



# Learning from Disasters

**The Importance of Human Behaviour in  
Emergency**

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# Introduction

We strive to design, build, operate and maintain safe infrastructure

Hazards, notably fire, cannot be fully eliminated

The possibility of an incident is always present

Operational controls are needed

Owners, operators, first responders all need to have robust processes

Planning and execution can be improved by studying what went wrong in past incidents



# Safety Culture

Safety culture is a key concept

Defined by the UK HSE:

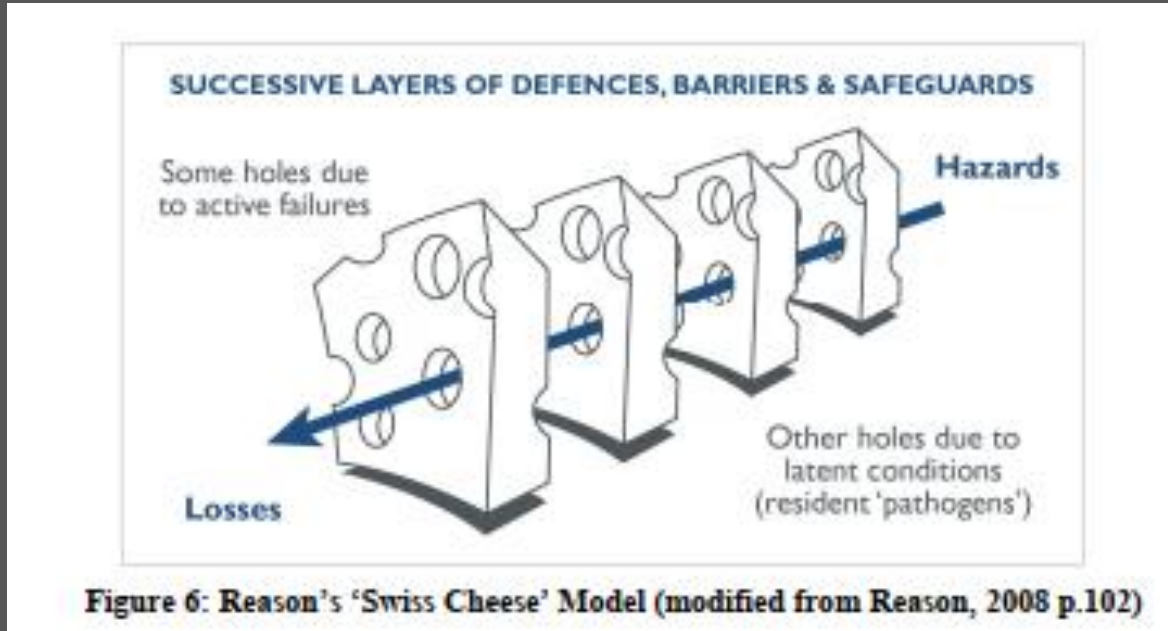
*“Safety culture is a combination of the attitudes, values and perceptions that influence how something is actually done in the workplace, rather than how it should be done.”*

i.e. practice what you preach

A commitment to safety is worthless if an organization and its people do not focus on safety at all times



# Accident models - examples



## Linear

e.g. Swiss Cheese model, *Models of Causation: Safety*, SIA, 2012 (after Reason, 2008)

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J. Rasmussen

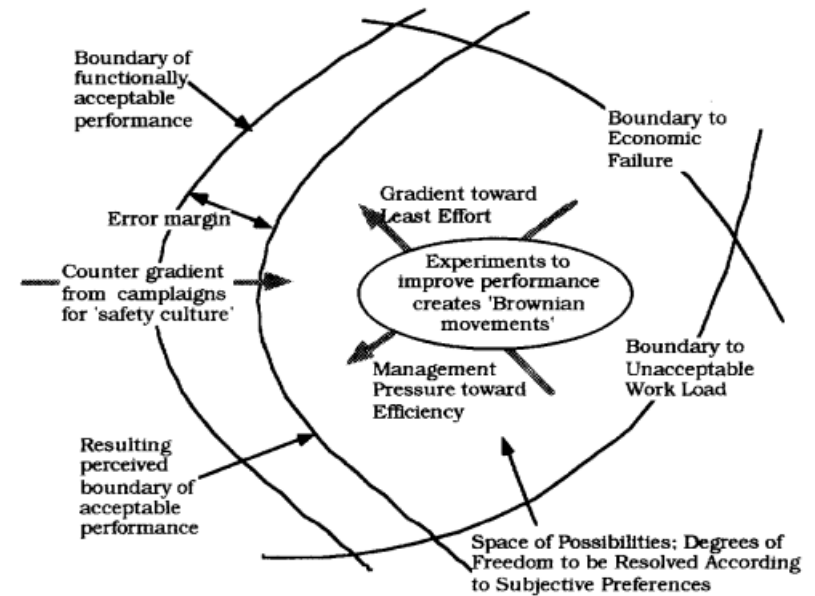


Fig. 3. Under the presence of strong gradients behaviour will very likely migrate toward the boundary of acceptable performance.

## Non-Linear

e.g. Drift To Failure model, Rasmussen, 1997

# Proximate cause vs root cause

To examine any serious incident we need to distinguish between:

Proximate cause: the initiating event

and

Root cause: how it was possible for the initiating event to cause a disaster

Simple Example:

- You are driving your car with worn-out tires
- A tire blows out
- You crash

The tire blow-out is the **proximate cause**  
But your failure to have safe tires is the **root cause**



# Case Studies

## 16 case studies

- All well-known incidents
- 9 underground facilities
- 7 from different sectors

## Consequences

- 12 fatal incidents
- 3 non-fatal incidents
- 1 near-miss

## Source data

- A = Public inquiry
- B = Published research
- C = News/media reports

No	Date	Incident	Location	Operator	Type of asset	Type of incident	Data Class
1	1995-10-28	Baku	Kazakhstan	Baku Metro	Underground rail	Fire	C
2	1986-01-28	Challenger	United States	NASA	Space vehicle	Explosion & disintegration	A
3	1996-11-18	Channel Tunnel	United Kingdom / France	Eurotunnel	Underground rail	Fire	A
4	2008-09-11	Channel Tunnel	United Kingdom / France	Eurotunnel	Underground rail	Fire	A
5	1986-04-25	Chernobyl	USSR	USSR Ministry of Power	Nuclear energy plant	Explosion, fire, radiation exposure	A
6	1988-12-12	Clapham Junction	United Kingdom	British Rail	Surface rail	Collision	A
7	2003-02-01	Columbia	United States	NASA	Space vehicle	Structural failure due to overheating	A
8	2003-02-19	Daegu	South Korea	Daegu Metro	Underground rail	Fire	B
9	2017-06-14	Grenfell Tower	United Kingdom	KCLBC	High-rise residential building	Fire	A
10	2004-01-05	Hong Kong MTR	Hong Kong	MTRCL	Underground rail	Fire	A
11	2000-11-11	Kaprun	Austria	Gletscherbahnen Kaprun AG	Underground rail	Fire	B
12	1987-11-18	King's Cross	United Kingdom	LU / LRT	Underground rail	Fire	A
13	1999-03-24	Mont Blanc	France / Italy	ATMB / SITMB	Underground road	Fire	A, B
14	1988-07-06	Piper Alpha	United Kingdom	Occidental Petroleum	Oil & gas offshore platform	Explosion & fire	A
15	1983-09-26	Soviet nuclear false alarm	USSR	Soviet Air Defence Forces	Nuclear attack early warning facility	Near miss - nuclear war	C
16	2015-01-15	WMATA Lac L'Enfant Plaza	United States	WMATA	Underground rail	Fire	A

# Contributory human behaviours *extracted from the data sources*

Factor No.	Behaviour description	Individual or organisational <sup>1</sup>	Stage of Incident
1	Poor planning	Organisational	Prior to incident
2	Poor maintenance	Organisational	Prior to incident
3	Failure to operate within safe parameters	Organisational	Prior to incident
4	Failure to learn from past near misses	Organisational	Prior to incident
5	Incorrect response	Individual	During incident
6	Inadequate communication	Individual	During incident
7	Complacency <sup>2</sup>	Organisational	At all times
8	Failure to prioritise life safety	Organisational	At all times
9	Poor safety culture <sup>3</sup>	Organisational	At all times

1 - Human behaviours can be differentiated by whether they are predominantly associated with individual human error, e.g. incorrect response during an incident, or more predominantly associated with organisational shortcomings, e.g. poor planning. This differentiation is not absolute, it is more nuanced.

2 - Complacency is used as defined by the Merriam-Webster Dictionary: “Self-satisfaction especially when accompanied by unawareness of actual dangers or deficiencies.”

3 - Safety culture is used as defined by the UK HSE.

# Incident data: Casualties

Date	Incident	Casualties			% fatalities
		Non-fatal	Fatal	Total	
1995-10-28	Baku	270	289	559	52%
1986-01-28	Challenger	0	7	7	100%
1996-11-18	Channel Tunnel	2	0	2	0%
2008-09-11	Channel Tunnel	14	0	14	0%
1986-04-25	Chernobyl (Note 1)	Not available	30	30	-
1988-12-12	Clapham Junction	484	35	519	7%
2003-02-01	Columbia	0	7	7	100%
2003-02-19	Daegu	151	192	343	56%
2017-06-14	Grenfell Tower	74	72	146	49%
2004-01-05	Hong Kong MTR	17	0	17	0%
2000-11-11	Kaprun (Note 2)	12	155	167	93%
1987-11-18	King's Cross	100	31	131	24%
1999-03-24	Mont Blanc	14	39	53	74%
1988-07-06	Piper Alpha (Note 3)	61	167	228	73%
1983-09-26	Soviet nuclear false alarm	0	0	0	0%
2015-01-15	WMATA Lac L'Enfant Plaza	91	1	92	1%

1. Fatalities for incident only. Chernobyl total casualty figures are debated due to uncertainty over long-term effects on the global population. Estimates have ranged from 4000 to as high as 60000. 4000 is the current estimate for the eventual fatalities. Non-fatal casualty data is not available.
2. Kaprun non-fatal injuries not reported; figure listed is total number of survivors.
3. Piper Alpha non-fatal injuries not reported, other than a number of survivors were burned; figure listed is total number of survivors.

# Incident summaries

Media reports immediately, but often not the true story

However, public inquiries uncover the full facts

Public inquiry reports record the facts in detail

It is valuable to read the original source reports

If these are not available, there may be published research

Otherwise media reports have to be used



# Disaster: Kaprun Tunnel fire, 2000

Funicular rail fire; 155 fatalities

Unauthorised fan heater in driver cabin (at low end of train)

Overheated and ignited

Train stopped in tunnel

Fire spread to train and ignited hydraulic fluid

Power & hydraulic pressure lost

Delay in opening the doors

(Eventually manually unlocked then forced)

No extinguishers or smoke detection in cabin

No comms in cabin

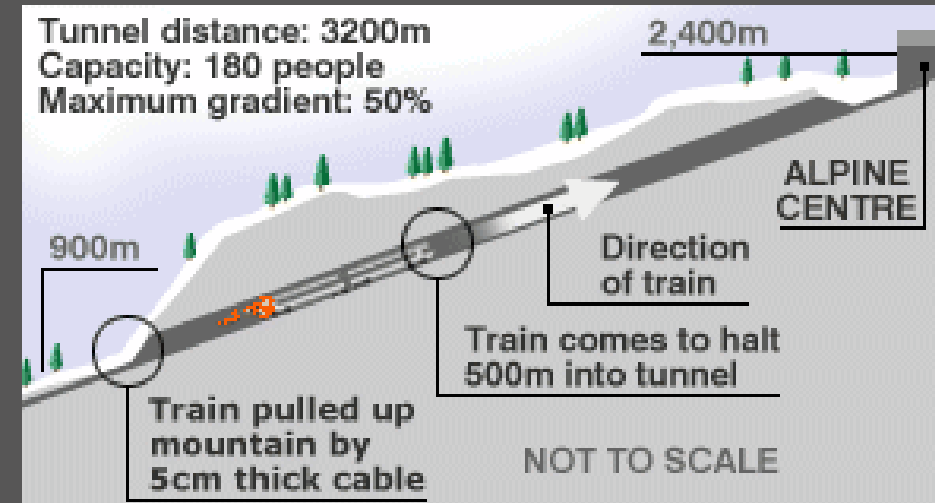
Workers in the Alpine Centre evacuated but left an exit door open

Chimney effect rapidly spread fire upwards

All who tried to evacuate upwards died

The few who evacuated downwards survived

Strong evidence of poor safety culture



# Major incident: Channel Tunnel, 1996

Train entered tunnel with an HGV with a load on fire

HGV railcars designed open-sided

Fire growth due to supply of oxygen through the open railcar

Incident was major, with significant damage

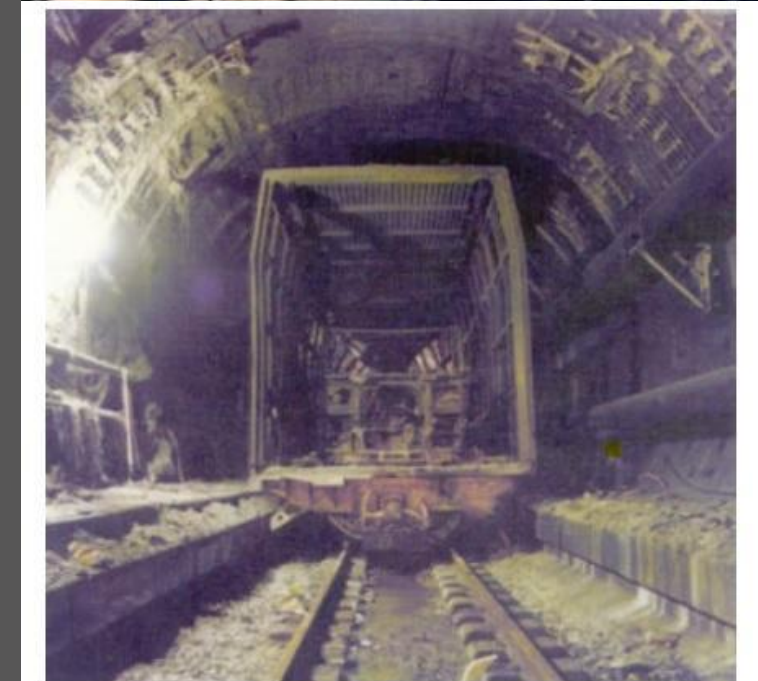
Safety systems functioned properly

Emergency response had a few issues but well-executed overall

Only 2 injuries reported:

- 2 first responders, no passengers or crew injured
- no fatalities

Evidence of good safety culture



# Near miss: Soviet nuclear attack early-warning system, 1983

September 26, 1983

Soviet early warning computers detect launch of a US ICBM  
Followed by 5 more...

Soviet MAD policy :

*Officer in charge (OIC) of detection system to report this immediately to superior officers ;*

*Massive retaliatory strike to be initiated automatically.*

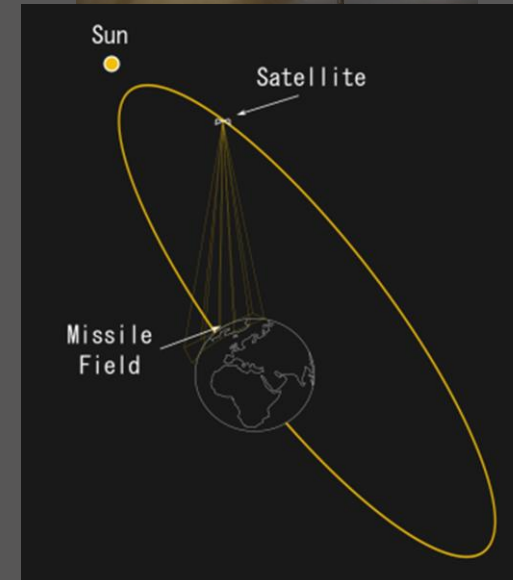
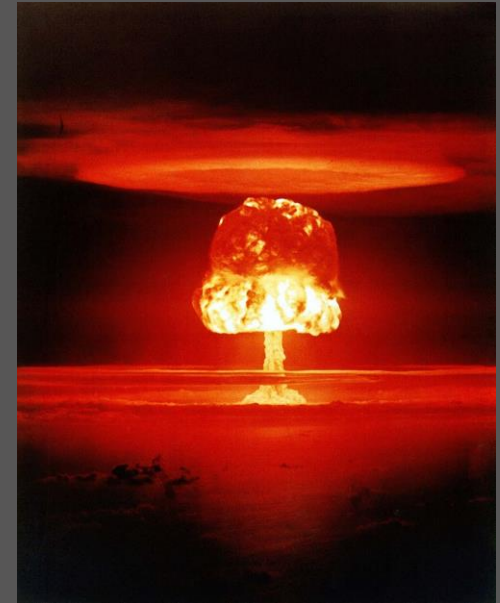
Stanislav Petrov, the OIC, did not report any ICBM launch :

- *He believed a US first strike would be massive, not a mere 6 missiles*
- *The satellite-based computer system was new and had misbehaved previously*
- *There were no corresponding reports from any ground-based radar*

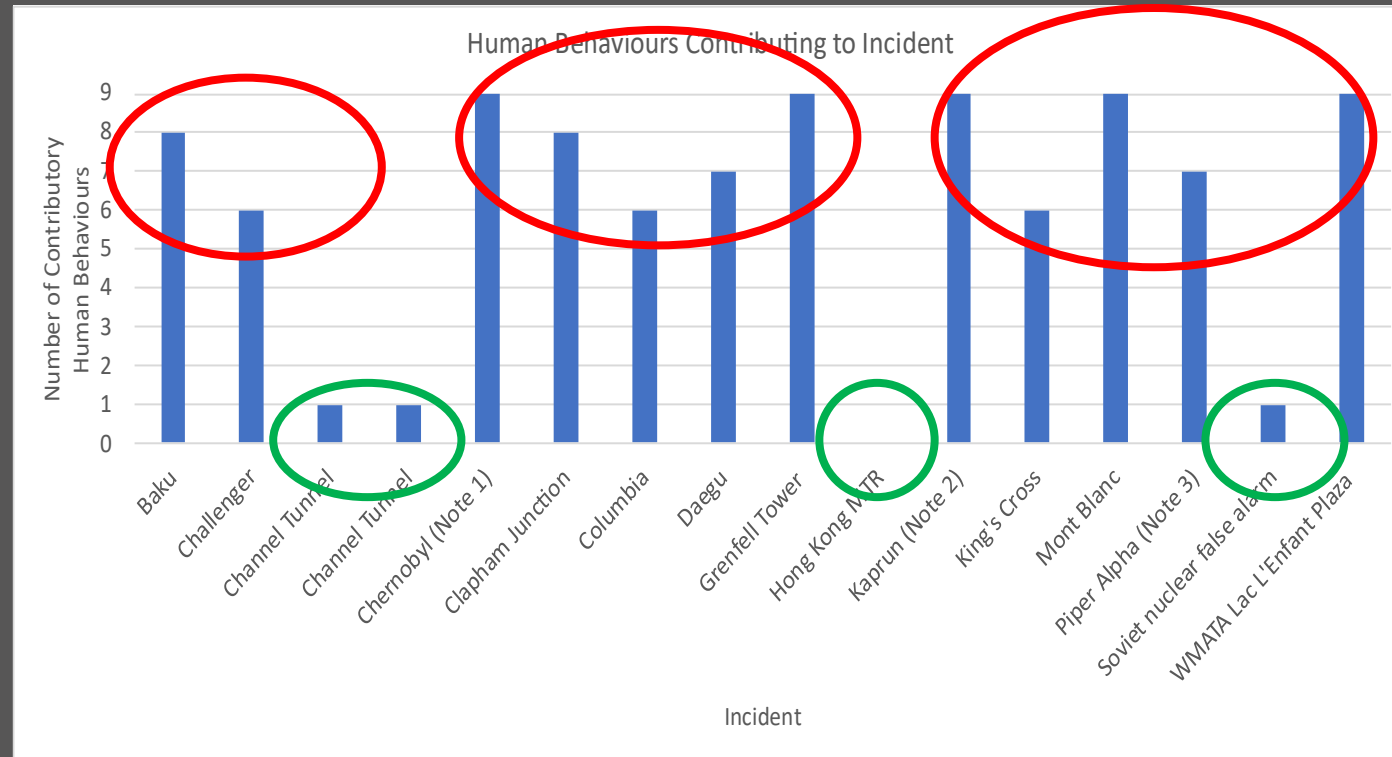
No missiles ever arrived on Soviet soil

Later analysis showed the error resulted from :

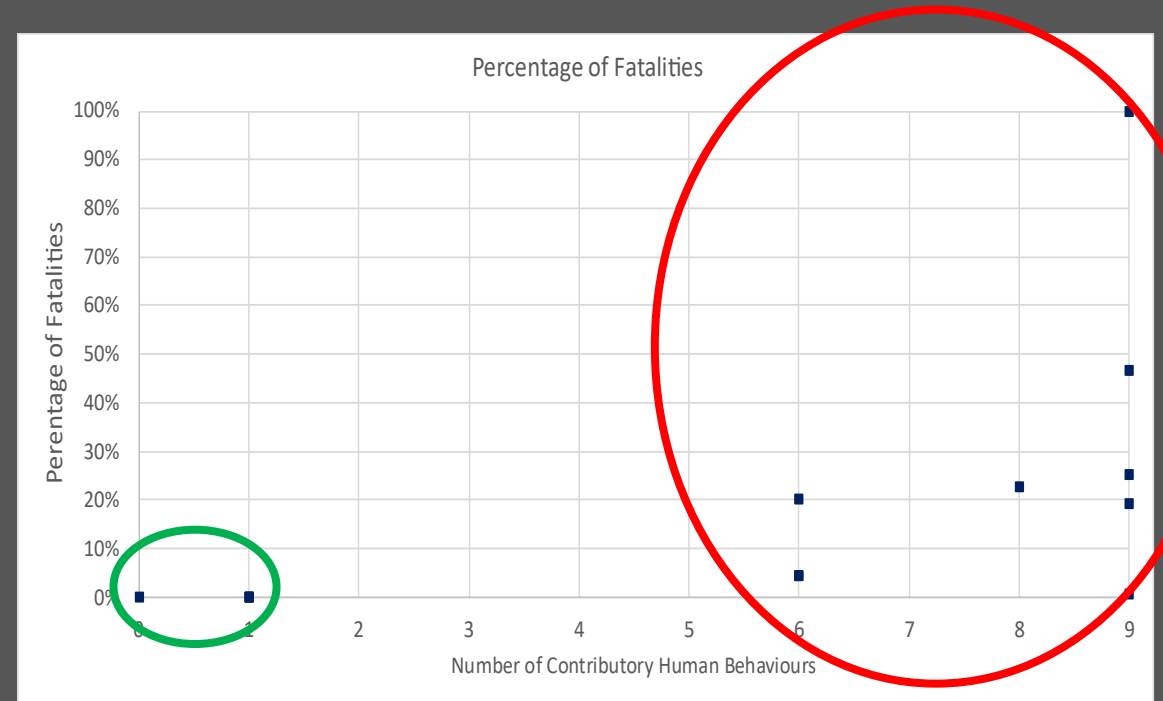
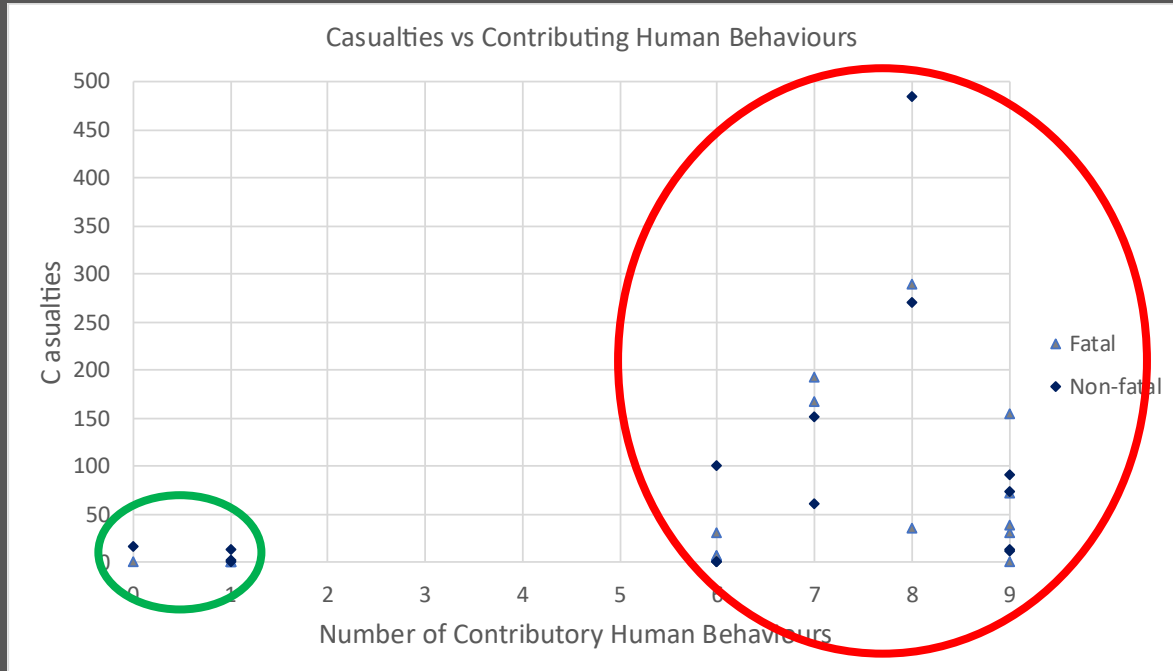
- *Satellite's extreme Molniya orbit and*
- *Sunlight on high altitude clouds*



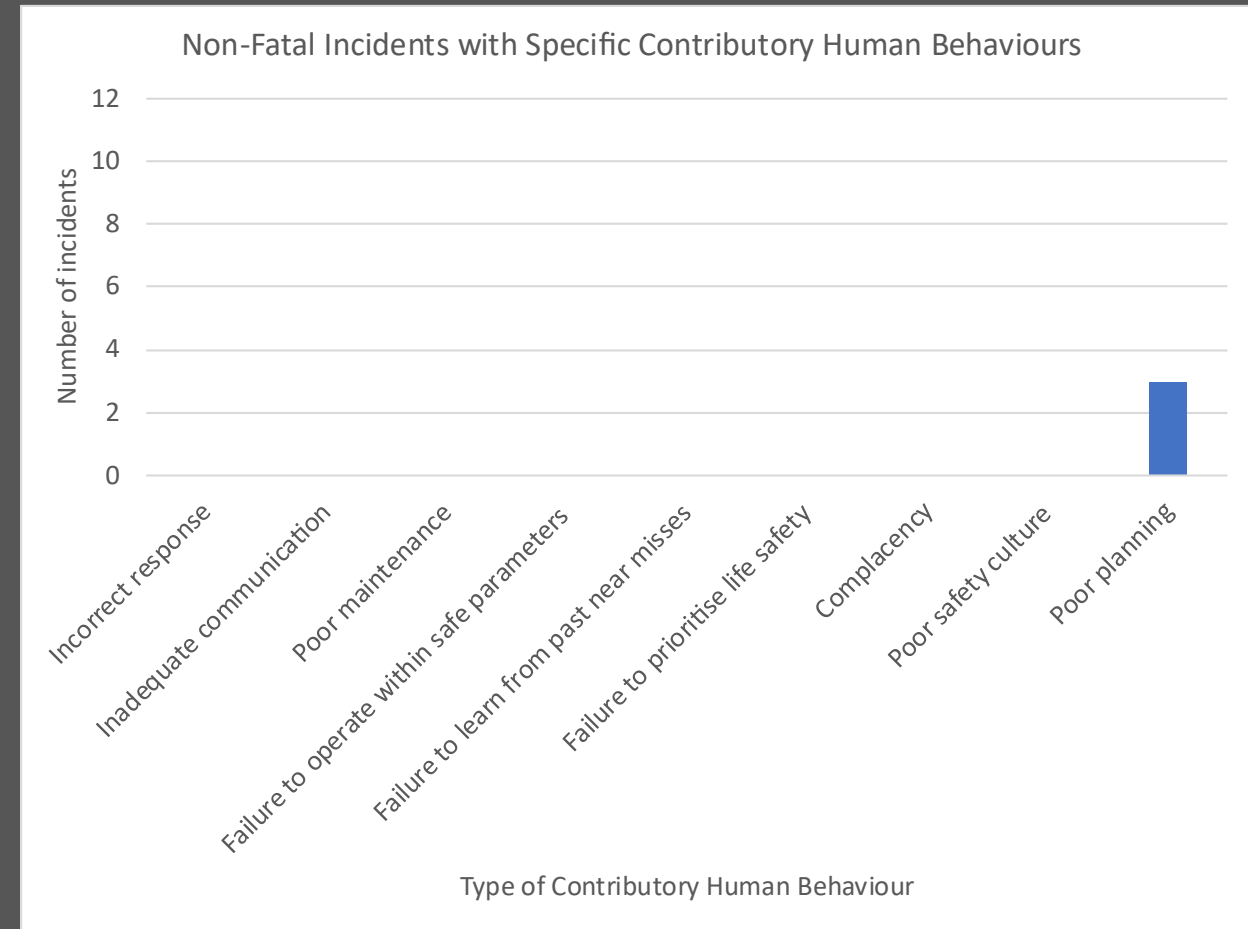
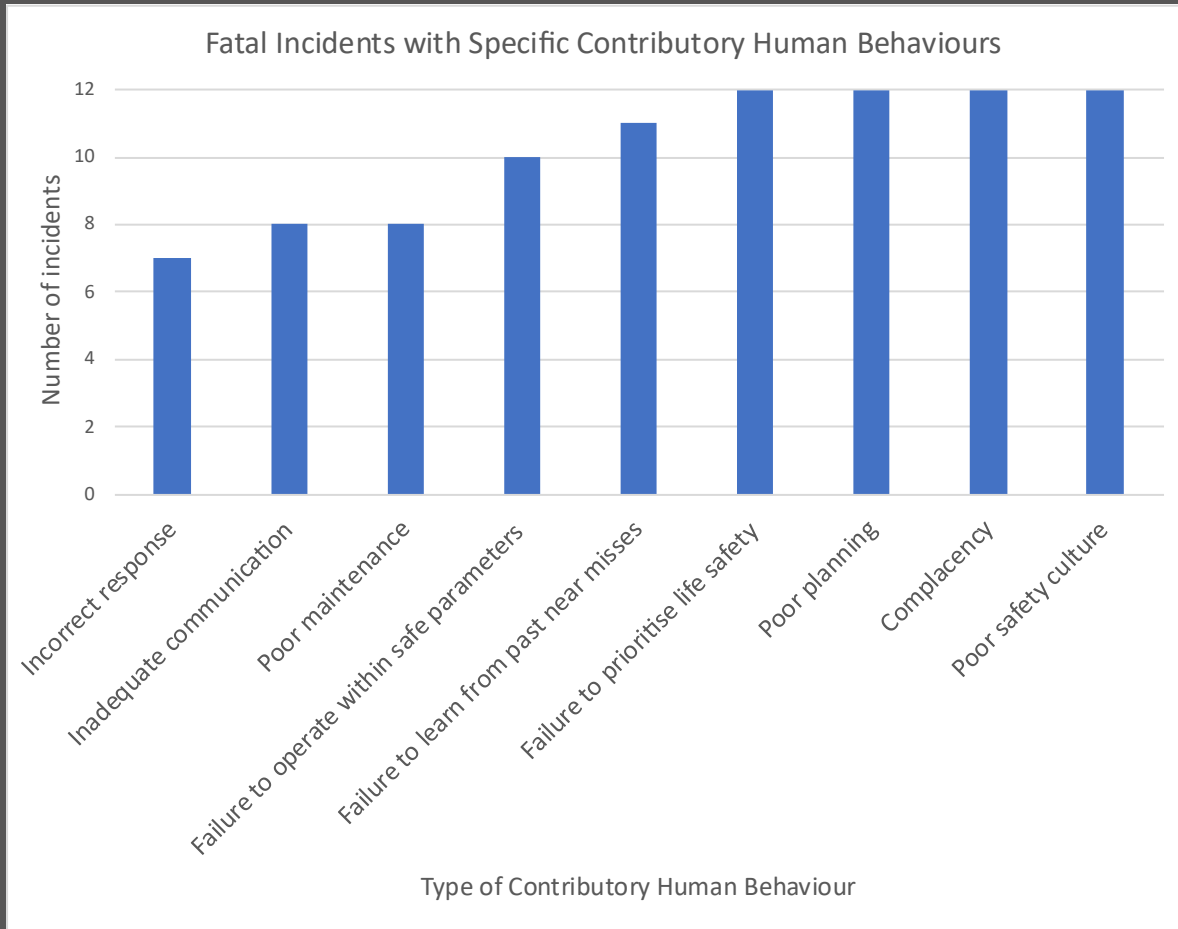
# Human behaviours assessed to contribute to incident



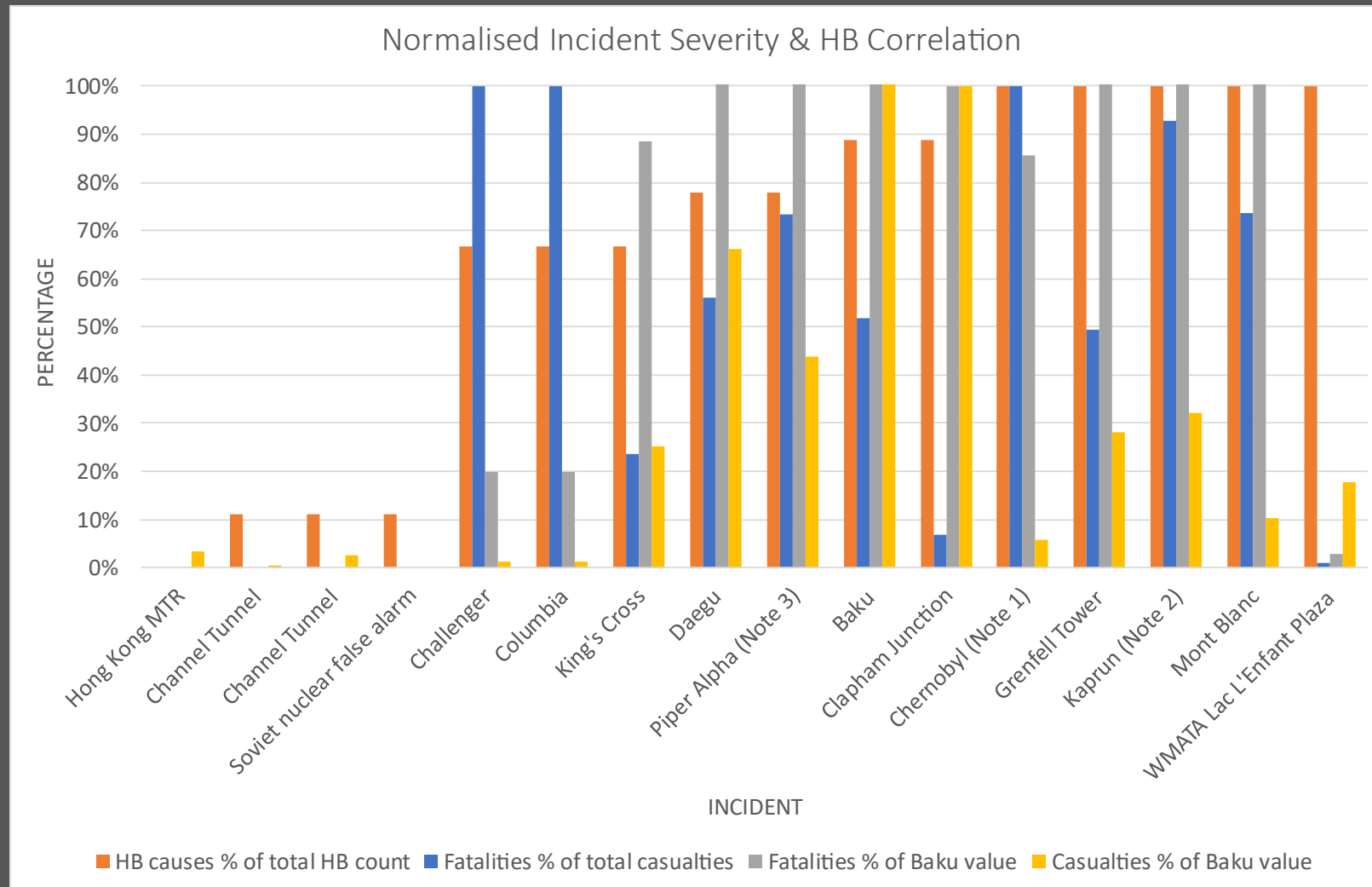
# Casualties



# Human behaviours correlation with fatality occurrence



# Normalized severity with human behaviours (HB) correlation



# Accident model discussion

## Non-fatal incidents

Non-fatal incidents appear to be adequately described by a linear model

The incident occurs due to some pre-existing factor which enables incident initiation

Layers of protection before, and during the incident mitigate the consequences

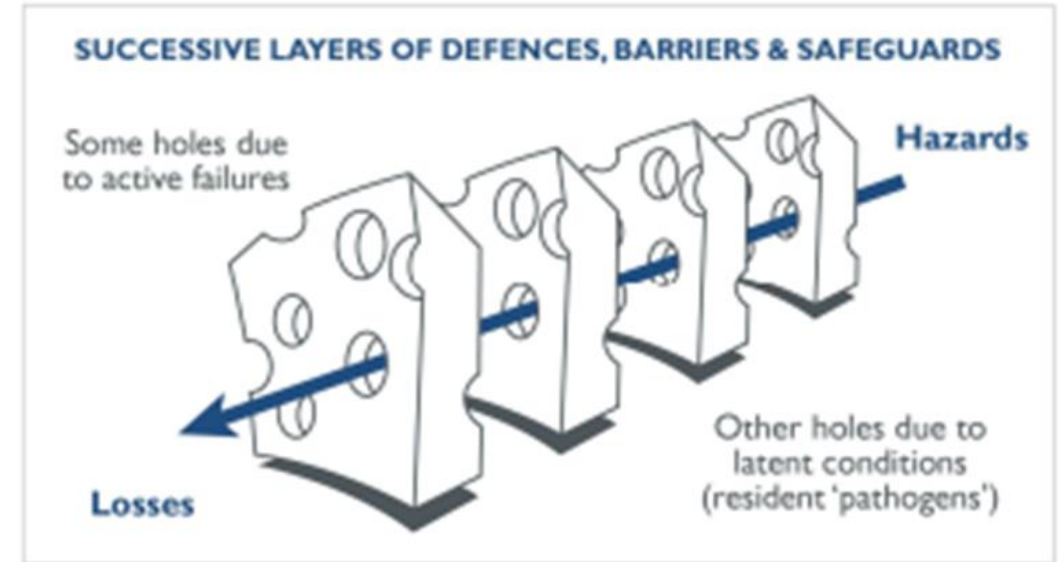


Figure 6: Reason's 'Swiss Cheese' Model (modified from Reason, 2008 p.102)

# Accident model discussion

## Fatal incidents

Fatal incidents and disasters appear to better fit a non-linear model

The asset starts with a 'safe operating space' with boundaries and the asset operates well within the boundaries

In each case, over time, human behaviours influence the actual operating point in that space

Thus the actual operating point drifts toward the boundary of the space, and then...

The proximate cause pushes the asset irretrievably outside the safe space and disaster follows

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J. Rasmussen

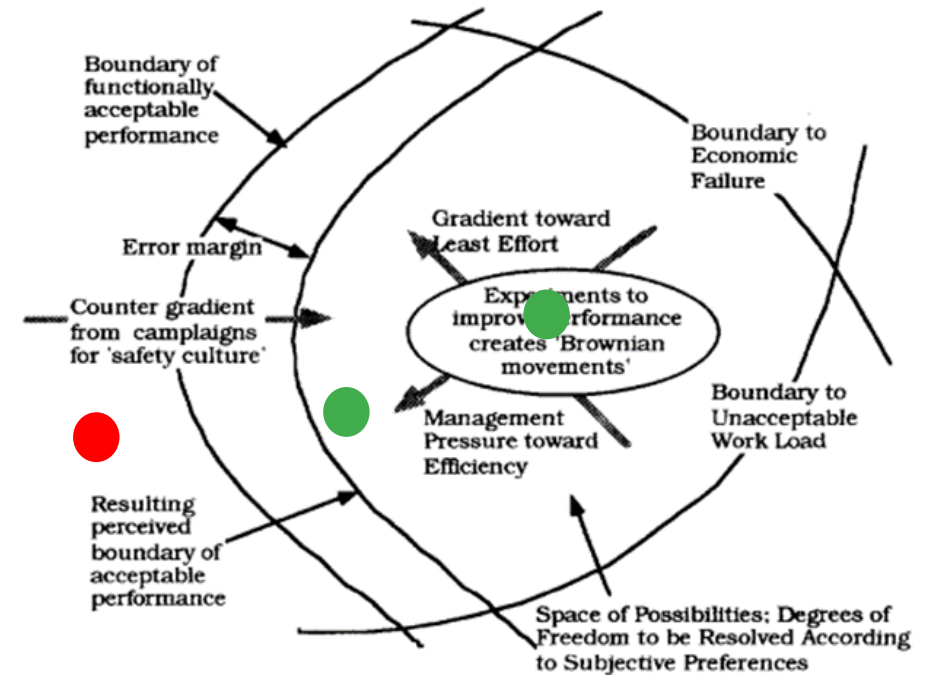


Fig. 3. Under the presence of strong gradients behaviour will very likely migrate toward the boundary of acceptable performance.

# Opportunities for further research

This preliminary study used a limited number of case histories, and so the data set is relatively sparse

Extension of the data set by reviewing additional case histories could:

- Improve confidence in the findings
- Yield more insight into the role(s) that specific human behaviours can have in a disaster
- E.g. are there specific behaviours that are most commonly associated with incident escalation?

Such insights could assist operators with future safety planning – i.e. are such behaviours already present in their system?



# Coda: How South Korean transit learned from a disaster

## 2003 Daegu Metro disaster vs 2025 Seoul Metro incident

2003



Consider two separate arson incidents in South Korea:

- 2003 Daegu: 192 fatalities, 343 total casualties
- 2025 Seoul: 0 fatalities, 23 minor casualties
  - <https://www.bbc.co.uk/news/videos/cn810xk11jeo>

Both major arson attacks involving accelerants

The primary difference?

- 2003 rolling stock was not constructed to modern fire resistance standards → PHRR ~ 70-100MW
- 2024 rolling stock was! (EN 45545) → PHRR ~ 2-4MW

There were also improvements in training, communications and response planning

Result:

- 2025 fire self-extinguished when the accelerant was fully consumed as the train materials did not support flame spread
- Everyone survived, with a small number of minor casualties only

2025



# Summary

16 events studied

Disaster occurrence appears to be linked to human behaviours

Incidents appear to escalate only if multiple human behaviours are present

This is observed across sectors and asset types

Human behaviours appear to be asset-independent common causes in escalation from incident into disaster





**Thank you**

