Attempt to predict Human Error Probability in different industry sectors using data from major accidents and Bayesian networks

PSAM 14 – 18 September 2018

Caroline Morais | Edoardo Patelli | Raphael Moura | Michael Beer

UNIVERSITY OF LIVERPOOL
Institute for Risk and Uncertainty

anp
Agência Nacional do Petróleo, Gás Natural e Biocombustíveis

Leibniz Universität Hannover

INSTITUTE FOR RISK AND RELIABILITY

Research Institute of Structural Engineering and Disaster Reduction

My results were wrong!

Why?

How have I found out the error?

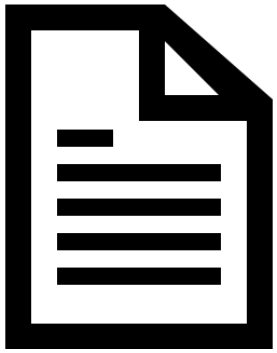
Previous results x Corrected results

UNIVERSITY OF LIVERPOOL | Institute for Risk and Uncertainty

- Data Collection
- Data Analysis
- Application of HRA data in Decision-Making

Data collection

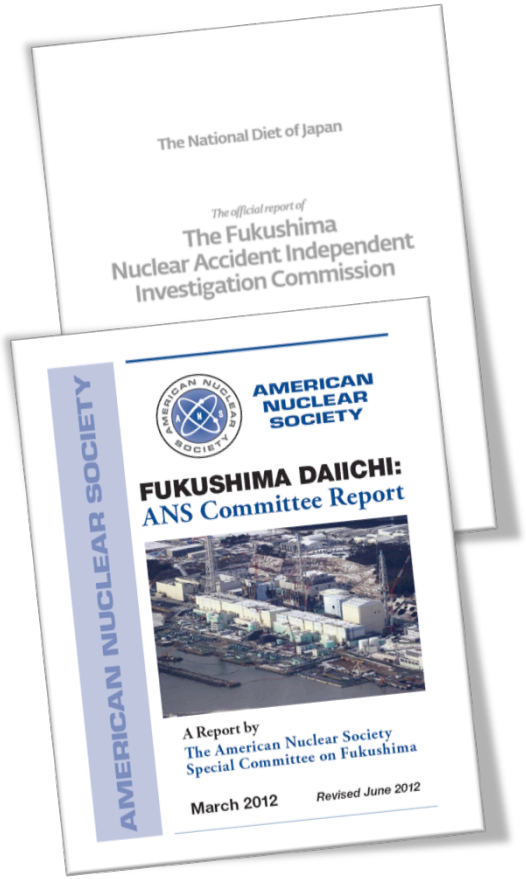
Taxonomy: CREAM (Hollnagel)



Major accident reports

Moura et al.(2016)

	Performance Shaping Factors	Cognitive error	Execution Error
Accident 1	1	0	0
Accident 2	1	1	1
…	0	1	0
…	1	0	0
…	1	1	1
…	0	0	1
Accident 238	1	1	1

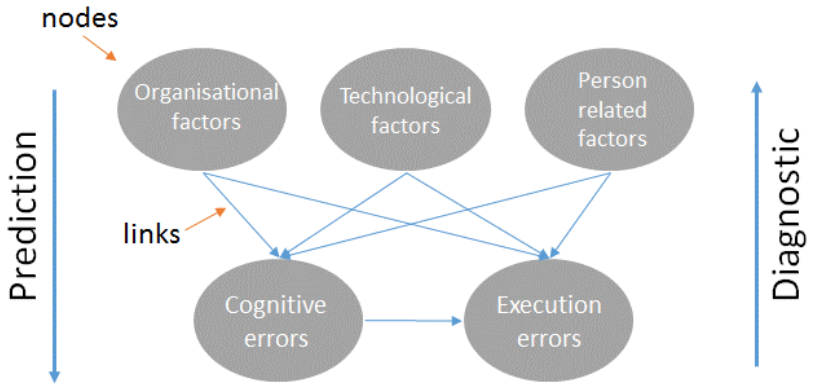


Workers had to work using a flawed manual: sections in the diagrams of the severe accident instruction manual were missing.

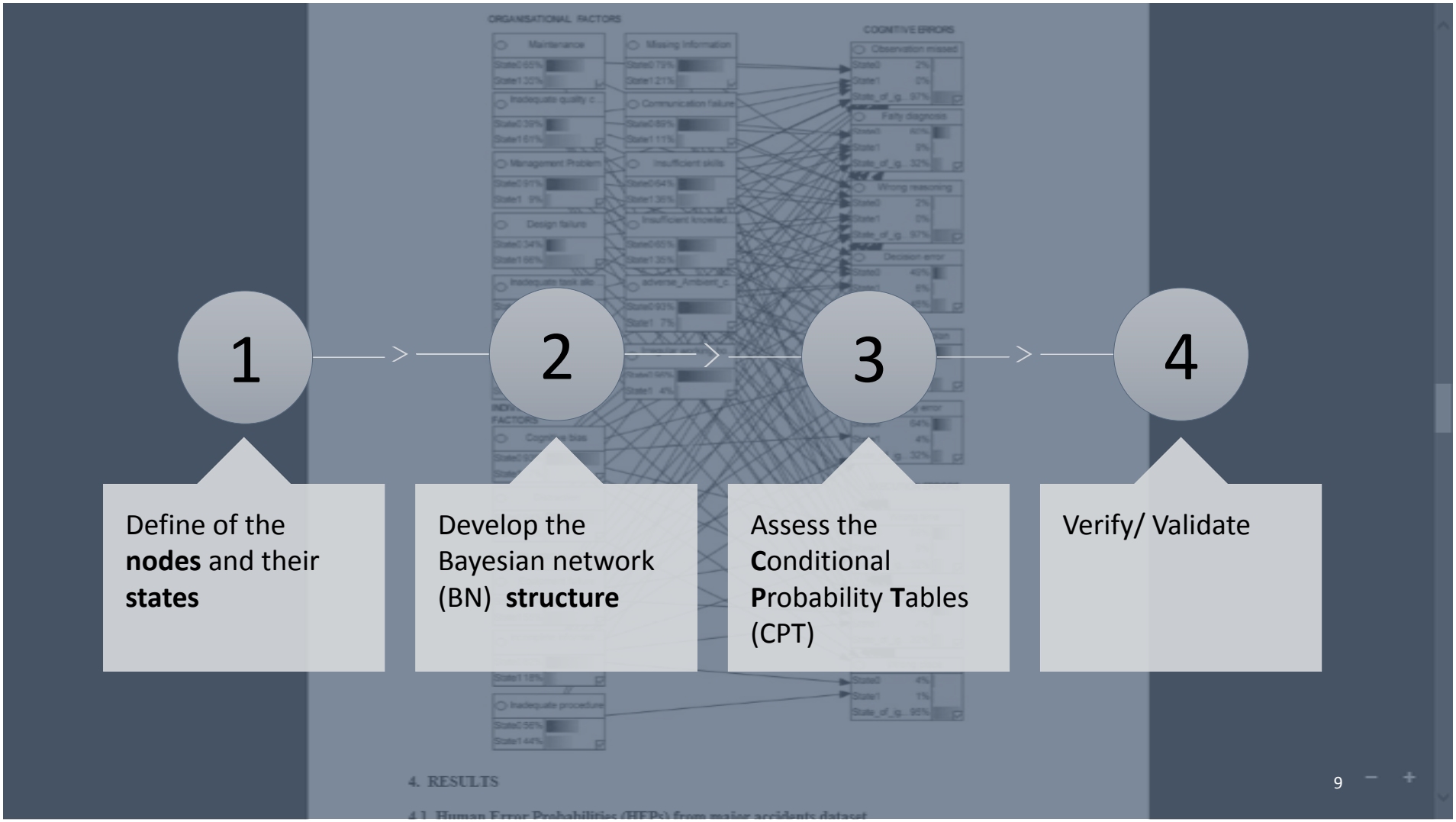
flood protection for the batteries was not provided.

INDUSTRY	LOCATION	Ind… Funct…	Technological factor	Organisatio… Factor	**Cognitive error**
		Fatigue	Inadequate procedure	Design f…lure	Observation Missed
NUCLEAR	Fukushima	0	1	1	0
UPSTREAM	Piper Alpha	0	1	1	1

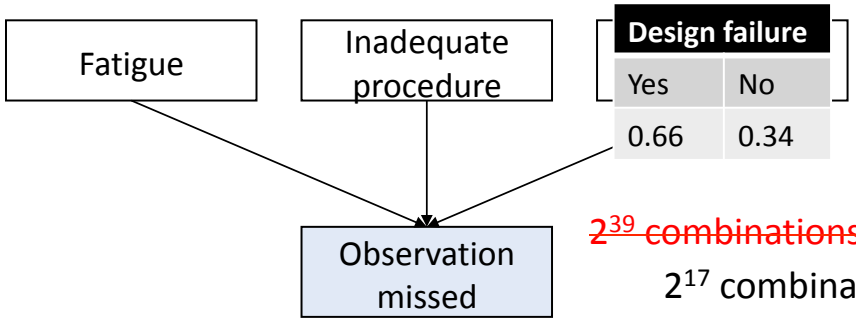
overlook cue/signal: not realised that PSV was out for maintenance.



Data analysis


1
2
3
4
Define of the **nodes** and their **states**
Develop the Bayesian network (BN) **structure**
Assess the **C**onditional **P**robability **T**ables (CPT)
Verify/ Validate
4. RESULTS

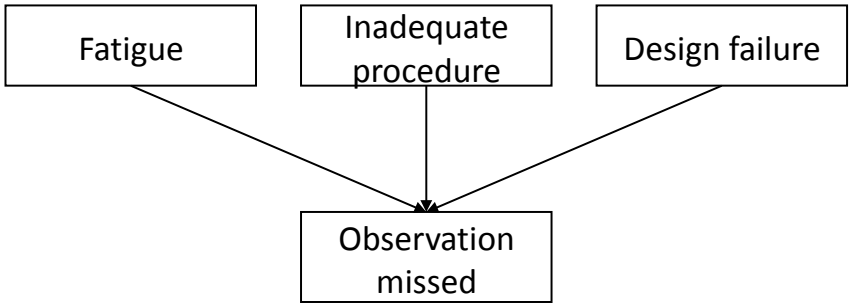
CPT



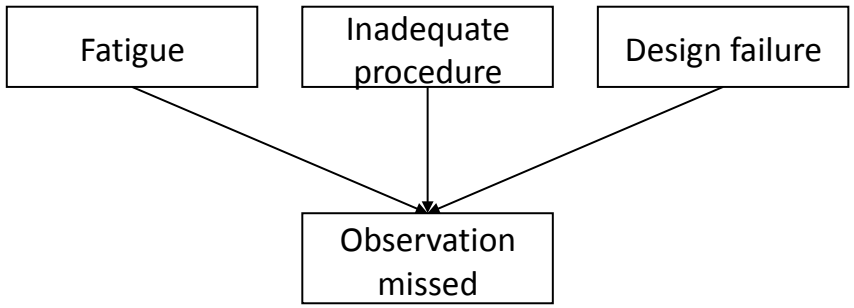
~~2^{39} combinations = 549,755,813,888~~

2^{17} combinations = 131,072

Fatigue		NO	NO	NO	NO	YES	YES	YES	YES
Procedure		NO	NO	YES	YES	NO	NO	YES	YES
Design failure		NO	YES	NO	YES	NO	YES	NO	YES
(…)									
Observation missed	NO	$\frac{\text{times the combination ocurred in accidents}}{\text{total number of accidents}}$							
	YES								



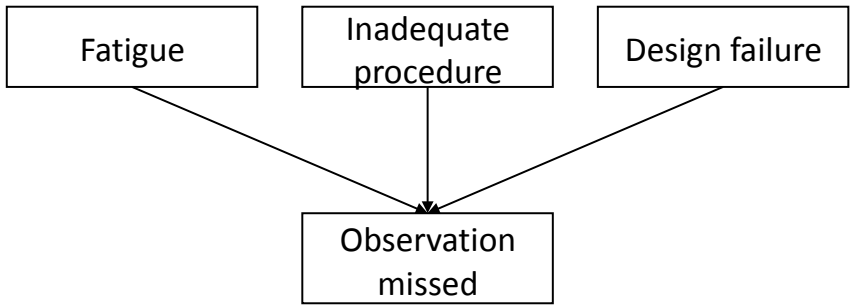
Fatigue		NO	NO	NO	NO	YES	YES	YES	YES
Procedure		NO	NO	YES	YES	NO	NO	YES	YES
Design failure		NO	YES	NO	YES	NO	YES	NO	YES
(…)									
Observation missed	NO	0.18	0.31	0.11	0.24	0	0	0.00	0.01
	YES	0.03	0.03	0.02	0.06	0	0.01	0	0.01



Fatigue		NO	NO	NO	NO	YES	YES	YES	YES
Procedure		NO	NO	YES	YES	NO	NO	YES	YES
Design failure		NO	YES	NO	YES	NO	YES	NO	YES
(…)									
Observation missed	NO	0.86	0.91	0.85	0.80	0	0	1	0.5
	YES	0.14	0.09	0.15	0.20	0	1	0	0.5

normalised

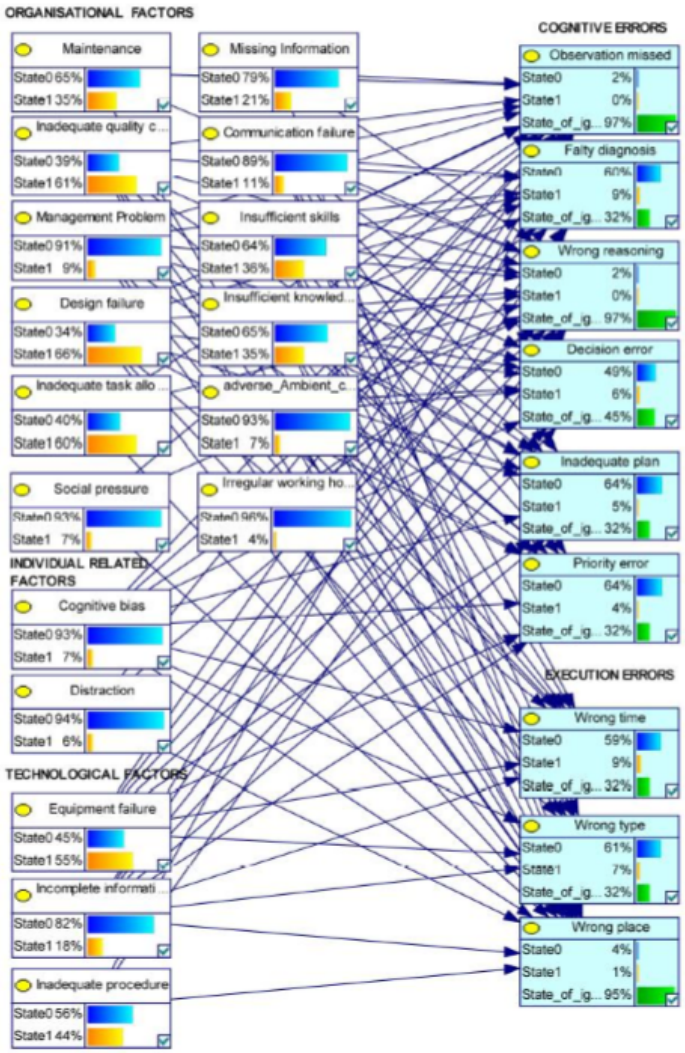
Undefined result
(Divided by zero)



Fatigue		NO	NO	NO	NO	YES	YES	YES	YES
Procedure		NO	NO	YES	YES	NO	NO	YES	YES
Design failure		NO	YES	NO	YES	NO	YES	NO	YES
(…)									
Observation missed	NO								
	YES								
	No data								

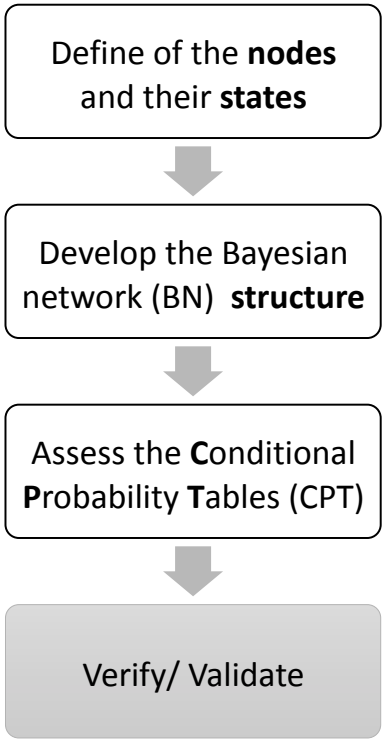
3rd state

Now, the computation of those probabilities…


ORGANISATIONAL FACTORS
Maintenance
State0 65%
State1 35%
Inadequate quality c...
State0 39%
State1 61%
Management Problem
State0 91%
State1 9%
Design failure
State0 34%
State1 66%
Inadequate task allo...
State0 40%
State1 60%
Social pressure
State0 93%
State1 7%
INDIVIDUAL RELATED FACTORS
Cognitive bias
State0 93%
State1 7%
Distraction
State0 94%
State1 6%
TECHNOLOGICAL FACTORS
Equipment failure
State0 45%
State1 55%
Incomplete informati...
State0 82%
State1 18%
Inadequate procedure
State0 56%
State1 44%
Missing Information
State0 79%
State1 21%
Communication failure
State0 89%
State1 11%
Insufficient skills
State0 64%
State1 36%
Insufficient knowled...
State0 65%
State1 35%
adverse_Ambient_c...
State0 93%
State1 7%
Irregular working ho...
State0 96%
State1 4%
COGNITIVE ERRORS
Observation missed
State0 2%
State1 0%
State_of_ig... 97%
Faity diagnosis
State1 9%
State_of_ig... 32%
Wrong reasoning
State0 2%
State1 0%
State_of_ig... 97%
Decision error
State0 49%
State1 6%
State_of_ig... 45%
Inadequate plan
State0 64%
State1 5%
State_of_ig... 32%
Priority error
State0 64%
State1 4%
State_of_ig... 32%
EXECUTION ERRORS
Wrong time
State0 59%
State1 9%
State_of_ig... 32%
Wrong type
State0 61%
State1 7%
State_of_ig... 32%
Wrong place
State0 4%
State1 1%
State_of_ig... 95%

HEP Results


Observation
Interpretation
Planning
Execution
Observation missed
Faulty diagnosis
Decision error
Priority error
Inadequate plan
Action of wrong type
Action at wrong time
Action of wrong place
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
3.91E-03
8.61E-02
6.12E-02
3.81E-02
3.81E-02
7.36E-02
8.99E-02
1.09E-02
BN results (corrected)



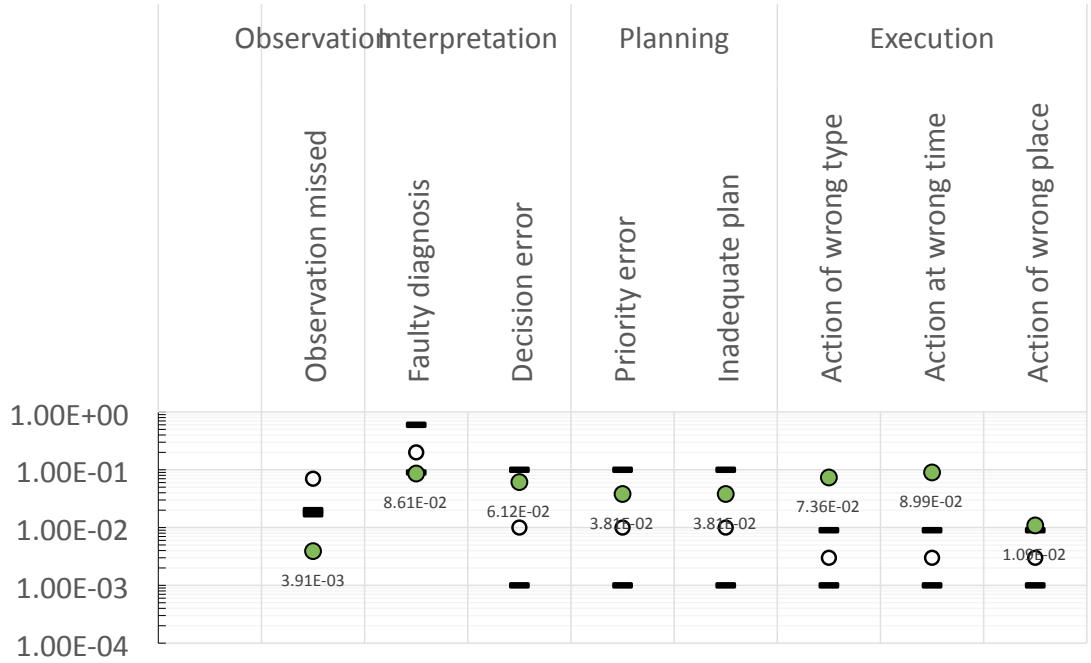
Validation:
If the system does what is supposed to do in the real world.

Verification:
If the system works as it is supposed to work.

Validation


Observation
Interpretation
Planning
Execution
Observation missed
Faulty diagnosis
Decision error
Priority error
Inadequate plan
Action of wrong type
Action at wrong time
Action of wrong place
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
3.91E-03
8.61E-02
6.12E-02
7.36E-02
8.99E-02
Basic value from literature
BN results (corrected)

Validation


Observation
Interpretation
Planning
Execution
Observation missed
Faulty diagnosis
Decision error
Priority error
Inadequate plan
Action of wrong type
Action at wrong time
Action of wrong place
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
3.91E-03
8.61E-02
6.12E-02
3.81E-02
3.81E-02
7.36E-02
8.99E-02
1.00E-02
Lower bound(0.5) from literature
Basic value from literature
Upper bound (0.95) from literature
BN results (corrected)

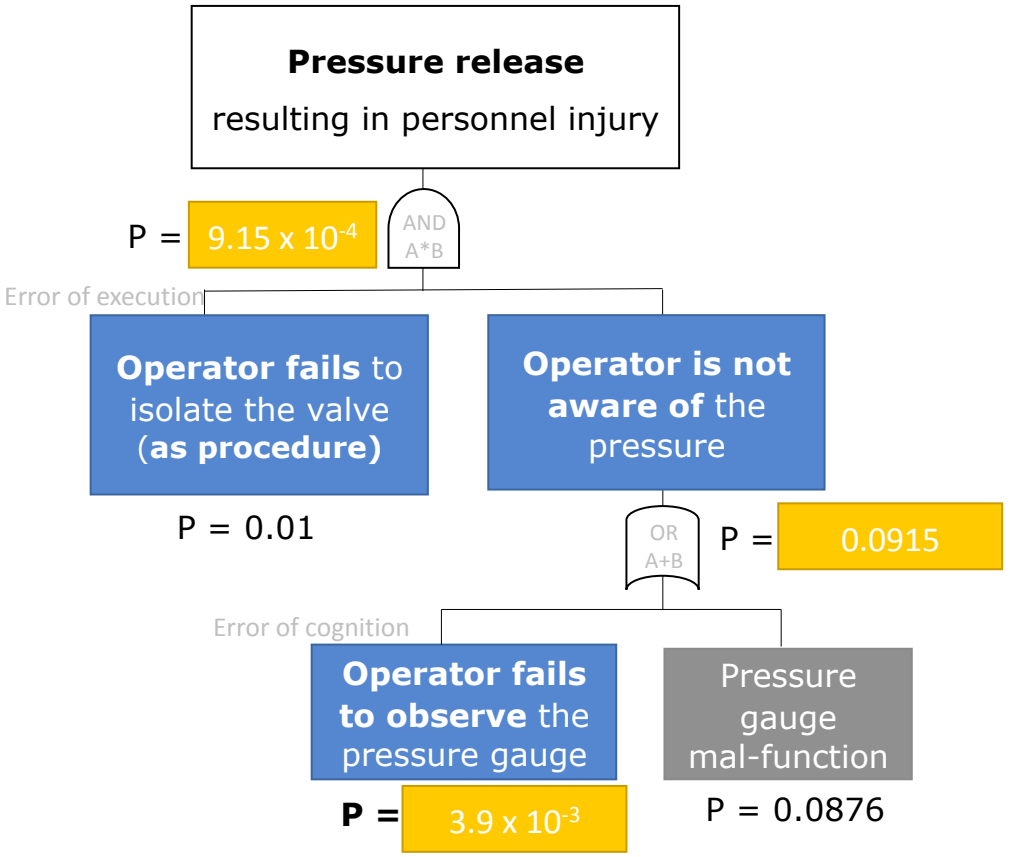
Verification

- Still having problems, mainly with organisational factors
- Dependencies of organisational PSFs?

Aplication of HRA Data in Decision-Making

Figure source: https://www.sofisglobal.com – About mechanical valve interlocks to eliminate human errors

… to check if a certain risk criteria is met



$$\text{Human Error Probability} = \frac{\text{Number of observed errors}}{\text{Number of opportunities for error}} = \text{4 observation failures for every 1000 times}$$

Aplication: Check the risk level

- Design phase
- Operational phase –risk level remains acceptable?
  (as part of the management of change)
- Life extension

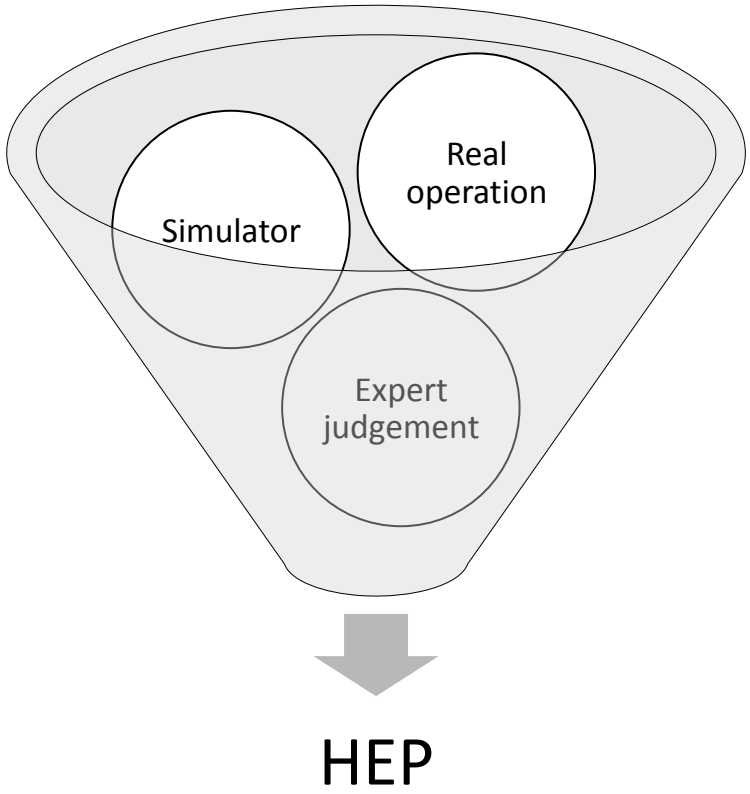
Research:

Not under-estimated nor over-estimated HEP (Human Error Probability).

Real operation

Simulator

Expert judgement

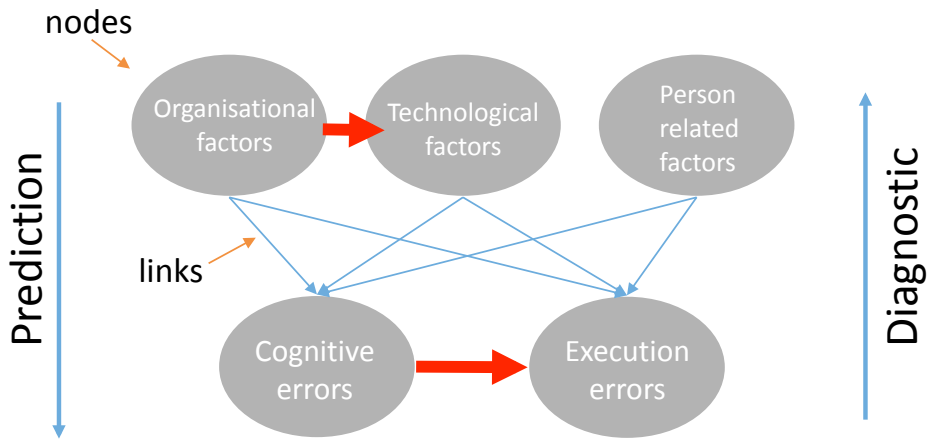


Problems to tackle

Probabilistic approach to analyse the dependencies of random variables

Many data sources

Accept new evidence



Limited number of connections if using a simple algorithm

P(**cognitive error**= YES) =

$S_{person,\ technology,\ organisation}$ P(person) P(tech) P(org)* P(cognitive error = YES|person, tech, org)