling of local resources, effective brake and steering system maintenance, effective SLAs for lamp room operation and safety equipment maintenance etc
  - Must be measurable
- ❑ Human change management (limited)
  - Must be neuroscience based and site specific
  - Must be leader led and experiential based (to do in a safe environment)
  - Multiple small interventions where people work
  - Must be measurable
- ❑ Mine engineering induced problems (VSD induced harmonics)
  - You cannot solve mine engineering induced problems with CAS. Typically problems such as EMI induced problems from harmonics generated by VSD cannot be accommodated in CAS.
- ❑ TMM composition, health and investment approach (unintelligent fleet, non OEM alignment)
  - TMM fleet composition and health of fleet must be understood and documented (serial numbers, machine composition, maintenance history, machine lifecycle management, intelligent versus unintelligent etc)
  - Every mine has an investment approach. Some mines opt for run to destruction, some mines opt for total hours, fuel through machine etc. This also holds true for CAS (stick with current and make it work etc)
- ❑ Lamp room cap lamp management (access control with healthy lamp for shift)
  - Critical to ensuring that cap lamps are healthy (proper voltage and capacity for double shift) are controlled access turnstiles that prevent access to the shaft without auto checking health of lamp (and other safety equipment)
- ❑ Effective warning (zone sizes)
  - The CPS legislation mandates the requirement for effective warning to be given to both the operator and pedestrian. Zones sizes must therefore allow for this (2,5 seconds response times etc)

Case study lessons learnt: Mine B visit to Mine A – Notes to support slides #2

Learnings from Mine B

- ❑ Ultra slow speed testing
  - Because of work methods used in underground coal mining, Mine B does testing at very low speeds (<1km/hr). Mine A lowest test speed is 3km/hr. One anomaly was detected at very low speeds which wasn't in the original testing regime.
- ❑ Emergency override
  - Mine B allows for operator override whereas Mine A only allows for authorised override (Both CxD and TMM). The reason for Mine B allows operator override is to remove the machine if machine has pinned someone to the side wall or trapped under a wheel.
- ❑ Ultra slow speed up to crawl
  - Mine A machines have dynamic zones with a auto retard zone crawl speed of 3km/hr. When a machine is travelling at 1km/hr or lower and a pedestrian walks into the auto retard zone the machine receives an instruction to crawl and then increase speed to 3 km/hr.
- ❑ Dead spot analysis
  - Mine A does dead spot analysis based on 12 points around the machine but only by walking into the machine checking for dead spots. Mine B walks around the machine and at many different points lowers the cap lamp to the floor and raises it, exposing any dead spot, no matter how small. This adds an 1,5 hours to each test and commissioning.
- ❑ Testing RCA anomaly analysis (incidents have highlighted issues)
  - During testing any anomaly detected must be fully investigated (see summary anomalies analysed slide 7 and 8)

- ❑ **Action from learnings:** Instituted urgent inclusion in testing (see slide 8)

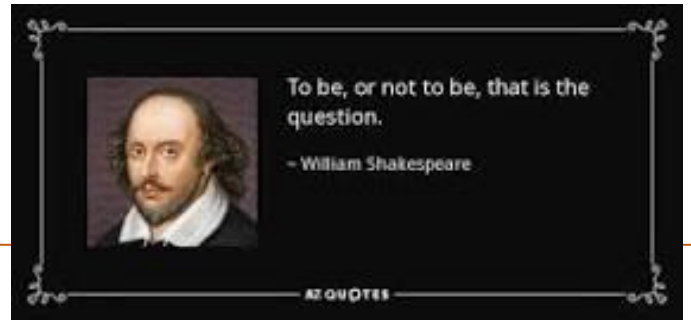
Case study lessons learnt: Mine B visit to Mine A – Notes to support slides #3

Mine B risks

- ❑ Effective warning compliance (zone sizes)
  - Mine B zones sizes do not allow for effective warning of both operator and pedestrians (static zones and not 2,5 second response time allowance.)
  - Mine B will have to approach the DMRE for exclusion from this part of the legislation.
- ❑ Relay system (log keeping, fail to safe etc)
  - We are not sure if you can have 10Hz data logging, time stamping and fail to safe with the current Mine B system.
- ❑ Work methods
  - Work methods induce V-P interactions and these work methods (outbye etc) have not been analysed to see how level 1-6 controls can be implemented.
- ❑ CPS to solve engineering induced problems (lamp interference)
  - A thorough EMI study must be conducted to find the root cause of the harmonics generated and solve the root cause of the EMI.
- ❑ Human change management
  - A properly designed human change management approach must be implemented using neuroscience methods to ensure delivery.
- ❑ Mine B business model
  - The Mine B business model and TMM life cycle management does not lend itself to upgrading of machines and an ISO 21815-2: 2021 interface. A revised function specification and testing regime will have to be compiled to support this business model.

Case study lessons learnt: Importance of independent verification

- **Definitions**
  - **Verification:** The process of establishing the truth, accuracy, or validity of something. The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition.
  - **Validation**: The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders.
  - **Quality system applicability:** These are critical components of a quality management system such as ISO 9000. The words "verification" and "validation" are sometimes preceded with "independent", indicating that the verification and validation is to be performed by a disinterested third party.
  - **Oversight:** A mistake made because of a failure to notice something (do not know what you do not know). Responsibility for a job or activity and for making sure it is being done correctly. This would be the minimum requirement for "Reasonably practicable". If a mine is confident that internal oversight can eliminate reasonably practicable mistakes (have the CPS ecosystem competence"), then this can be performed by an internal function.
- **Verification, validation and oversight CPS "ecosystem" applicability**
  - Both independent verification and validation are applicable for all control levels 1 -9.
  - Independent verification is applicable for TRL 4. (testing)
  - Both independent verification and validation are applicable for TRL 6, 7, 8 and 9 with validation being extremely important in operational CPS.
  - Oversight is applicable to all control levels and TRLs.
- **Mine decisions / questions**
  - Verification, validation or oversight…….that is the question!
  - Independent or disinterested third party involvement.
  - Legal exposure / risk: have I done everything reasonably practicable….?



Case study lessons learnt: Importance of independent verification

❑ CPS sources available

- **Global and local fora:** There are many global fora available for mine involvement.
- **Global documents:** EMESRT etc
- **Minerals Council CPS documents**: These are available on the MOSH web site.
- **Learnings from SAMI:** Critical to ensuring that other mining experiencers in the CPS ecosystem are incorporated into your verification and validation - "you don't miss something".
- **Learnings from people who have done it:** Verification, validation and oversight disinterested third parties.
- **Accidents or incidents:** Critical in validation (ongoing testing – have we missed something?)

❑ So, what have we learnt?

- The above sources understanding and applicability are essential to effective and efficient CPS implementation and operationalisation. Do we have the competence and time "in house" to perform validation, verification and oversight?
- Our legal liability is reduced if we have been reasonably practicable in the verification, validation and oversight.
- Disinterested and competent third party involvement gives assurance that reasonably practicable steps have been taken to ensure that the CPS (CxD and TMM) basics are in place.
- Edge cases can then be included as found and informed by SAMI learnings.

- Beware of anomalies!