Energise to trip?
De-energise to trip?

Simple Choice?

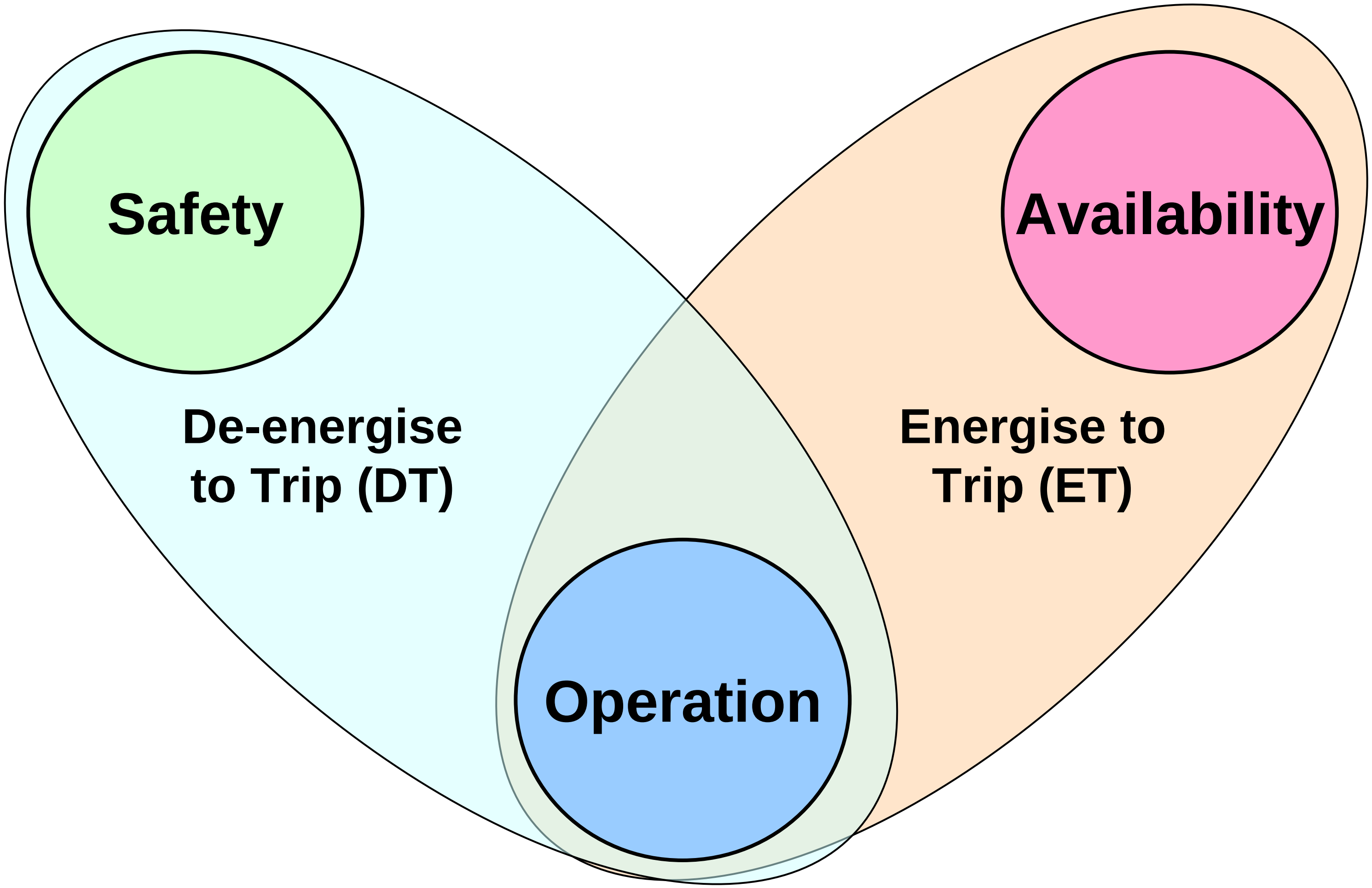
Tony Foord & Colin Howard
www.4-sightConsulting.co.uk
+44 (0)1 582 462 324

Examples

Overview

- Available guidance
- Why do trip systems fail?
- Trip system issues
- System failure modes
- 3 examples
- Architecture and Spurious trip frequency
- Diagnostics and Reverse acting transmitters
- References
- Conclusions

Traditional Choices



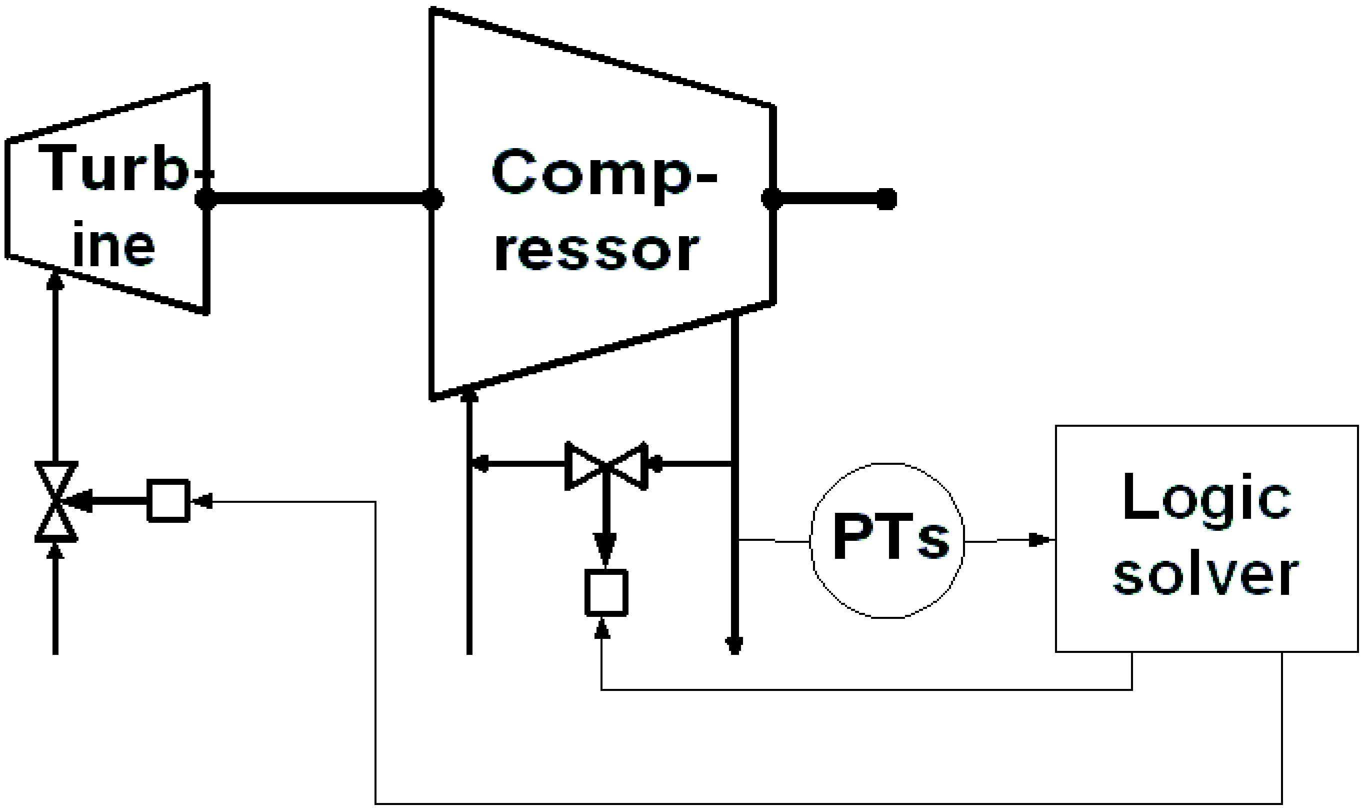
Available Guidance

- Very little specific guidance published
- One or two paragraphs only
    - Concentrate on “fail safe”

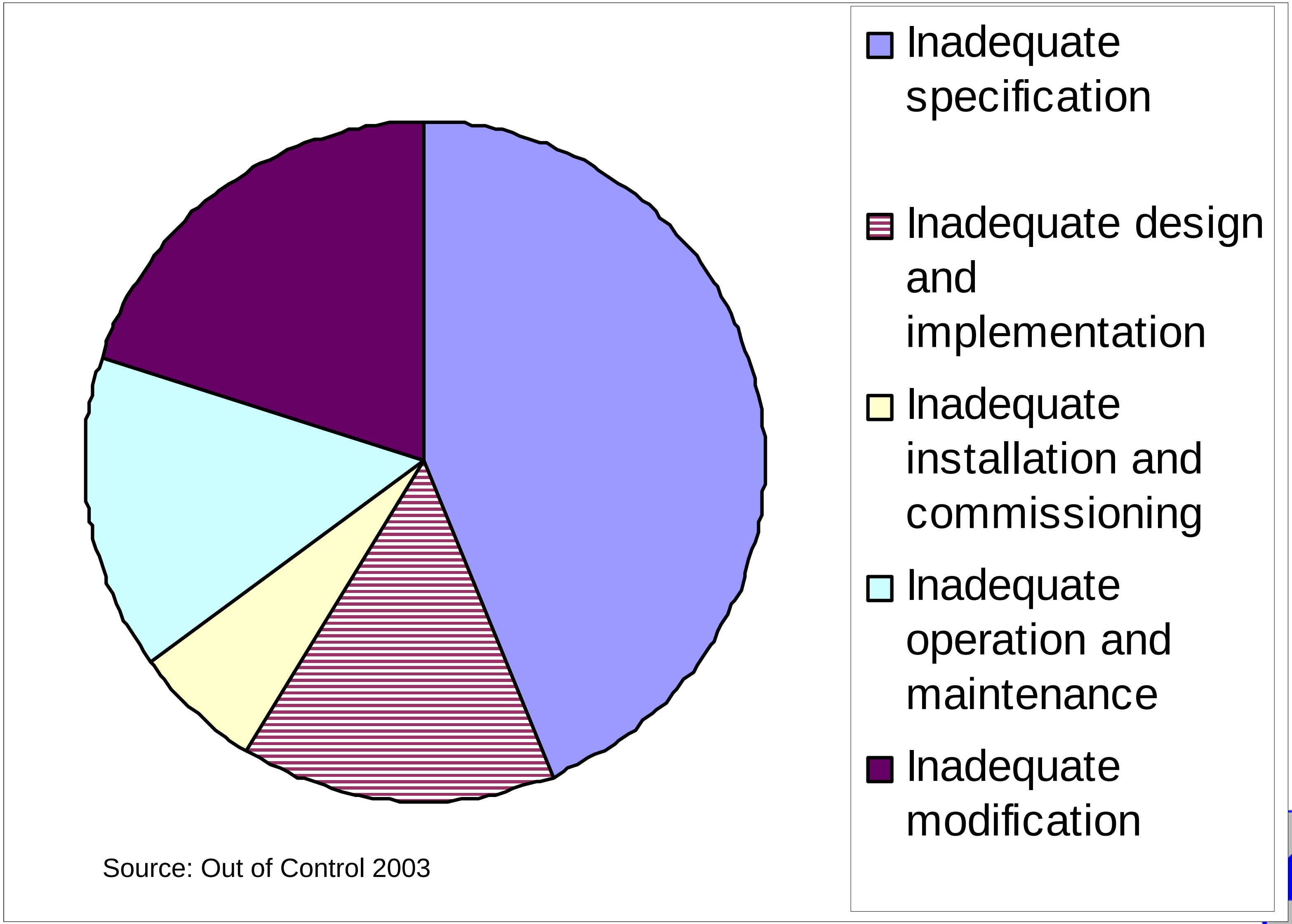
WHY?

- Custom and practice?
- Taken for granted?
- Principles assumed?

Overpressure protection for a turbine driven compressor



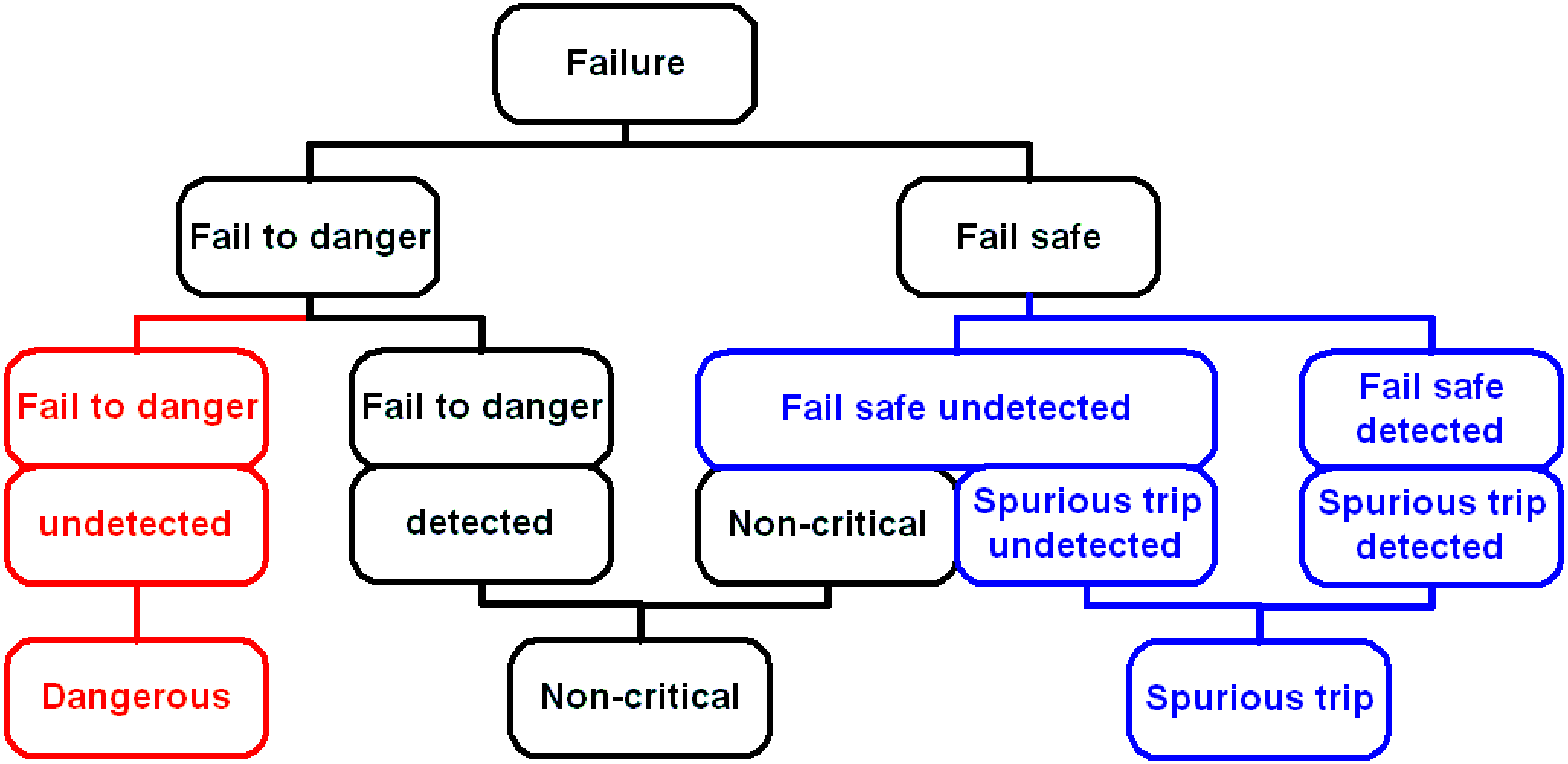
Why do trip systems fail?



Trip system issues

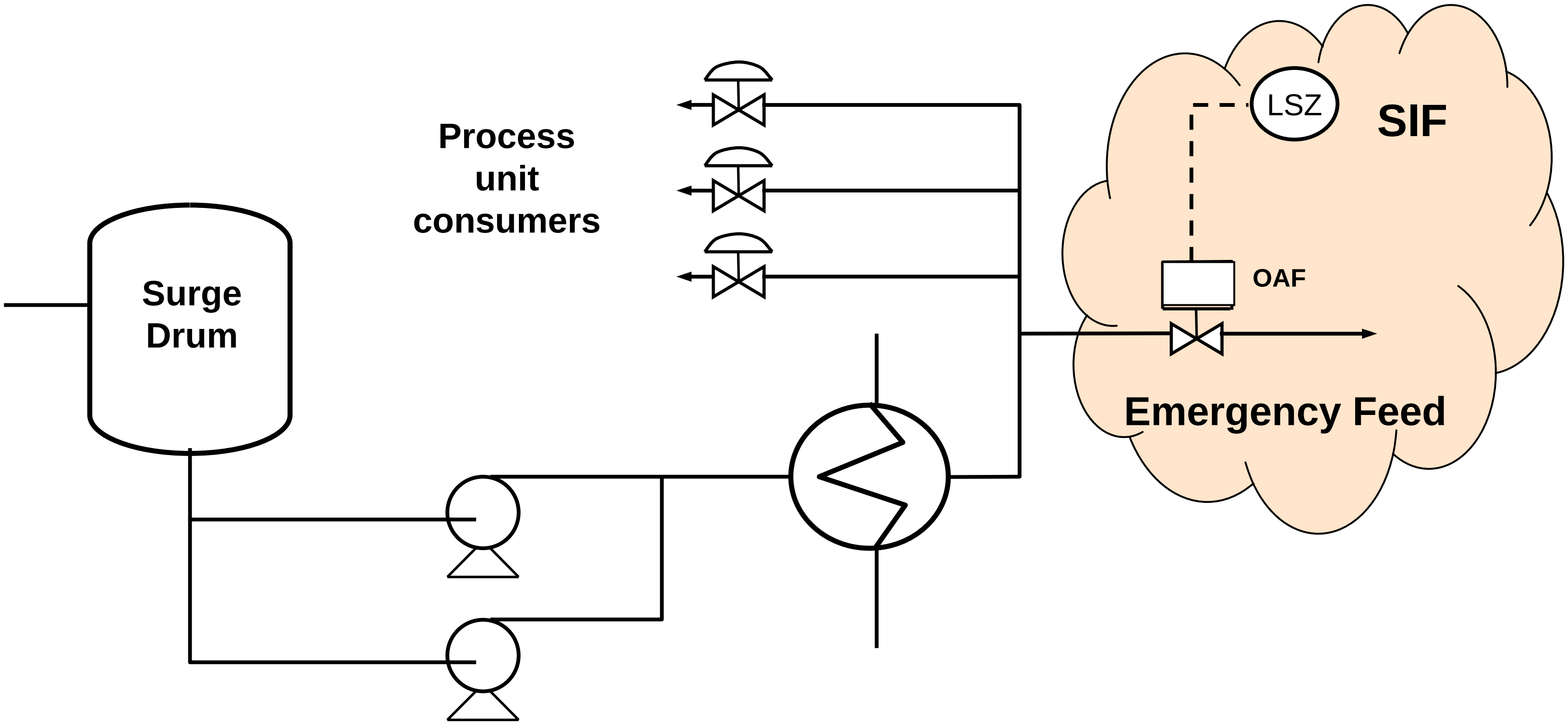
- SIF Requirements
- Passive / active systems
- Utility Requirements
- Effect on Fail to Danger and Spurious Trips
  - Design policy / Architecture / Overrides (defeats)
  - People issues
  - Operate / Test / Repair policies
  - Component reliability
  - Diagnostics

System failure modes

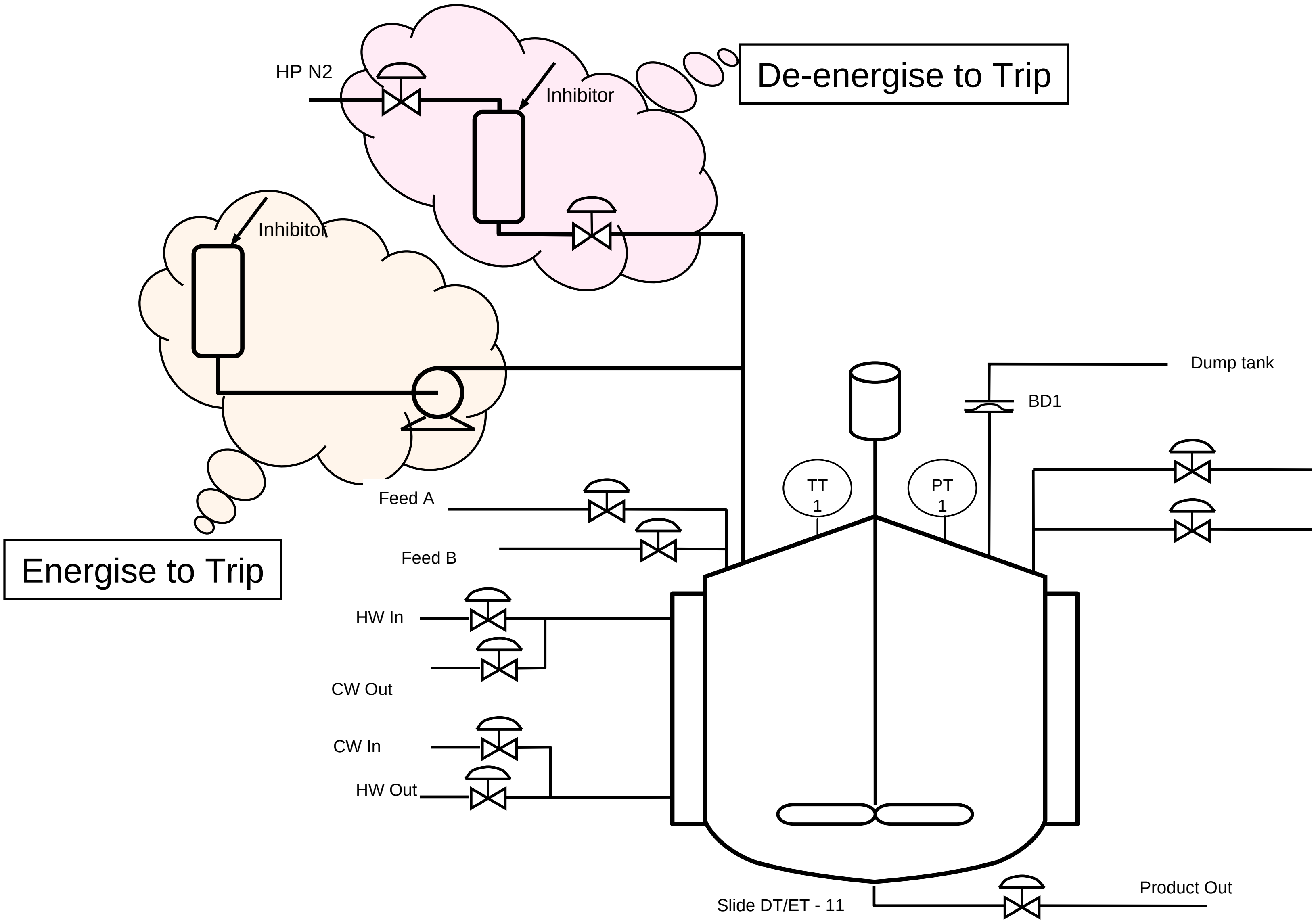


Source: Sintef PDS Method Handbook 2006

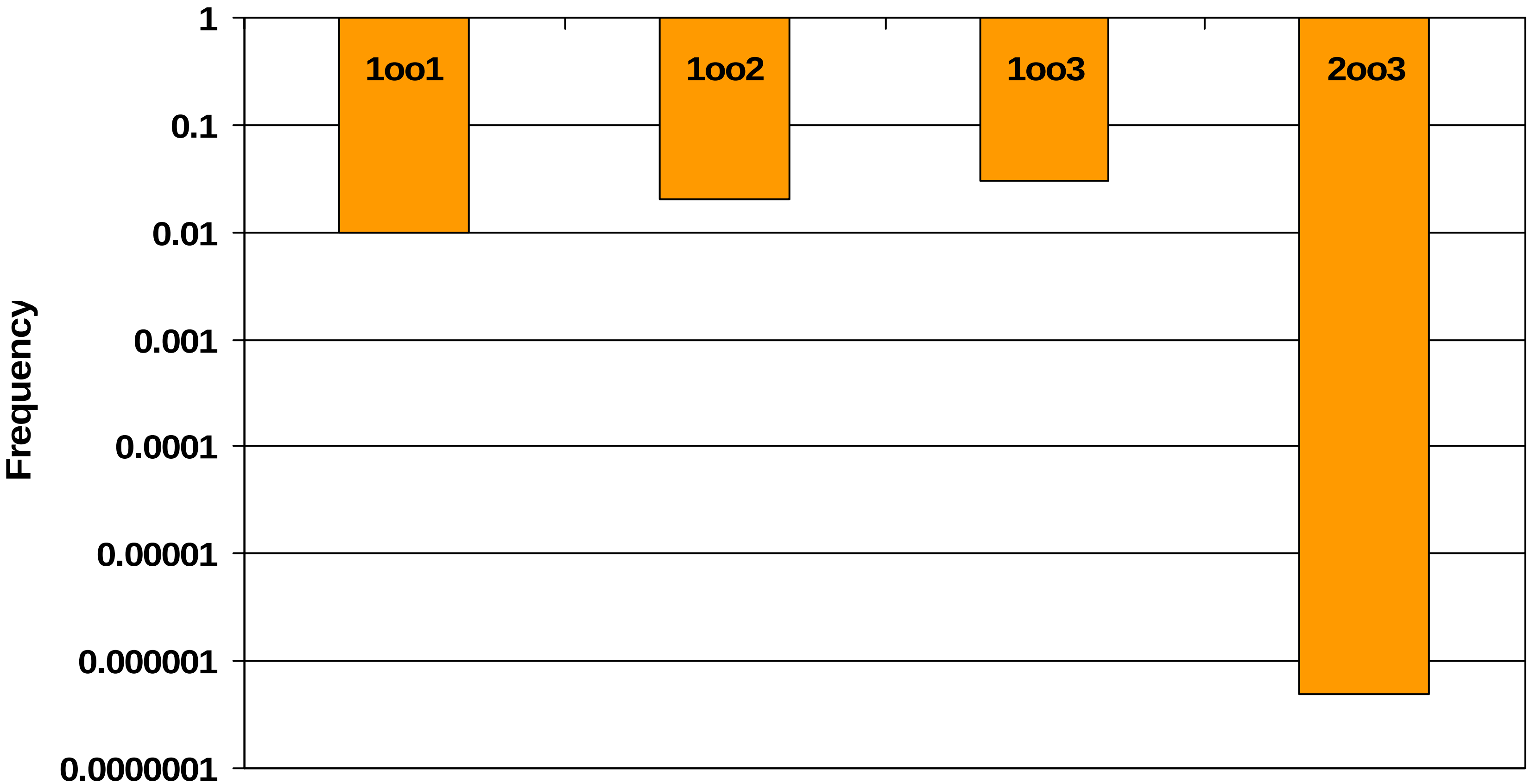
Energise or De-energise to Trip?



Addition of Reactor Inhibitor Options

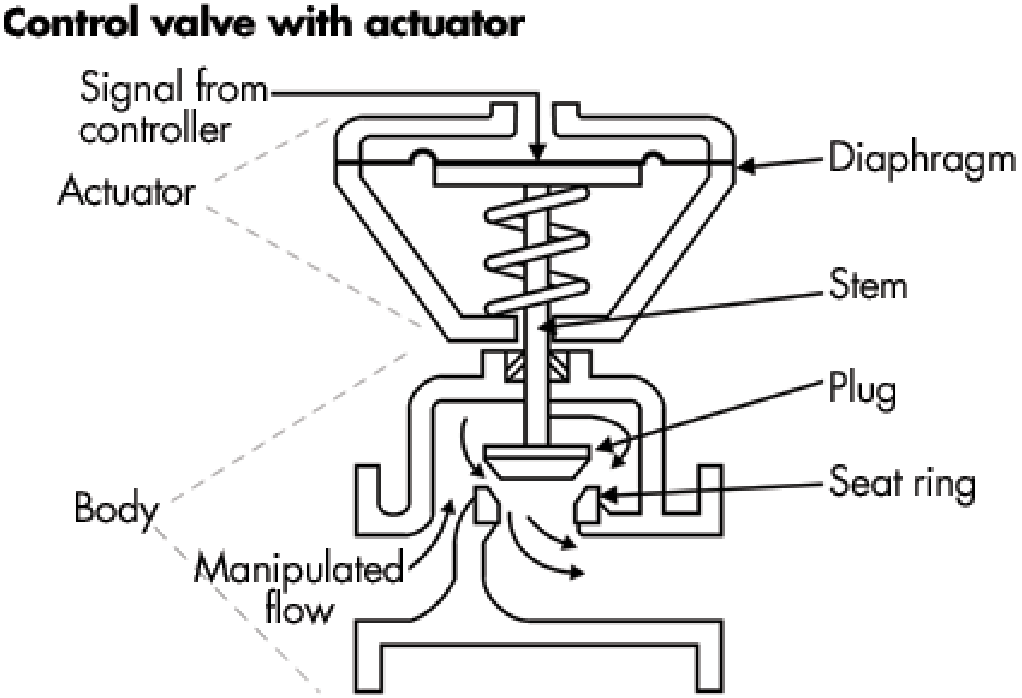


Architecture and Spurious Trip Frequency



Valve failure modes ~ 80% open

Failure mode	%
Blocking	5
External leak	15
Passing	60
Sticking	20



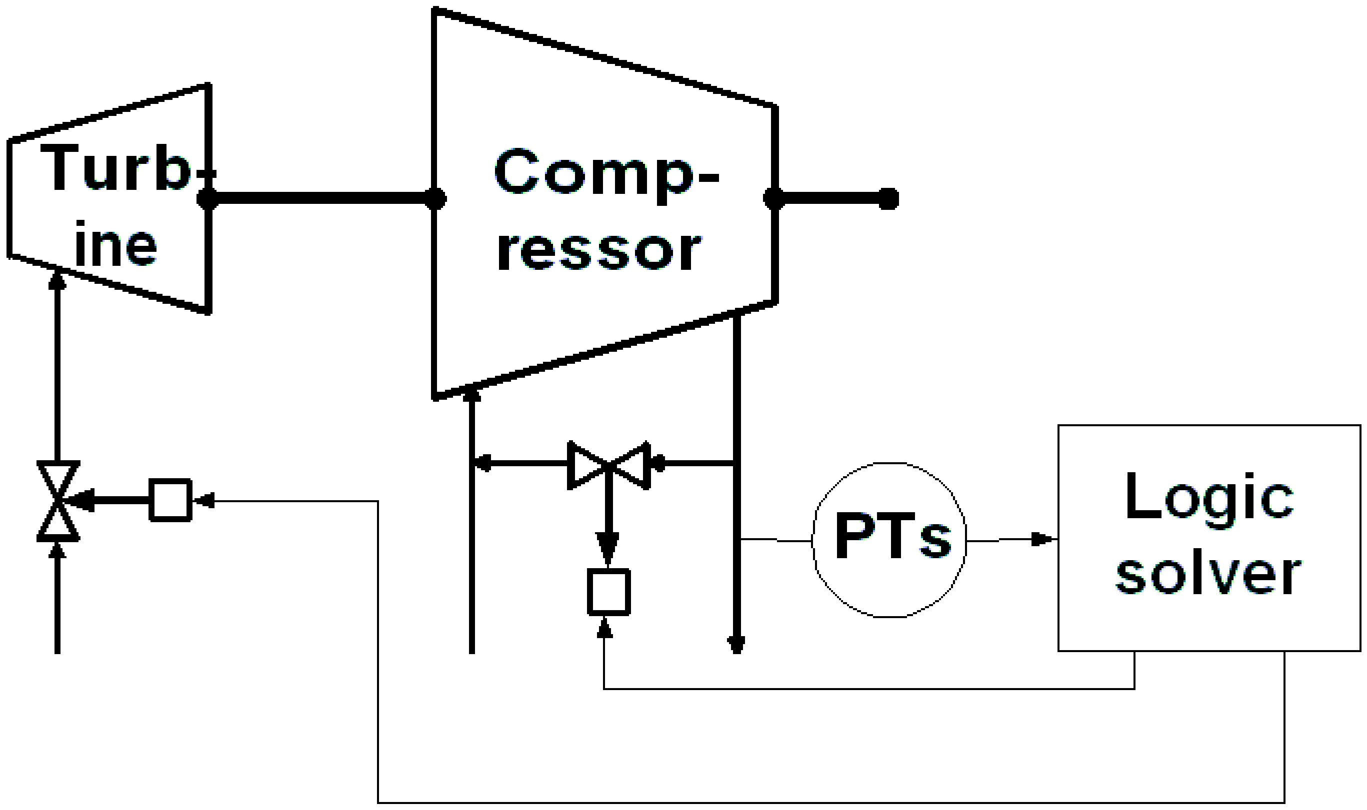
Data source: Smith: Reliability, Maintainability and Risk

Relay failure modes ~ 90% open

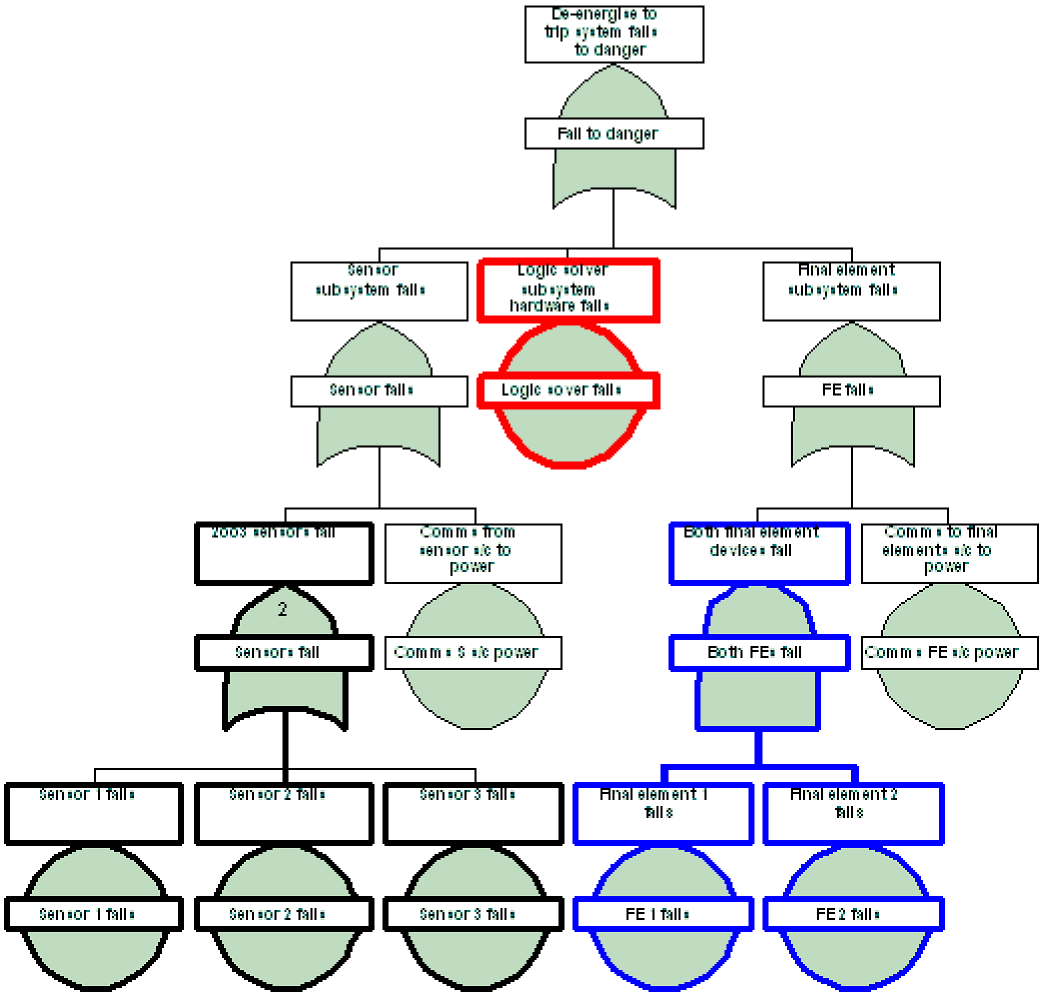
Failure mode	%
Contacts short circuit	10
Contacts open circuit	80
Coil	10

Data source: Smith: Reliability, Maintainability and Risk

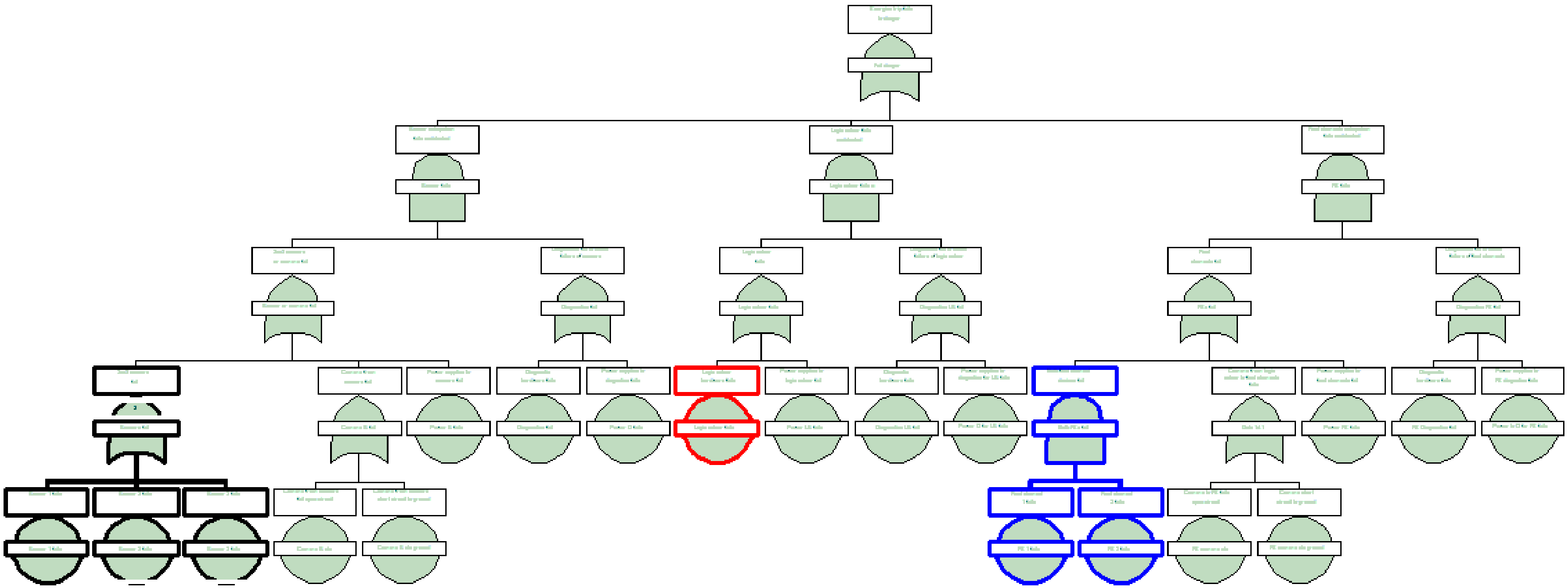
Overpressure protection for a turbine driven compressor



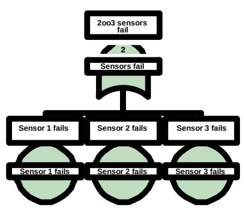
DT fails to danger



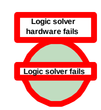
ET fails to danger



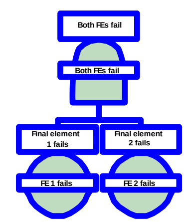
Key to Fault Trees



Sensors

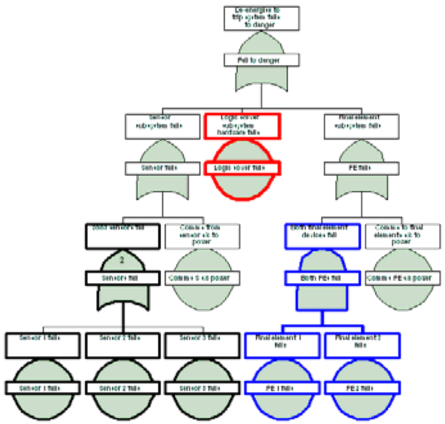


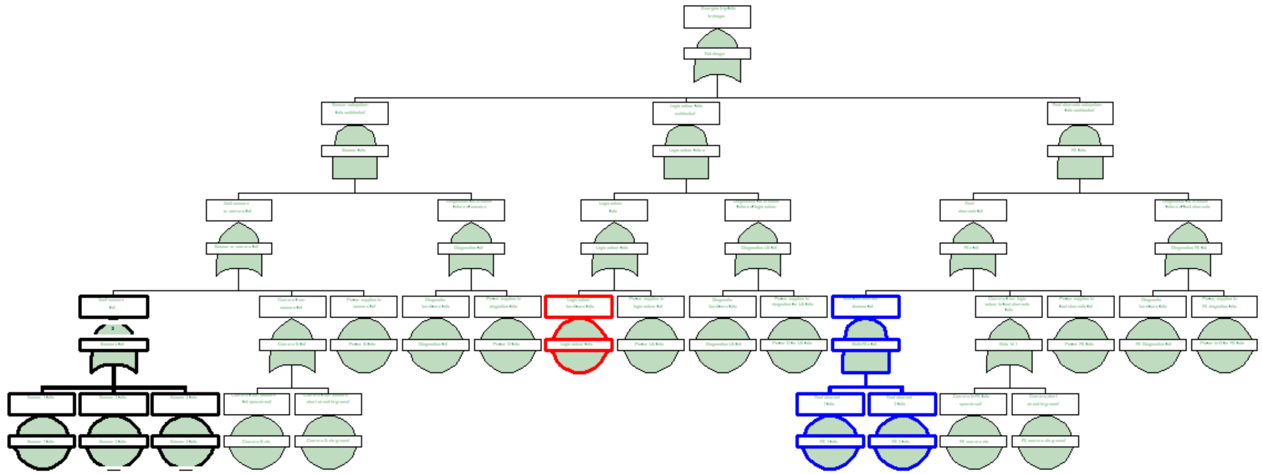
Logic solver



Final elements

DT (left) and ET fails to danger





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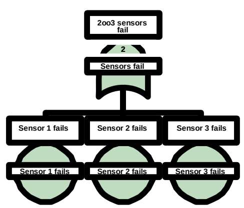

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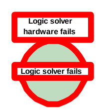

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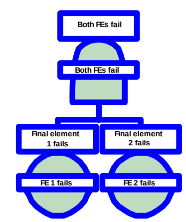
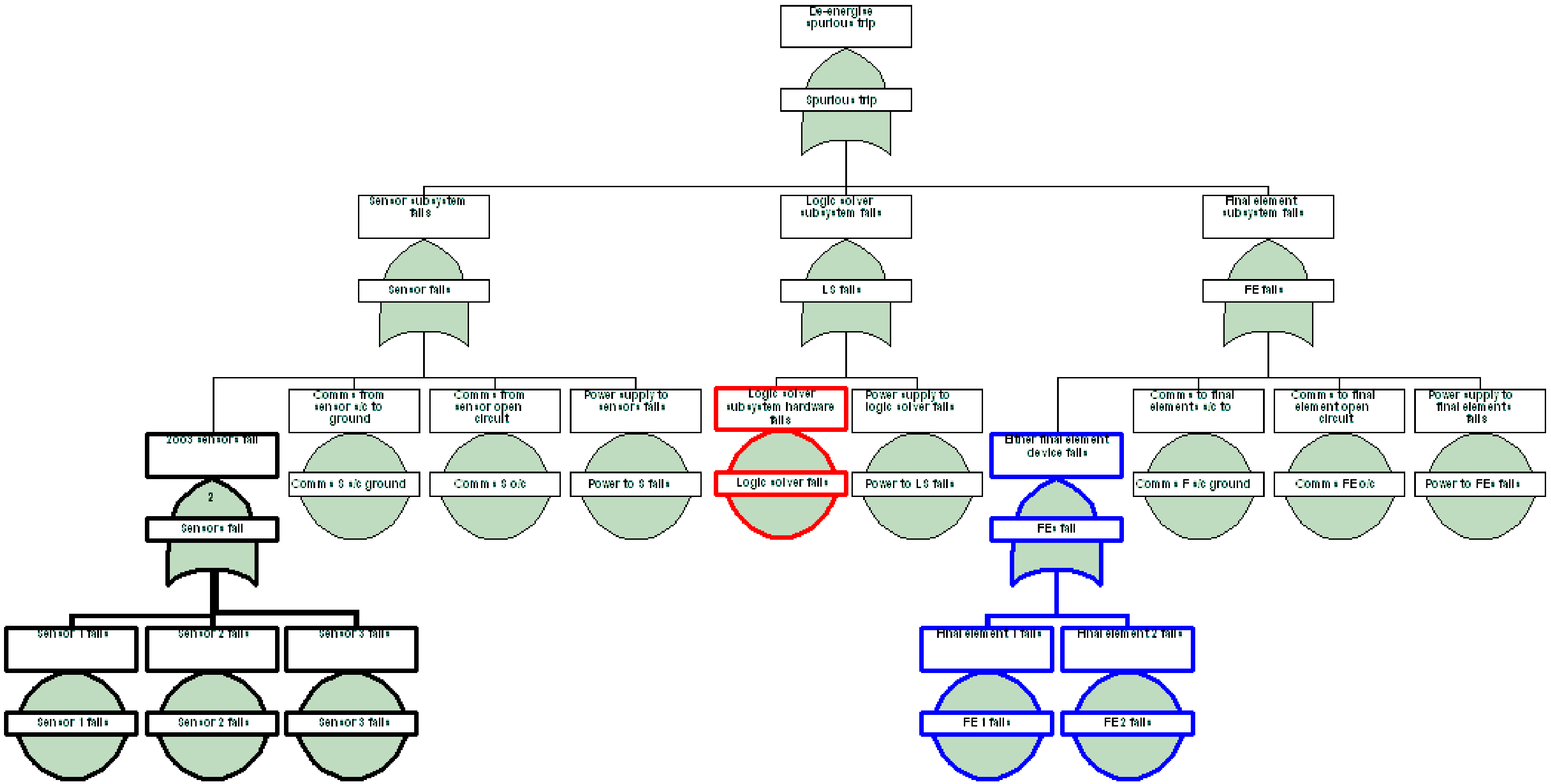
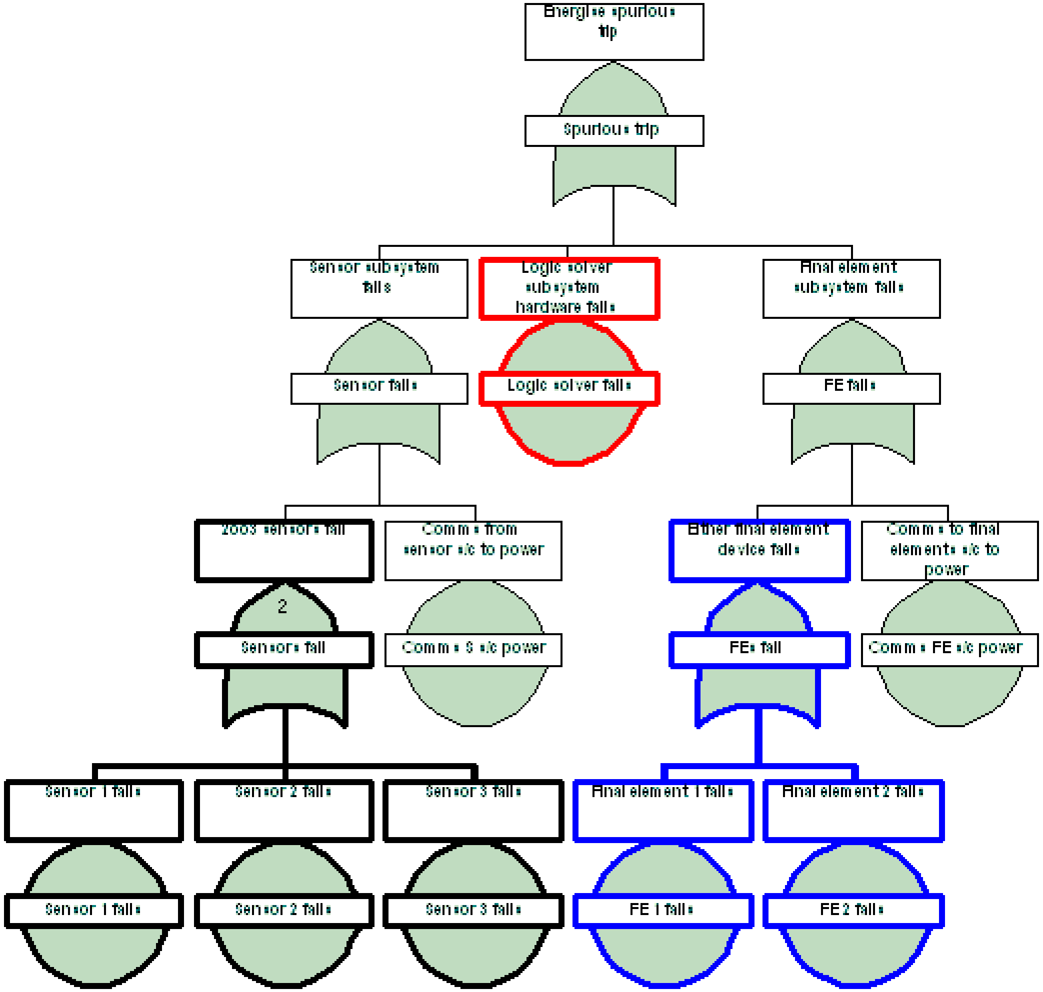


Final elements

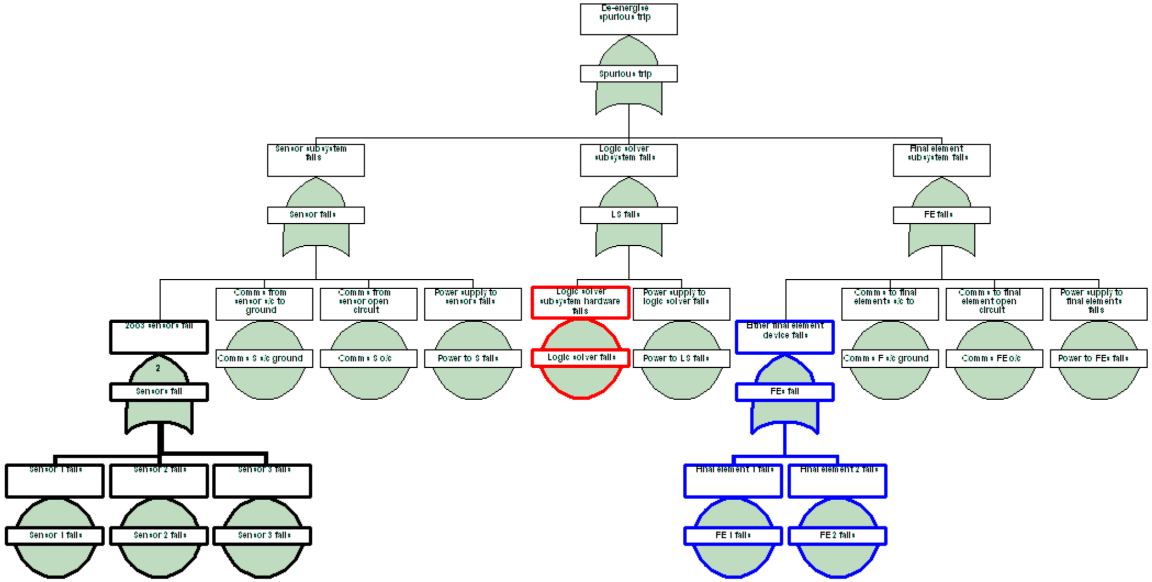
DT spurious trips

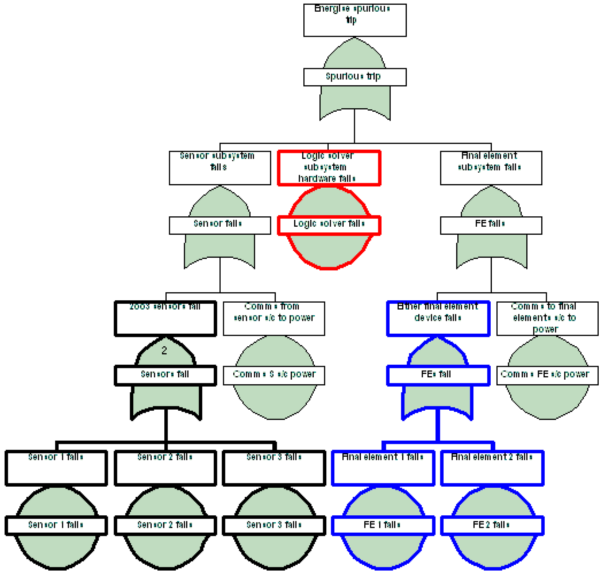


ET spurious trips



DT (left) and ET spurious trips





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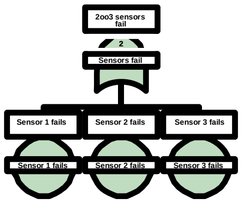

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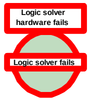
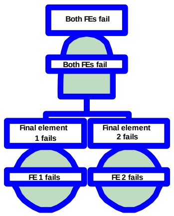


Logic solver



Final elements

Diagnostics and Reverse Acting Transmitters

- Safety Function operates on “high” signals
- Transmitter failure leads to low signal
- ↓ Diagnostics require separate input
- ↑ Reverse acting transmitter provides automatic protection
  - Avoids technical complexity BUT introduces human factors and management complexity

References - 1

- http://www.hse.gov.uk/comah/sragtech/index.htm

  which includes links to Case Studies illustrating the importance of Control and Protection Systems, for example
  - Texaco Refinery - Milford Haven - Explosion and Fires (24/7/1994)
  - International Biosynthetics Ltd (7/12/1991)
  - BP Oil (Grangemouth) Refinery Ltd (22/3/1987)
  - Seveso - Icmesa Chemical Company (9/7/1976)

- Out of Control (2003), Second edition, HSE Books, ISBN 0-7176-2192-8
- IEC 61508 (1998 & 2000), Functional safety of electrical/electronic/programmable electronic safety-related systems Parts 1-7

References - 2

- Reliability Prediction Method For Safety Instrumented Systems. PDS Method Handbook (2006) SINTEF
- ISA-TR84.00.02 (2002) - Safety Instrumented Function (SIF) - Safety Integrity Level (SIL) Evaluation Techniques Part 1: Introduction – page 57
- Reliability Maintainability and Risk (2001) David J Smith ISBN 0-7506-5168-7
- Safety Shutdown Systems Design, Analysis and Justification (1998) Paul Gruhn and Harry Cheddie ISBN1-55617-665-1
- Safety-Critical Computer Systems (1996), Neil Storey, ISBN 0-201-42787-7
- Safeware: system safety and computers (1995), Nancy Leveson, ISBN 0-201-11972-2

Available Guidance on ET

Is there anything else out there?

Conclusions

- Choice less clear-cut than at first sight
  – Need to look holistically
  – Wider than simply the core SIF
- ET can be made to work – possibilities of getting it wrong are greater
- ET inherently more complex
  – Does everyone understand the complexity?
- Some DT systems have ET elements