NSW Department of Trade & Investment
Electrical Engineering Safety Seminar
5th - 6th November 2014

When SIL2 Will Just Not Do !

Presented by
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Overview

- A retrospective overview of the use of the functional safety approach in mines since 2006.
- Focussing on three (3) common implementation pitfalls:

1. By-passing the process.
2. Inadequate specification of safety requirements.
3. When SIL2 will just not do.

- And briefly, two (2) knowledge / competence issues:

1. The root of all confusion.
2. The elephant in the training room.

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By-passing the Process

The Case of the Lost Opportunity

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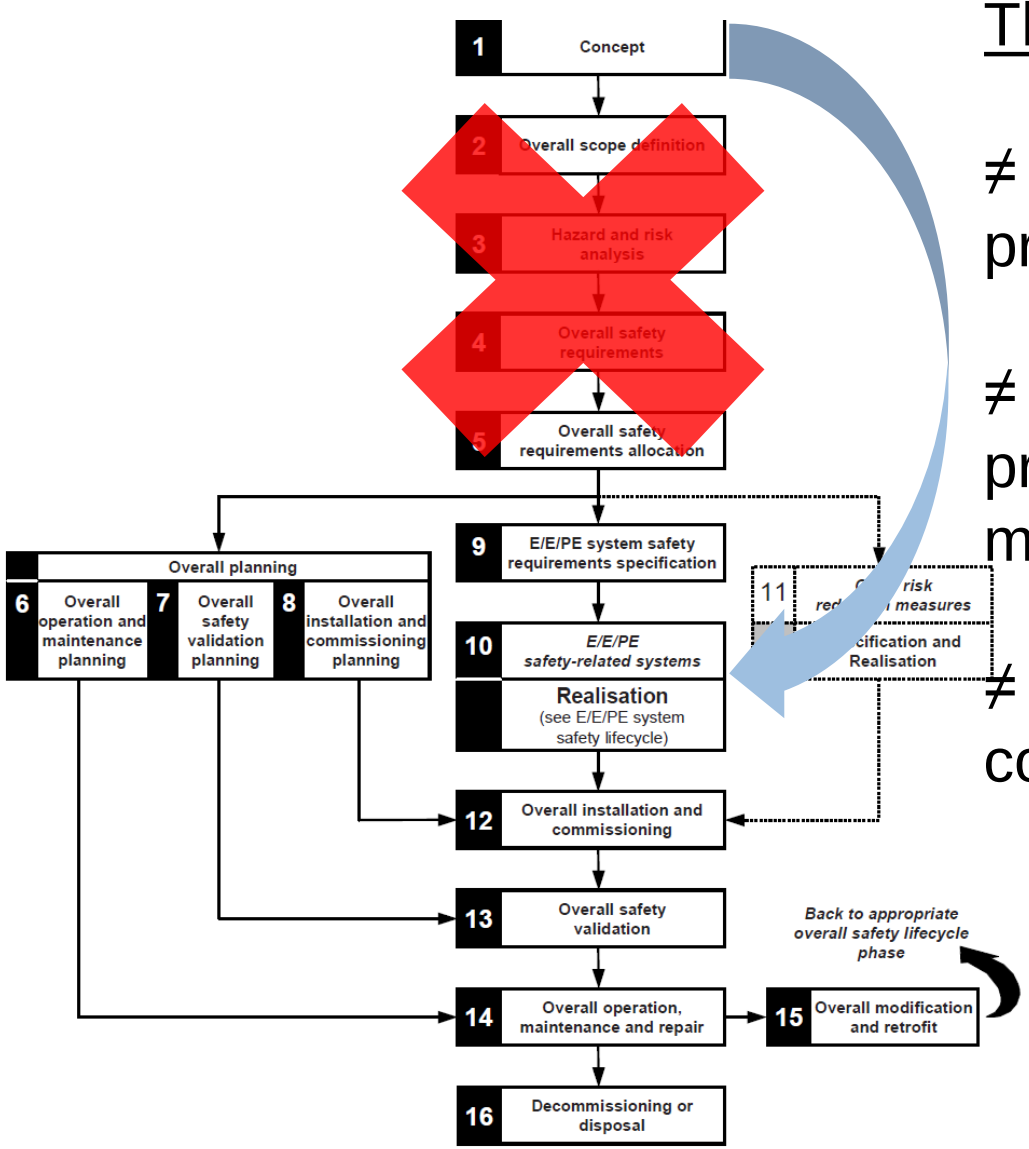

<u>The by-pass flick-pass:</u>

≠ The supplier shall provide a SIL2 E-Stop…

≠ The supplier shall provide a SIL2 machine…

≠ The supplier shall comply with AS61508...

The Case of the Lost Opportunity

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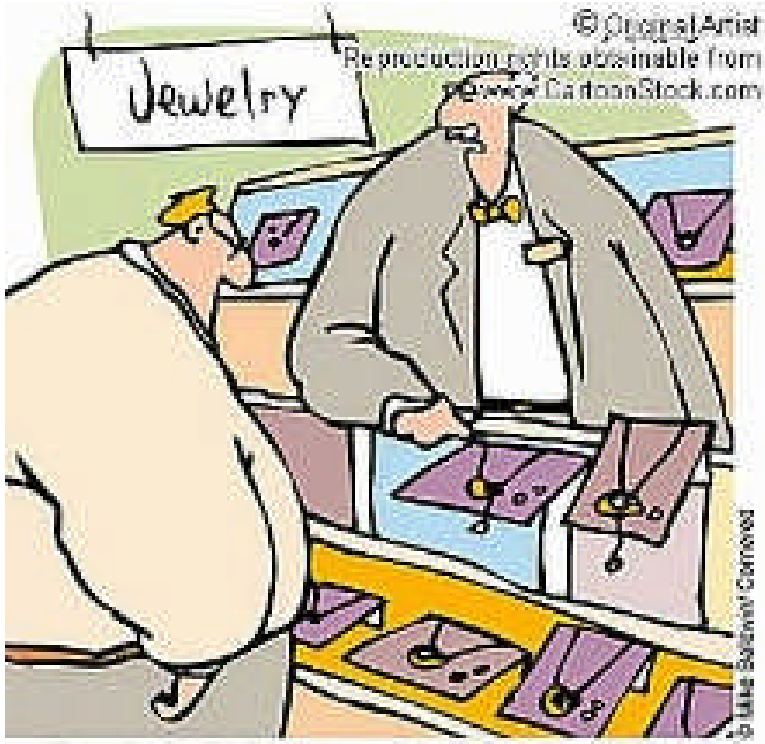
The upside:

- Less time / cost / effort / inconvenience.

The downside:

- Insufficient and / or ineffective risk controls selected.
- Inadequate specification of safety requirements.
- Supplier either ‘gold-plates’ the machine or makes a token effort, depending on their contract terms.
- Level of safety assurance is open to question.



"Too pricey? Perhaps you wish to see something in macaroni and spray paint?"

The Case of an Ineffective Control…

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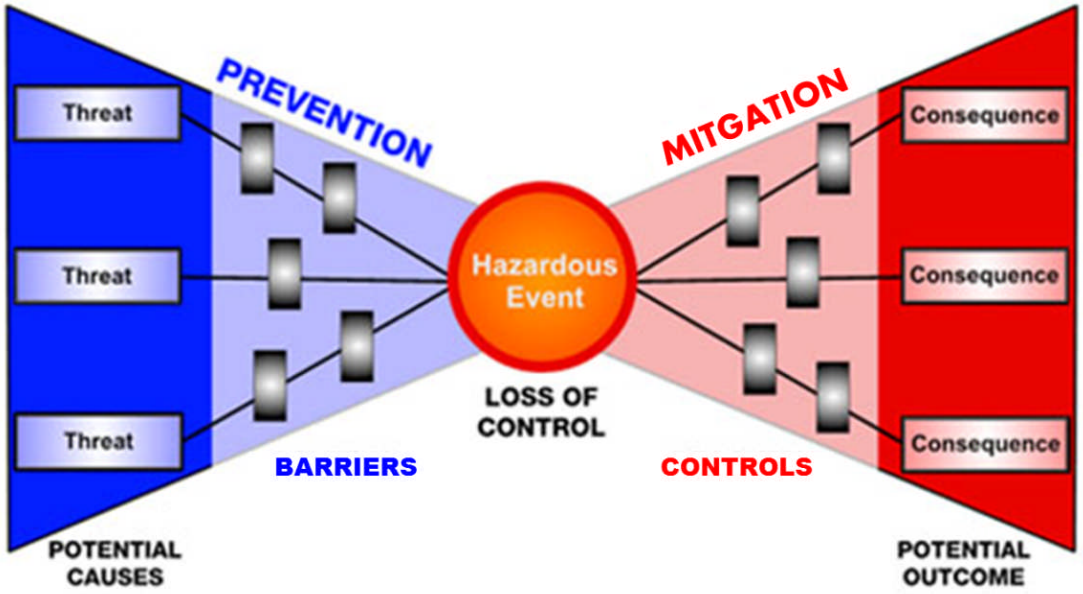
What is a risk control…….?

- Think of the 'Bowtie'.



- The function of a risk control is to stop the accident sequence (ie. arrest it), or to deviate its propagation to a less severe consequence (ie. deflect it).

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What is a risk control…….?

- A **tangible / physical object or system**, which **of itself**, arrests/deflects an unwanted event.
  - May be passive (eg. guarding) or active (eg. proximity detection).
  - May be automatically operated (eg. fire suppression) or rely upon a human act to operate (eg. emergency brake).
- A **human act** (eg. behaviour or response to stimuli), which **of itself**, arrests/deflects an unwanted event.
  - May be derived from the contents of a procedure, training or experience about what is expected of a person in a given situation.
  - Can often be described using a verb / noun pair.

eg. obey speed restrictions, isolate electrical supply, apply emergency brake, wear safety glasses, drink water.

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What is not a risk control…….?

- A control is often supported by things which help assure its reliability, potency, robustness etc…, but sometimes these things are mistaken as being controls too.

- But, of themselves, they do not arrest/deflect an unwanted event.

eg. training,
procedures.
competency assessment.
a maintenance task.
common-sense.
a prayer.

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What is control effectiveness…2P4R ?

- **Pro-active** – prevent the unwanted event, rather than control the consequences.
- **Potent (ie. efficacy)** - technically capable of arresting or/ deflecting the accident sequence without imposing additional risk.
- **Responsive** – in place, or operates within sufficient time.
- **Robust** – can cope with changes to the operating environment.
- **Realistic** – value for money, simple, with ease of legacy.
- **Reliable** – high probability of successful operation.

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What is control effectiveness…ESMA?

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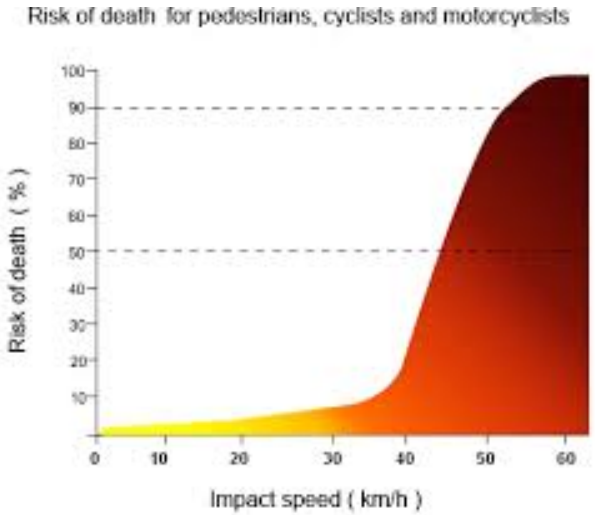
Evidence-based



Specifiable

Measureable

Auditable

But….back to those pesky E-Stops…

- NSW / QLD WH&S Regulation Cl.191.2.(c).

"…cannot be adversely affected by electrical or electronic circuit malfunction".

- Hierarchy: Act > Regulation > CoP > Standard > Guideline
- Must be complied with regardless of E-Stop effectiveness or SIL allocated.
- So far as is reasonably practicable?
- Effective use of scarce financial resources?

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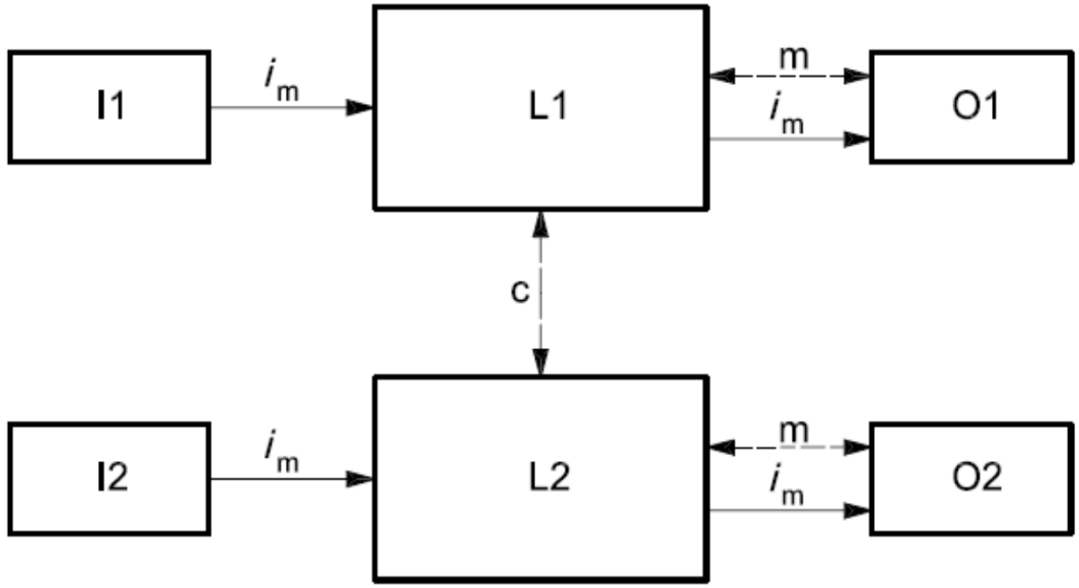
A Solution…..

- Determine if / when any E-Stop is an effective control.
- If it is, determine a SIL requirement for it - design for fault tolerance regardless of the SIL required.
- If not, design for fault tolerance anyway.



Refer ISO13849-1 Section 6.2.6 (now in AS4024.1503).

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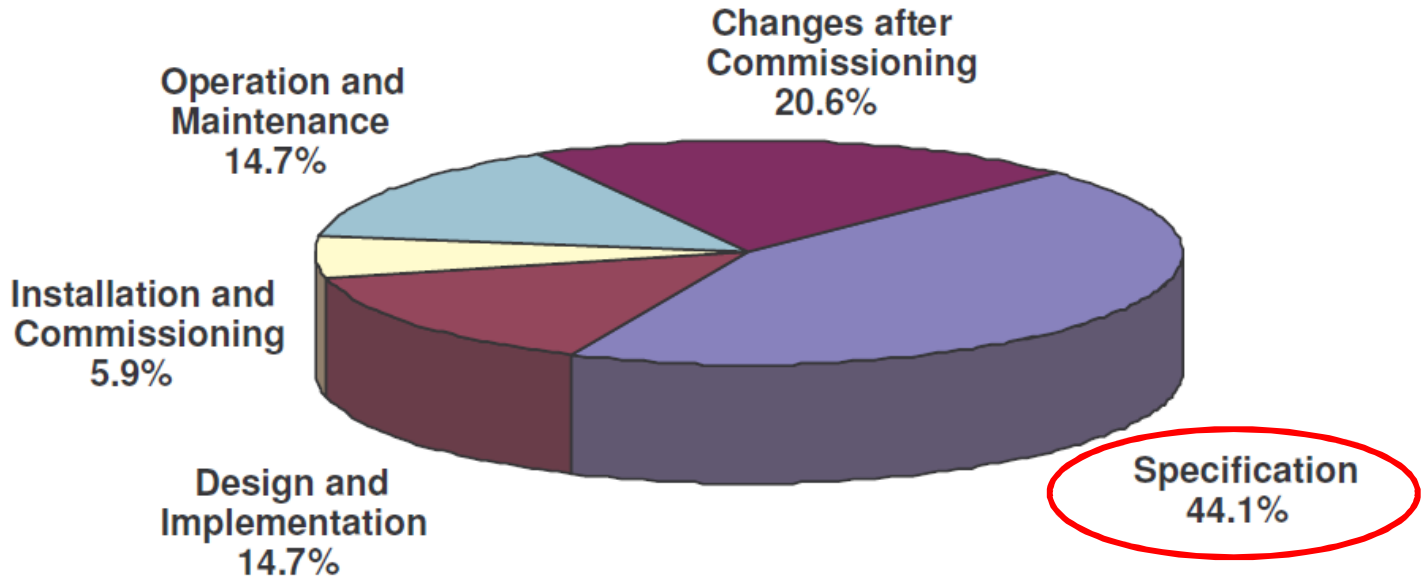
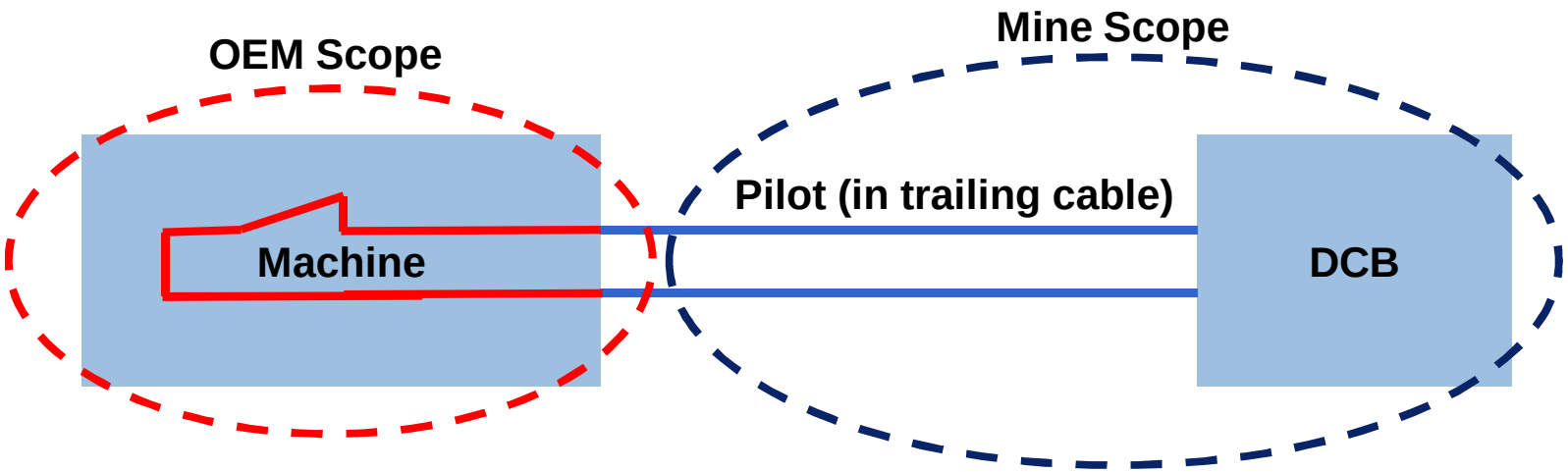
Inadequate Specification of Safety Requirements



The Case of the Pilot Circuit

- Safety functions utilising the pilot circuit of the machine require consideration of on-board and off-board parts.
- OEM → On-board parts (eg. pushbutton, etc…)
- Mine → Off-board parts (eg. cable, DCB, etc…).
- What happens if the mine passes responsibility to the OEM to meet a SIL but does nothing itself?



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The Case of the Vent Fan Inter-trip

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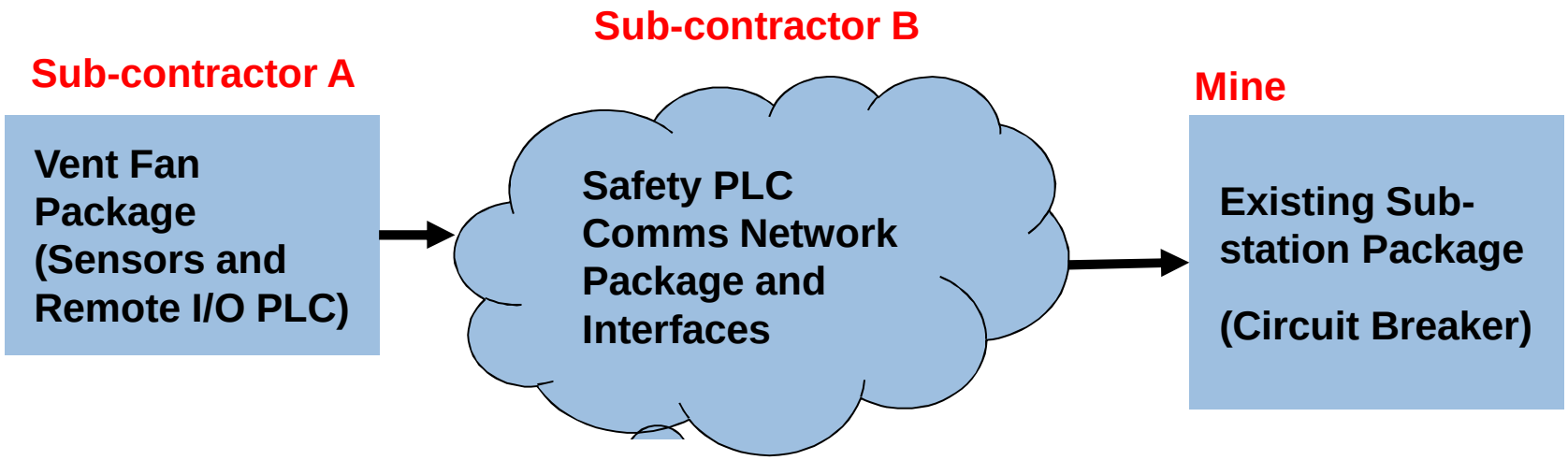
Someone needs to have overall control of system specification, verification and integration.

- Subcontractor A (less experienced) delivered SIL2 sensors and a SIL1 network interface.
- Sub-contractor B (experienced) delivered a SIL3 capable comms network, network and sub-station trip relay interfaces.
- The mine (inexperienced) used a legacy sub-station with a single shunt trip.



An Exception to the Rule…?

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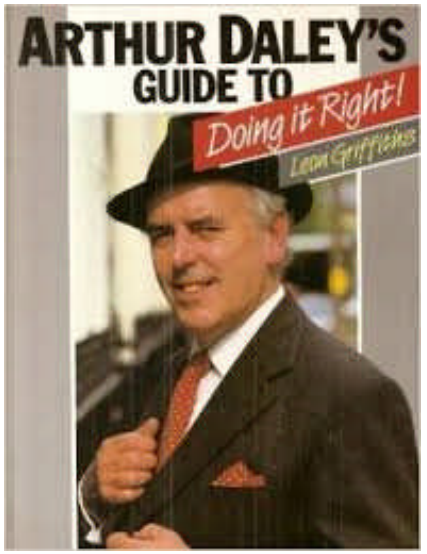
- Safety lifecycle problematic for high volume / commercial off-the-shelf (COTS) equipment. eg. mine haul truck.



- **User focussed compliance approach**
  - Requirements based on user's actual use and environment.
  - Risk-based approach – subjective.
  - OEM receives many user-based safety requirements specifications.
  - Does any customer or corporation have sufficient market power?
  - OEM can't / won't meet requirements → after-market mods?
- No easy answer but an **OEM-focussed compliance approach** for high volume / COTS would help. eg. car industry ADR's & ANCAP, EU Machinery Directive.

The Case of the OEM's Intended Use

- An OEM should analyse, specify safety requirements and design on the basis of reasonably foreseeable use and misuse.
- This should include functional safety requirements.
- Use AS62061 or ISO13849 (< 200 pages)

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The Case of User's Actual Use

- The OEM's analysis, specification and design provides a baseline for further consideration by end-users.
- Confirm it meets the actual / intended user requirements.

- If not, modify the safety requirements.

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When SIL2 will just not do!

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Remote Isolation – The SIL2 Safety Catch….

NSW Mines Work Health and Safety Regulation 2014 (Public Consultation Draft), Clause 33:

(1)(m)…. that any electrical safeguards provided to control the risk from both electrical and non-electrical hazards have a safety integrity ***sufficient*** *for the level of risk being controlled,*

- People in the line of fire if remote isolation fails.

- Remote Isolation Systems need proper consideration – tasks, exposure of workers, other safeguards, ability to escape etc….

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What is SIL2? Is it sufficient?

- Probability of Dangerous Failure Per Hour (PFH) < 0.000001.
- MTBF (dangerous) = 1 / PFH = 1,000,000 hrs = 114.2 yrs.
- If the life of mine (LoM) is 20 yrs, the likelihood of a dangerous failure at some time is up to **16%**
- A SIL2 Remote Isolation System **may** fail at some time during the life of a mine.
- What happens next? – Who is exposed? What other controls are in place – alarms, back-up trips etc…? Time to escape?
- Worst case: 16% LoM risk of death → tolerable, sufficient?

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What SIL is “sufficient”?

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- SIL1 up to 83% likelihood of dangerous failure in 20 yr LoM.
- SIL2 up to 16% likelihood of dangerous failure in 20 yr LoM.
- SIL3 up to 1.7% likelihood of dangerous failure in 20 yr LoM.
- SIL4 up to 0.2% likelihood of dangerous failure in 20yr LoM.

- **Is SIL3 sufficient, SIL4…?**
- **….Should we be using remote isolation?**
- **….How does this compare to the reliability of a human-based, manual isolation?**

But what SIL is a Person?

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- Assume ~3 isolations per day.
- ie. ~1000 per yr or ~20,000 during 20yr LoM.
- How reliably is manual isolation performed?

- **What error rate is realistic for a human?**
- 1-in-10 → 2000 errors in 20yr LoM
- 1-in-100 → 200 errors in 20yr LoM
- 1-in-1,000 → 20 errors in 20yr LoM
- 1-in-10,000 → 2 errors in 20yr LoM
- 1-in-100,000 → 0.2 errors in 20yr LoM

But what SIL is a Person?

- Assume ~3 isolations per day, or ~1000 per yr.

- SIL1 → < 1-in-11,400, per isolation → <2 errors in LoM.
- SIL2 → < 1-in-114,000, per isolation → <0.2 errors in LoM
- SIL3 → <1-in-1,140,000, per isolation.
- SIL4 → <1-in-11,400,000, per isolation.

- **Even SIL1 is probably better than a human !**
- **….Does this mean that humans should not be doing manual isolations where a SIL-rated remote isolation system is known, available and suitable?**

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A 'Reasonably Practicable' Solution…..

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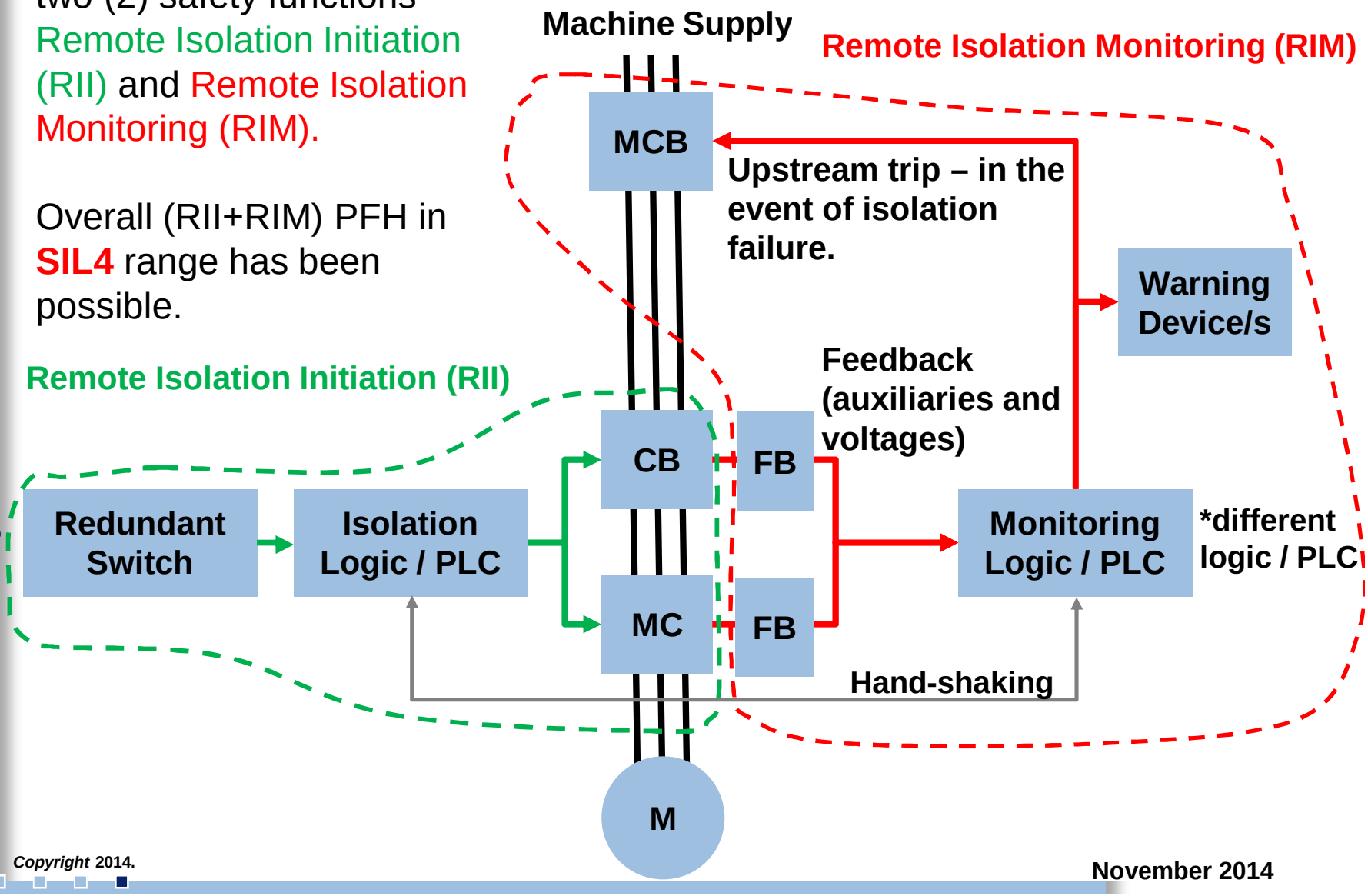
Segregate the system into two (2) safety functions - Remote Isolation Initiation (RII) and Remote Isolation Monitoring (RIM).

Overall (RII+RIM) PFH in **SIL4** range has been possible.



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The Root of All Confusion

The Rules Get Made By Those Who Turn Up!

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- AS61508 has 8 parts and ~600 pages !
- AS62061 has 1 part and ~100 pages !
- AS61511 has 3 parts and ~200 pages !
- ISO13849 has 2 parts and ~200 pages !
- AS4024.1 now has 27+ parts and ~900+ pages !
- **These numbers are increasing…..**

- Only AS61508 covers all lifecycle phases.
- Only ISO13849 covers all technologies.
- Numerous schemes for describing and determining safety integrity.
- Conflicting terms and definitions.
- Differing methods for designing, verification, documentation etc…

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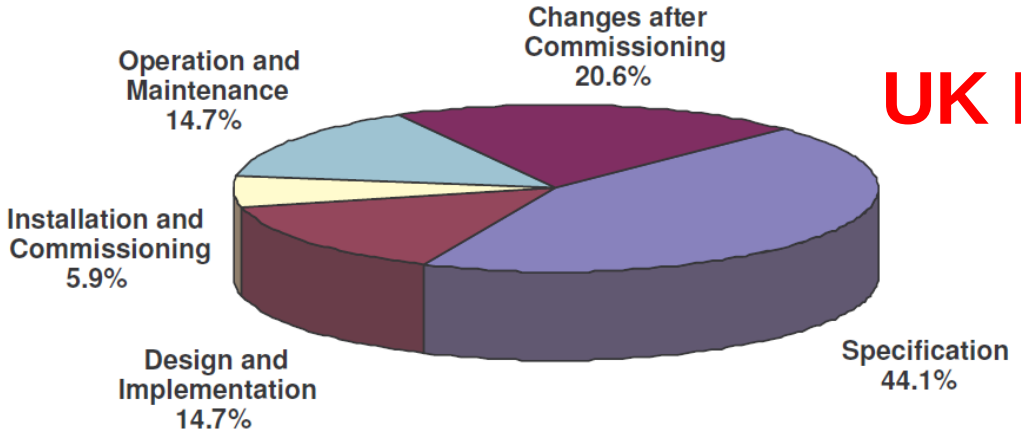
The Elephant in the Training Room

Nertney...Competent People...Safe Practices!



UK H&SE Study

- 58.8% incidents caused during engineer-dependent phases.
- 41.2% incidents caused during technician-dependent phases.
- Training and certification for FS Engineers, but not for technicians?
- Coming in 2015…Marcus Punch Pty. Ltd. in co-operation with TÜV Rheinland…FS Technician certification for the mining industry!

http://**www.tuvasi.com**/en/trainings-and-workshops/tuev-rheinland-functional-safety-program/tuev-rheinland-fs-technician/trainings/181-marcus-punch

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