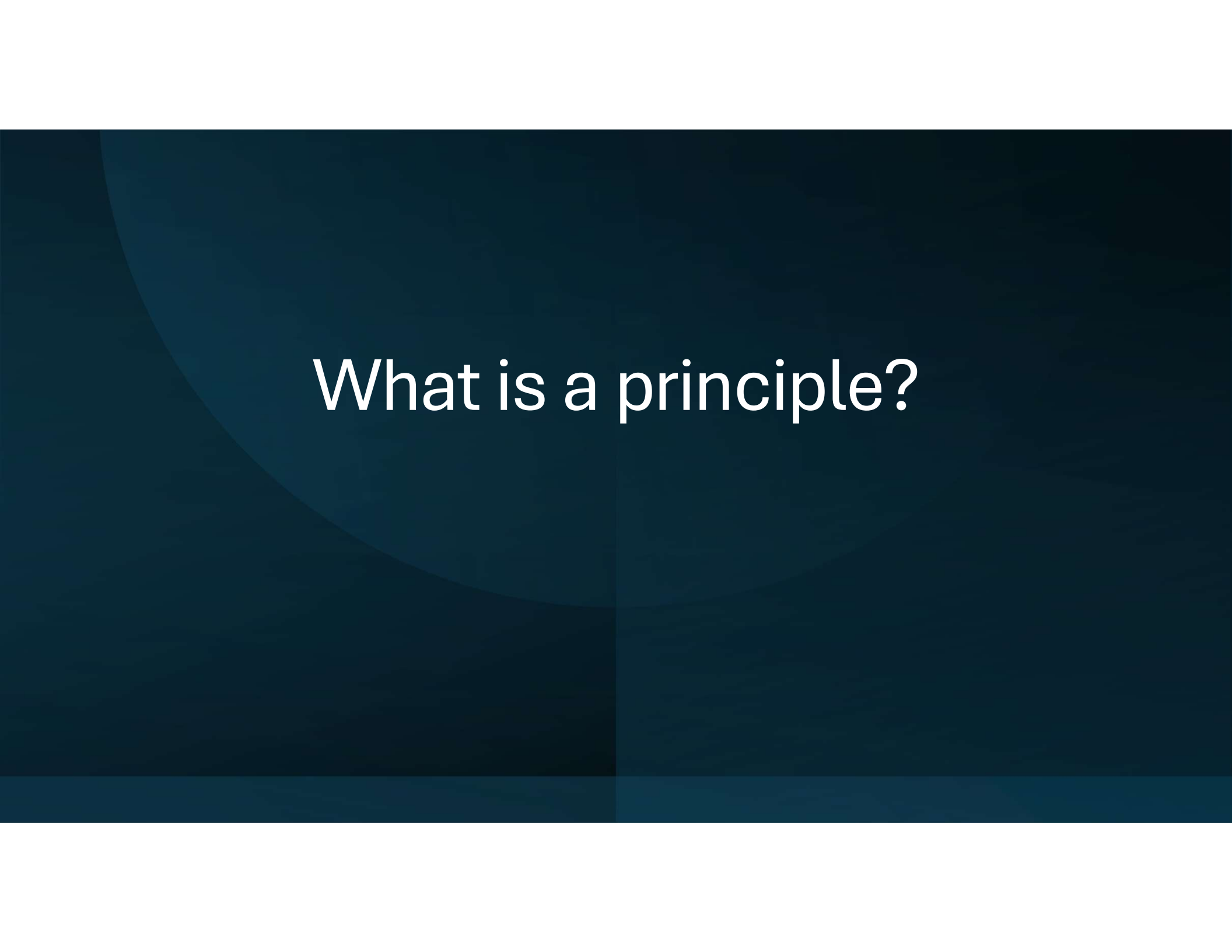


Exploring FRAM Principles in US Chemical Safety Board Investigations using Models Built by the FRAM

Michael Behm, PhD CSP
Keene State College

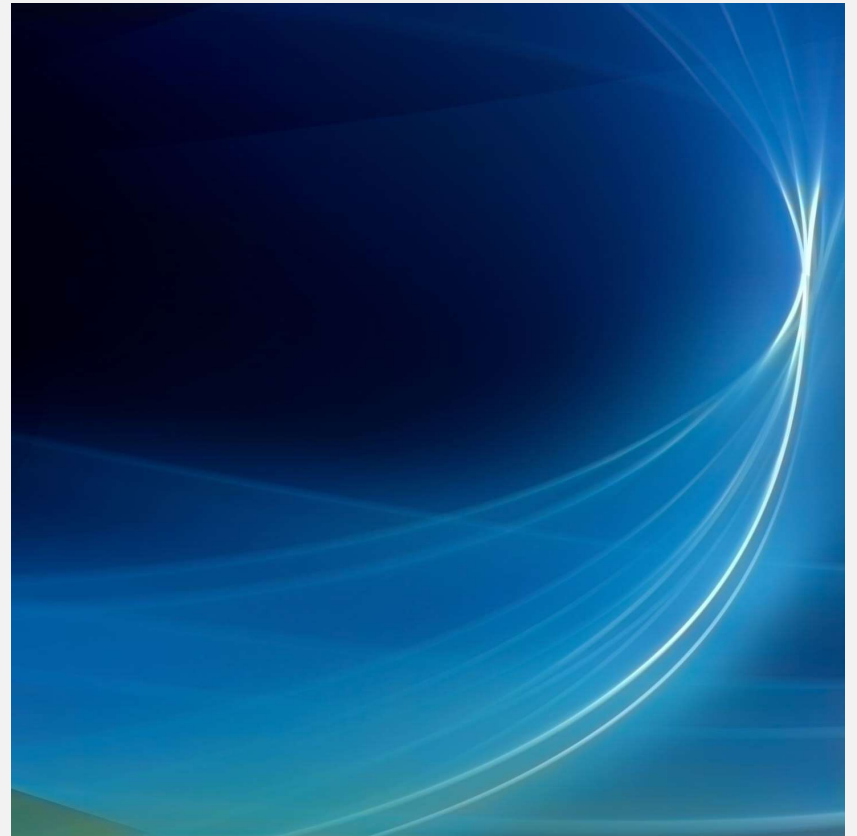


What is a principle?

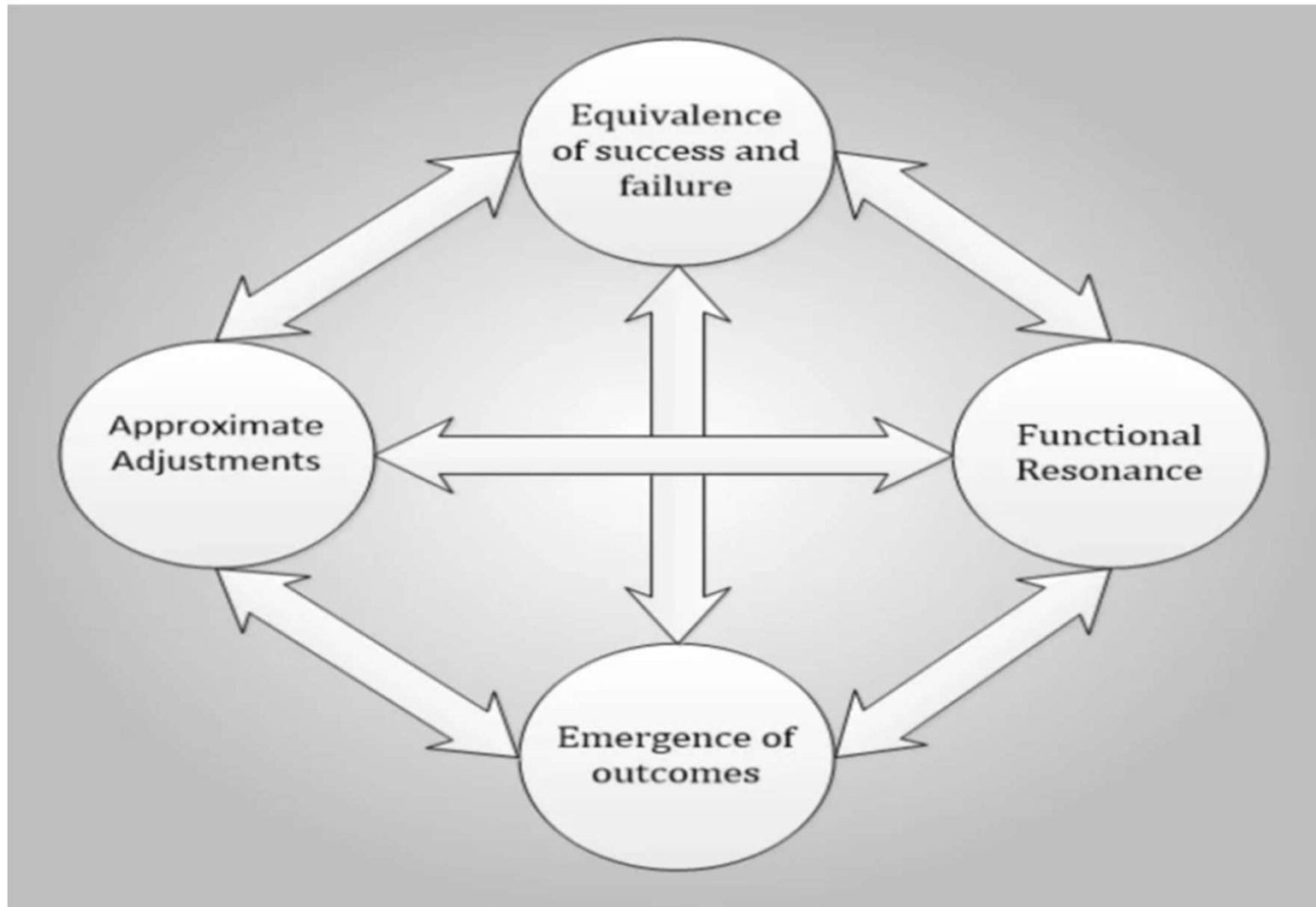
Principle

A general, foundational truth or mechanism that guides specific systems.

A principle tells us **why** and **how** things happen.



What are the four FRAM principles?



The four principles of Functional Resonance Analysis Method (FRAM) [19].

Pedro's Keynote

The interesting thing is not the model but the act of thinking to get to constructing the model.

It's the experience not the end model.

FRAM is a means to socially construct the reality.

Should we investigate
accidents?

Do we learn from
accident investigation?

Some concepts

- Accidents emerge from the dynamic coupling of functions, where local adjustments align and produce unexpected system-level effects.

Steen, R. and Johnson, S. O. (2026). A maturity model for accident investigation: beyond technical and functional analysis. *Safety Science*, 196, 107108.

- WYLFIFYF

Lundeberg, J., Rollenhagen, C., and Hollnagel, E. (2009). What-You-Look-For-Is-What-You-Find – The consequences of underlying accident models in eight accident investigation manuals. *Safety Science*, 47, 10, 1297-1311.

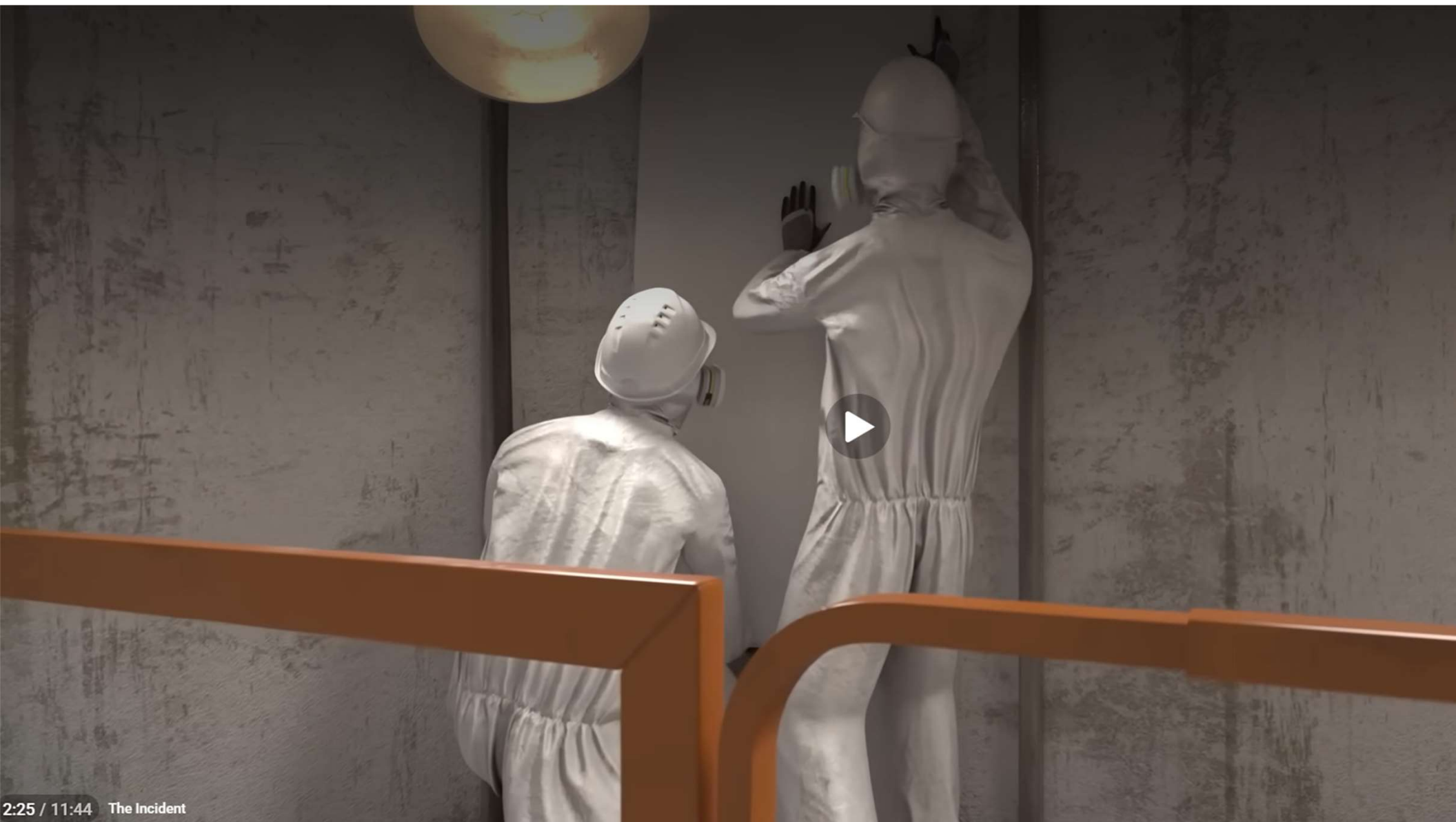
The primary limitation to
this research is
_____ bias.

The primary limitation to
this research is
HINDSIGHT bias.

Background

- US Chemical Safety Board
- Fire During Hot Work at Evergreen Packaging Paper Mill
- Show website!
- Then the model built by FRAM





2:25 / 11:44 The Incident

A FRAM requirements analysis for Safety Differently investigations

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ABSTRACT

The present study reports on the transition of a critical incident investigator group within a University Medical Center to a Safety Differently paradigm. The most salient findings of this transition relate to the requirements that investigators themselves identify for the success of Safety Differently investigations in their institution. We conducted a FRAM (Functional Resonance Analysis Method) analysis of the requirements related to inputs, outputs, time, control, preconditions and resources for a successful Safety Differently investigation. The findings are applicable to Safety Differently investigations independent of the domain in which they might take place. The results show a critical need of training, coaching, time, human resources and commitment of institutional leaders for the transition to Safety Differently investigations.

Table 1
 a contrast between traditional root cause investigations and safety differently investigations. Inspired by [Lay \(2019\)](#).

Traditional Root Cause Investigations	Safety Differently Investigations
What went wrong?	How does this normally go right?
What rules or protocols were violated?	What is the distance between work-as-imagined versus work-as-done, and how does the latter normally control hazard?
What should people have done?	What sacrifice judgements did people make?
What factors made it worse or better?	What tight and loose couplings influenced incident progression over time?
What must we fix so that it doesn't go wrong again?	What capacities must be enabled or empowered to make things go well?

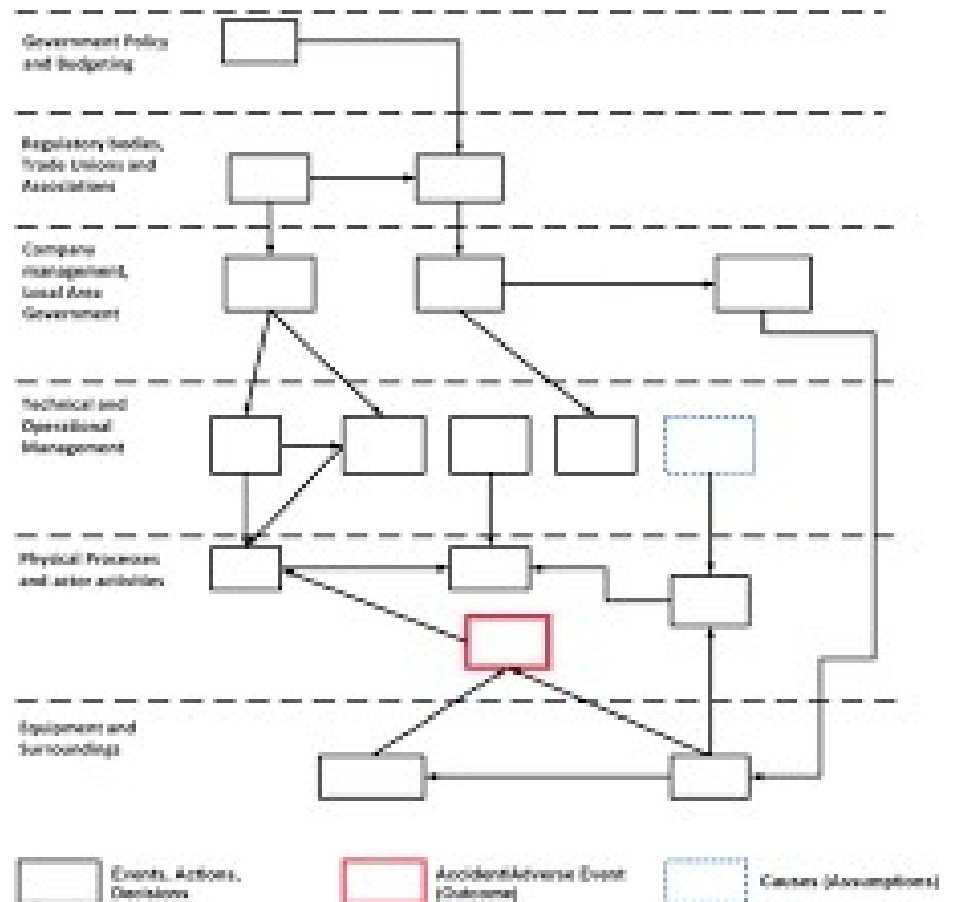
Lay, B. 2019. The Beth Lay Toolbox. In: Paper Presented at the 8th Resilience Engineering Association Symposium, 24–27 June 2019, Kalmar, Sweden. There is no such paper archived by REA. I contacted Beth Lay on LinkedIn and she has replied but not with this article.

Referenced by:

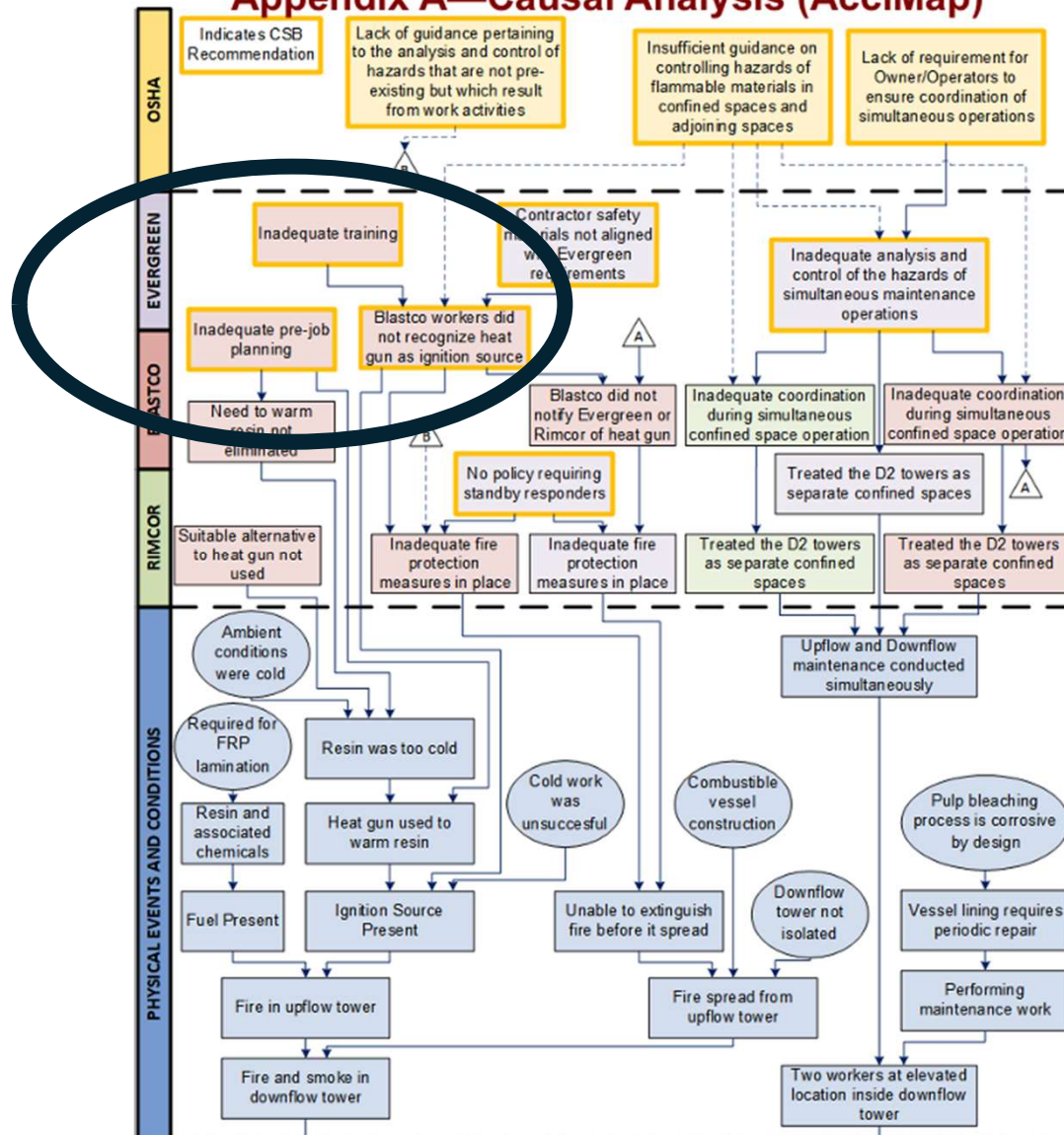
Meeuwis C.J. et al. (2020) A FRAM requirements analysis for Safety Differently investigations, Safety Science, 125, 104653.

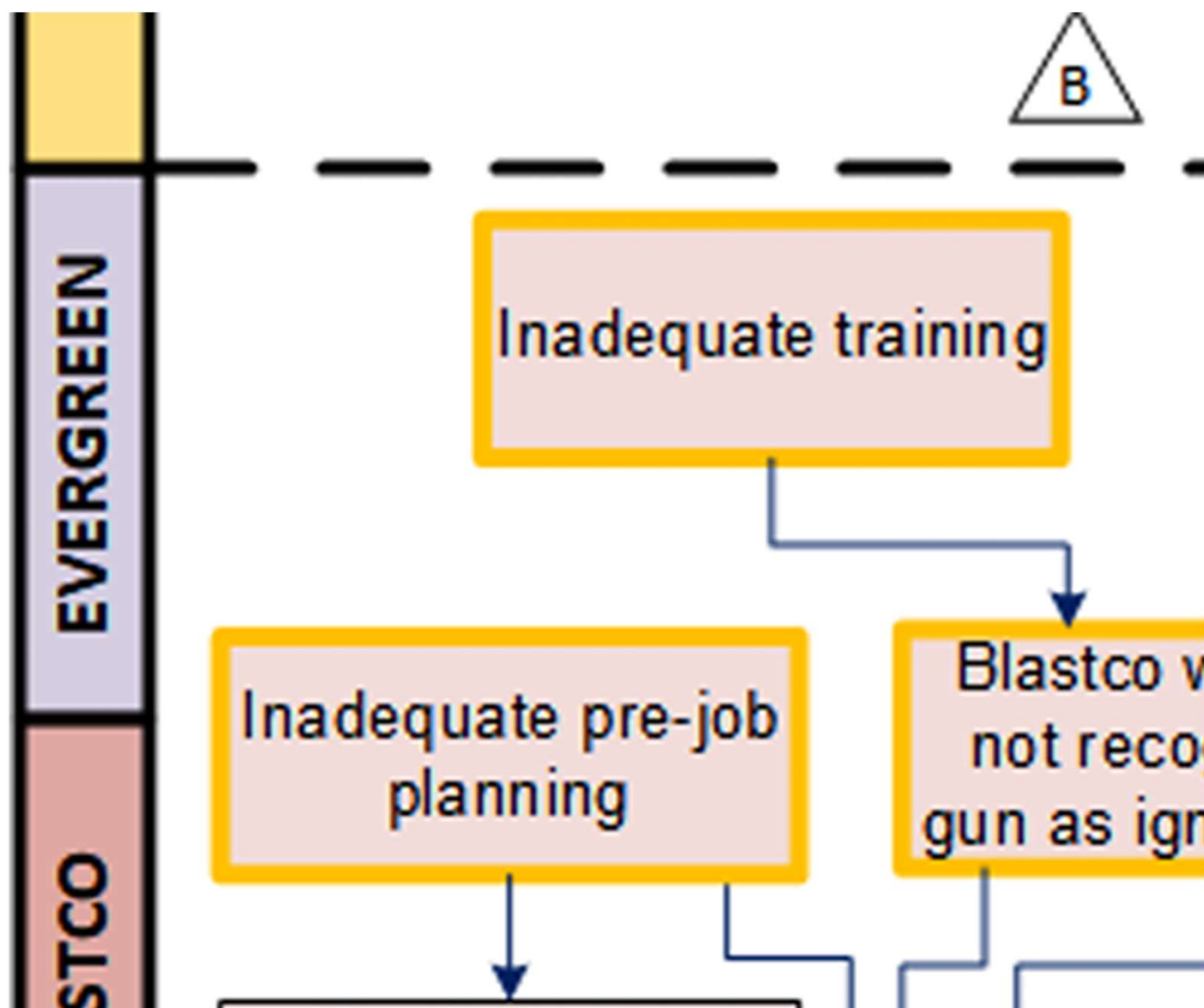
AcciMap

- An AcciMap maps contributing factors across multiple socio-technical layers and the causal relationships between them.
- AcciMap method introduced as part of _____ risk management framework.
- CSB has used AcciMap since around 2014.



Appendix A—Causal Analysis (AcciMap)





I hypothesize there is some contribution that FRAM based thinking could have in accident investigations to facilitate learning

Equivalence of successes and failures



Equivalence of successes and failures

- A safety differently investigation would have asked about the capacities necessary to make the task go well with the heat gun.
- It would have clarified under what conditions heat guns were used with FRP application in the past.



Approximate adjustments

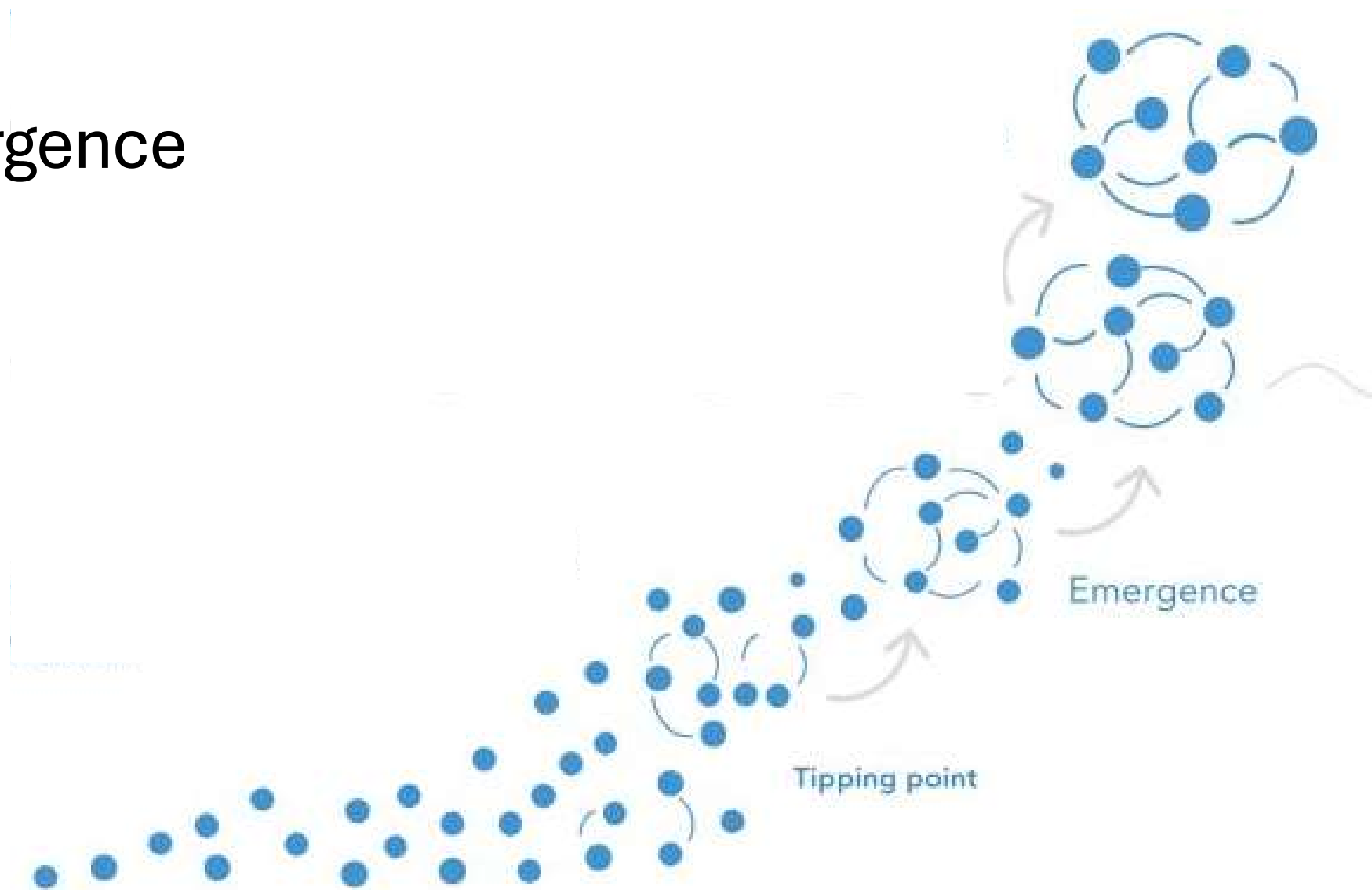


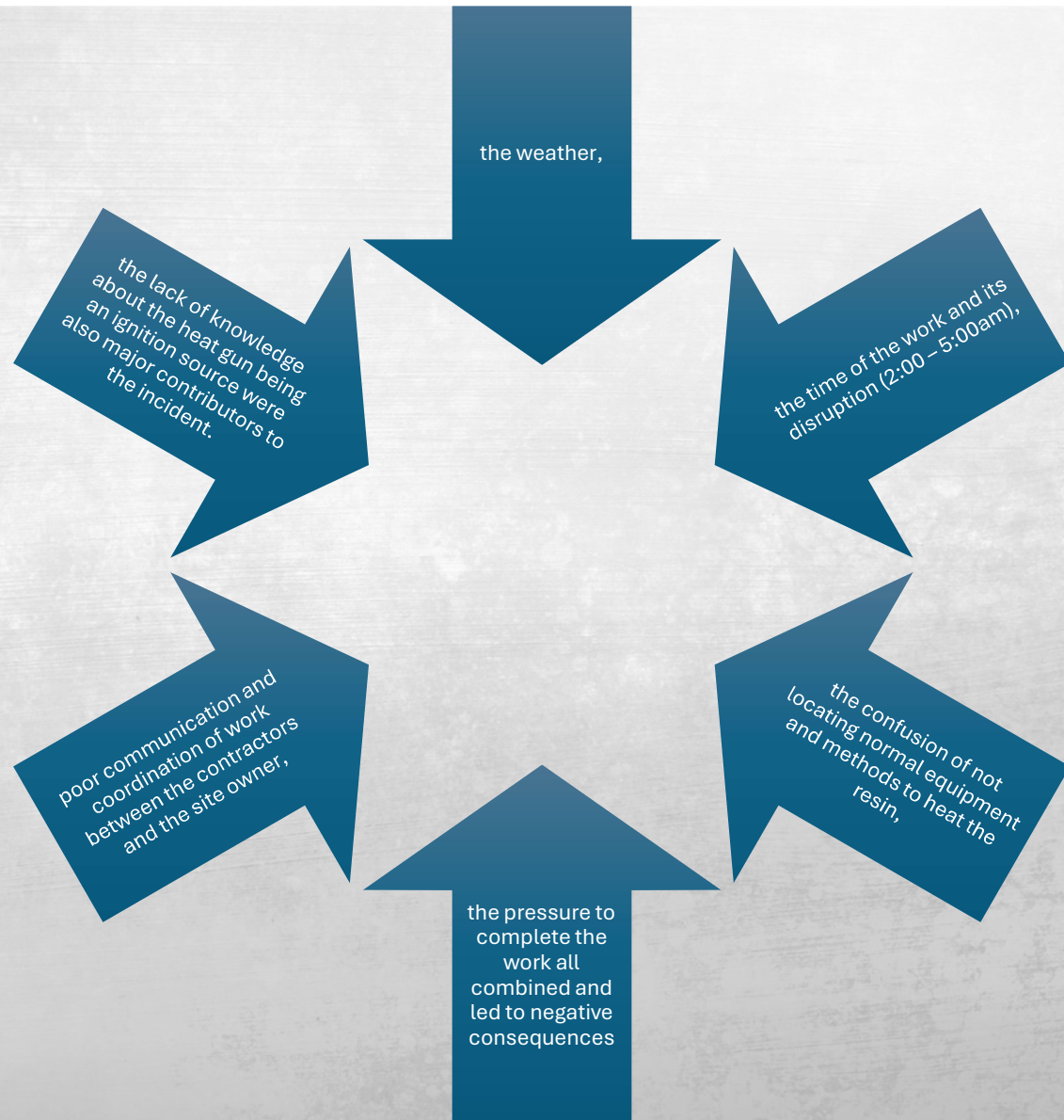
Approximate adjustments

- Understanding this principle encourages the analyst to focus on how people cope with complexity, rather than trying to enforce compliance with ideal procedures.
- A FRAM informed Safety Differently investigation would have asked when they began the resin application operation and what adjustments had to be made in the present situation and for how long this had been occurring.
- It also would have inquired about previous resin applications and the use of a heat gun and under what conditions.

Emergence

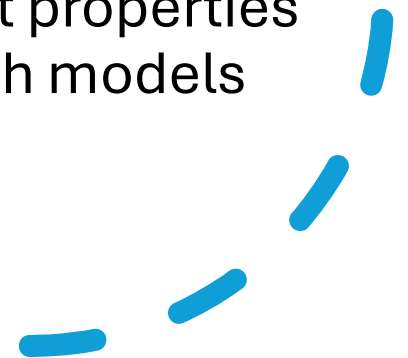
Emergence





Emergence

- A FRAM informed Safety Differently investigation would have asked what sacrifice judgements the workers made in their attempts to keep the job going and on schedule and determined how the interplay of these activities, resources, and operating conditions resulted in the emergent outcome.
- It is contended these emergent properties could have been described with models built by FRAM.



Easy to find in hindsight!!!

Functional Resonance

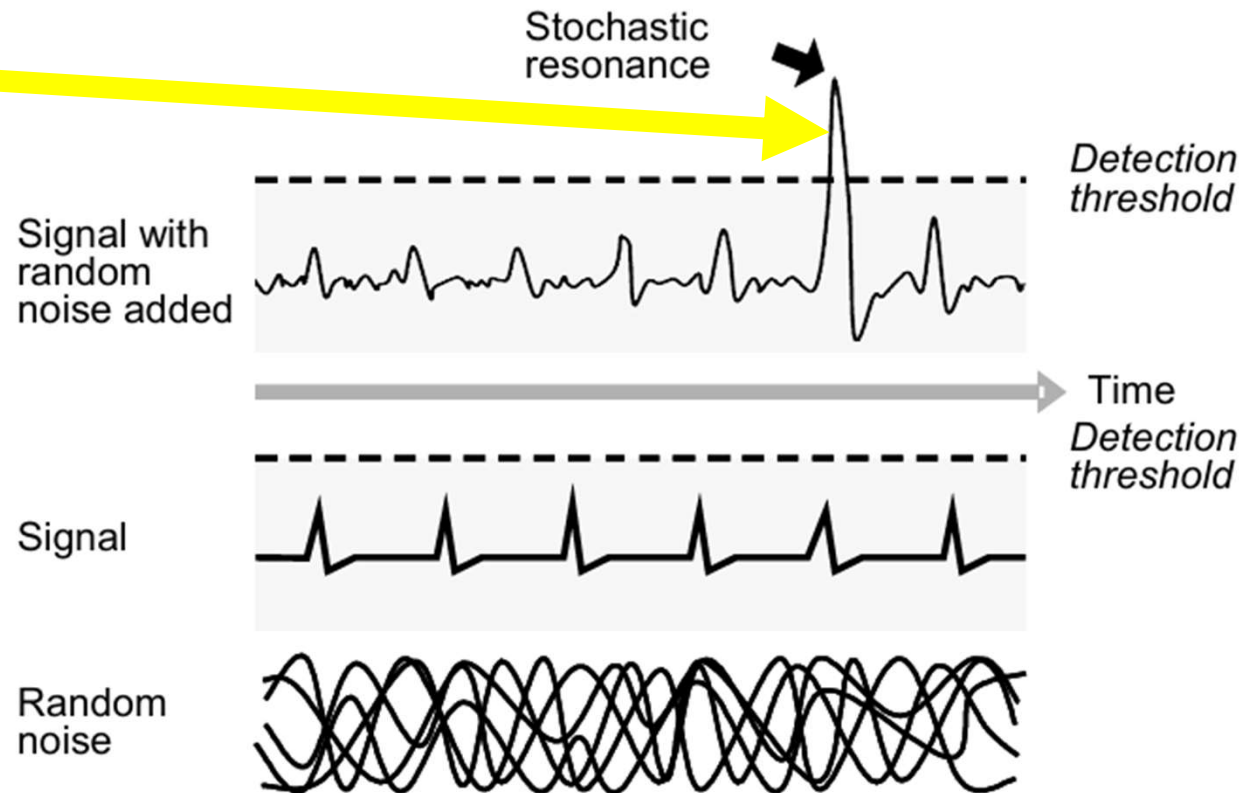
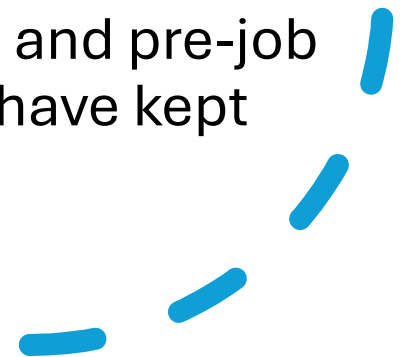


Figure 1: Stochastic resonance

Hollnagel, E. and Goteman, Ö. (2004) The Functional Resonance Accident Model. Cognitive Systems Engineering in Process Control, Sendai, Japan, 4-5 November 2004.

Functional Resonance

- A FRAM informed Safety Differently investigation would have asked what systemic conditions produced their simultaneous convergence and what organizational capacities would need to be strengthened to ensure they never again align.
- The answer points to the connection between existing capacities of coordination, communication, and pre-job planning functions that would have kept these dampeners active.



If our accident causation and investigation models do not include these four principles we may never move from hindsight to foresight

Show the FRAM model and
how I hope to use Niklas'
improved version

Where to
from here...

Analyze additional CSB investigations and incorporate the four principles and complexity thinking

Develop more general FRAM / Safety Differently questions that investigators could use



Seeking collaborators

Additional coders and thinkers

Thank you!

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