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Introduction to FRAM -
The Four Underlying Principles

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Principles for the FRAM

- I -
THE PRINCIPLE OF EQUIVALENCE OF SUCCESSES AND FAILURES

- II -
THE PRINCIPLE OF APPROXIMATE ADJUSTMENTS

- III -
THE PRINCIPLE OF EMERGENCE

- IV -
THE PRINCIPLE OF FUNCTIONAL RESONANCE

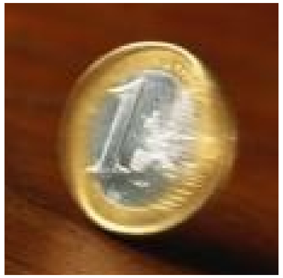
I - Equivalence of success and failures

Failure is normally explained as a breakdown or malfunctioning of a system and/or its components.

This view assumes that success and failure are of a fundamentally different nature.

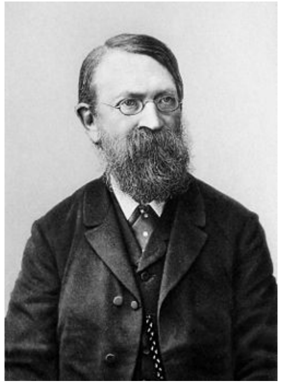
Resilience Engineering recognises that individuals and organisations must adjust to the current conditions in everything they do. Because information, resources and time always are finite, the adjustments will always be approximate.

- Success is due to the ability of organisations, groups and individuals correctly to make these adjustments, in particular correctly to anticipate risks before failures and harm occur.
- Failures can be explained as the absence of that ability – either temporarily or permanently.

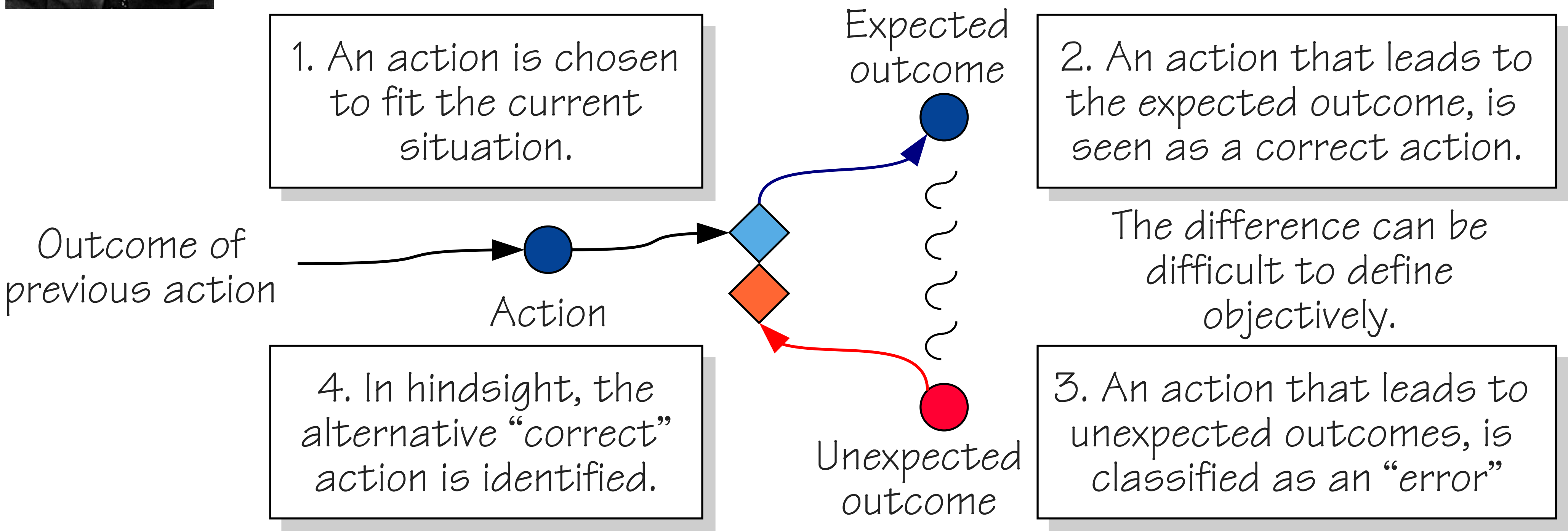


The aim of Resilience Engineering is to strengthen that ability, rather than just to avoid or eliminate failures.

Actions and “errors”



"Knowledge and error flow from the same mental sources, only success can tell one from the other."
(Ernst Mach, 1838-1916)



II: Approximate adjustments

Availability of resources (time, manpower, materials, information, etc.) may be limited and uncertain.

People adjust what they do to match the situation.

Performance variability is inevitable, ubiquitous, and necessary.

Because of resource limitations, performance adjustments will always be approximate.

Performance variability is the reason why everyday work is safe and effective.

Performance variability is the reason why things sometimes go wrong.

Efficiency-Thoroughness Trade-Off

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Thoroughness: Time to think

Recognising situation.
Choosing and planning.

If thoroughness dominates, there may be too little time to carry out the actions.

Neglect pending actions
Miss new events

Efficiency: Time to do

Implementing plans.
Executing actions.

If efficiency dominates, actions may be badly prepared or wrong

Miss pre-conditions
Look for expected results

Time & resources needed

Time & resources available

Some ETTO heuristics

Cognitive (individual)

Judgement under uncertainty

Cognitive primitives (SM – FG)

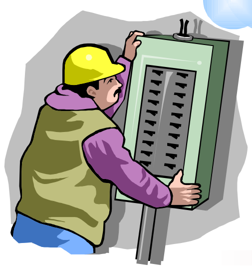
Reactions to information input overload and underload

Cognitive style

Confirmation bias

Idiosyncratic (work related)

Looks fine
Not really important
Normally OK, no need to check
I've done it millions of time before
Will be checked by someone else
Has been checked by someone else
This way is much quicker
No time (or resources) to do it now
Can't remember how to do it
We always do it this way
It looks like X (so it probably is X)
We must get this done
Must be ready in time
Must not use too much of X



Collective (organisation)

Negative reporting

Reduce redundancy

Meet "production" targets

Reduce unnecessary cost

Double-bind

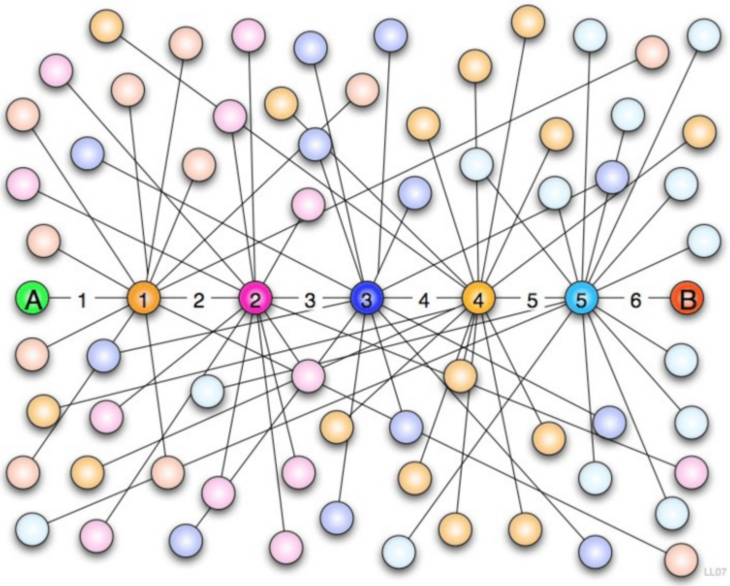
Reject conflicting information

III - Principle of emergence

The variability of normal performance is rarely large enough to be the cause of an accident in itself or even to constitute a malfunction.

The variability from multiple functions may combine in unexpected ways, leading to consequences that are disproportionally large, hence produce non-linear effects.

Both failures and normal performance are emergent rather than resultant phenomena, because neither can be attributed to or explained only by referring to the (mal)functions of specific components or parts.

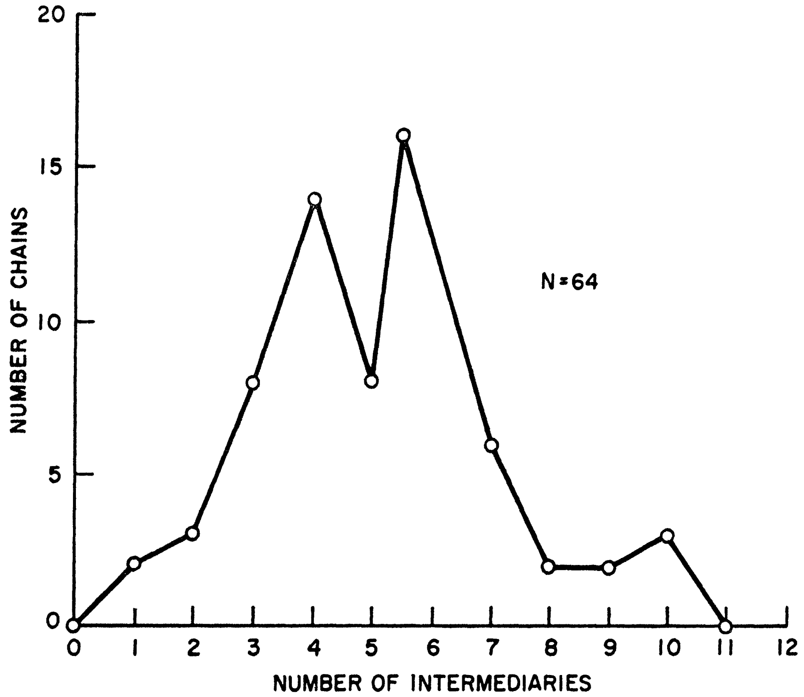


The Small World Problem

Socio-technical systems are intractable because they change and develop in response to conditions and demands. It is therefore impossible to know all the couplings in the system, hence impossible to anticipate more than the regular events. The couplings are mostly useful, but can also constitute a risk.

The small world problem

What is the probability that any two persons, selected arbitrarily from a large population, will now each other, or be linked via common acquaintances?



A "target person" (Boston) and three groups of "starting persons" were selected (Nebraska: n=296, Boston: n=100). Target was identified by name, address, occupation, place of work, college & graduation year, military service, wife's maiden name, hometown. Each starter was given a document and asked to move it by mail toward the target, via first-name acquaintances, who was asked to repeat the procedure.

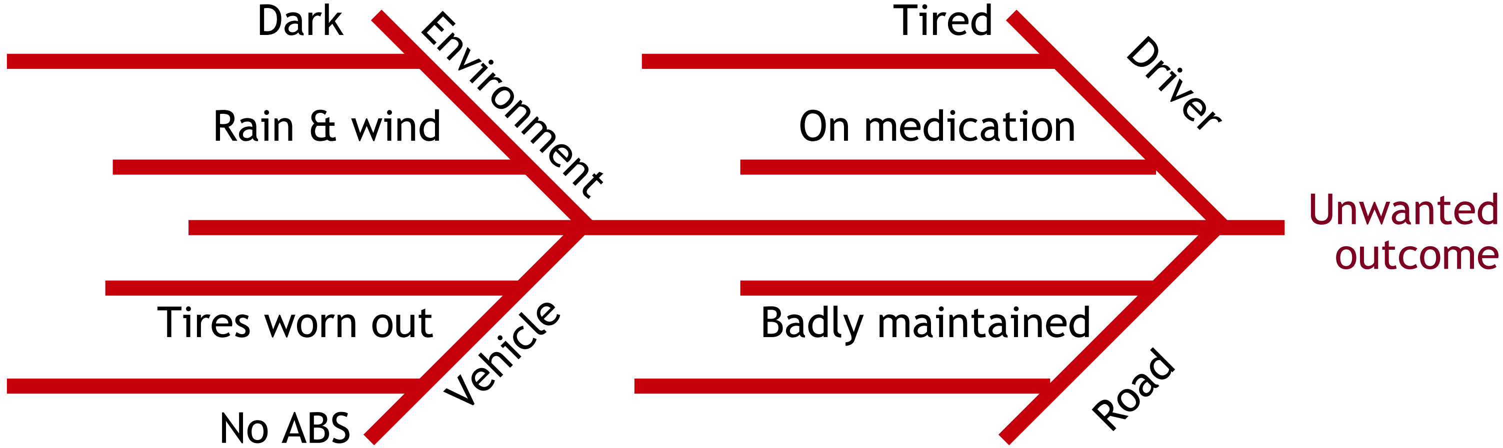
Stanley Milgram (1933-1984)

Travers & Milgram (1969). An experimental study of the small world problem. Sociometry, 32(4), 425-443.

Stable causes

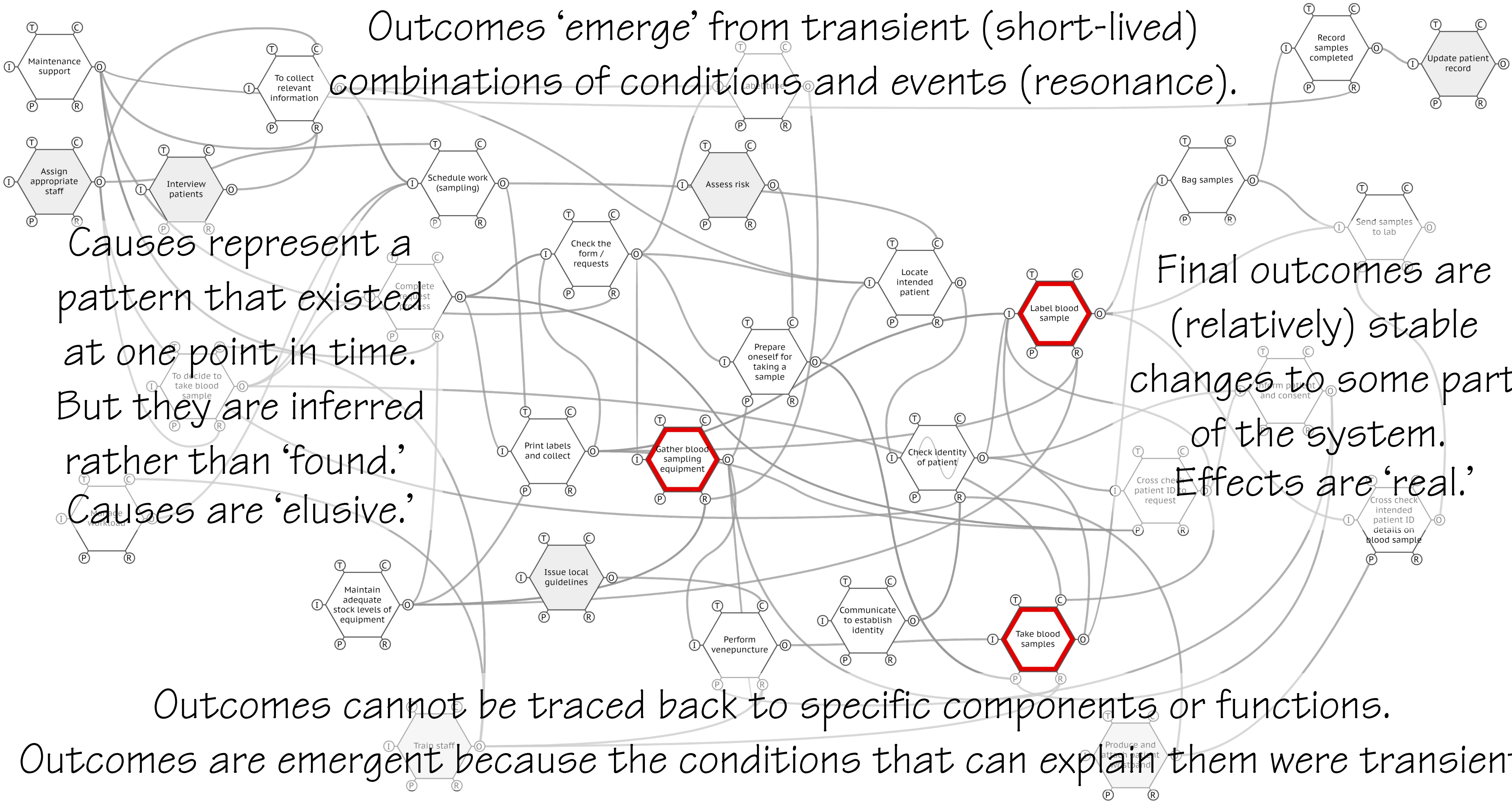
Causes are assumed to be stable. Causes can be 'found' by backwards tracing from the effect. Causes are 'real.'

Final effects are (relatively) stable changes to some part of the system. Effects are 'real.'



Causes can be associated with components or functions that in some way have 'failed.' The 'failure' is either visible after the fact, or can be deduced from the facts.

Transient causes



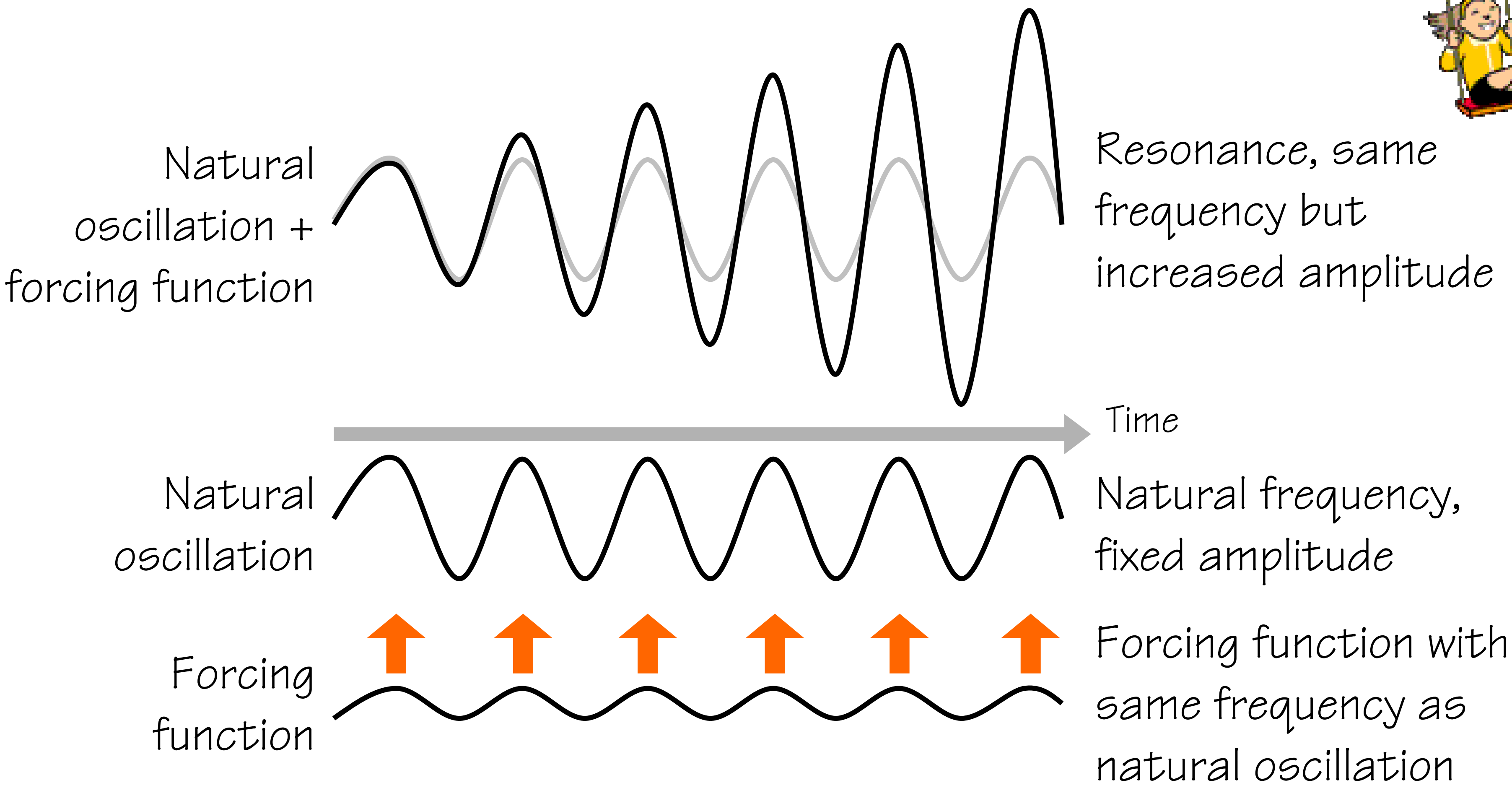
Outcomes 'emerge' from transient (short-lived) combinations of conditions and events (resonance).

Causes represent a pattern that existed at one point in time. But they are inferred rather than 'found.' Causes are 'elusive.'

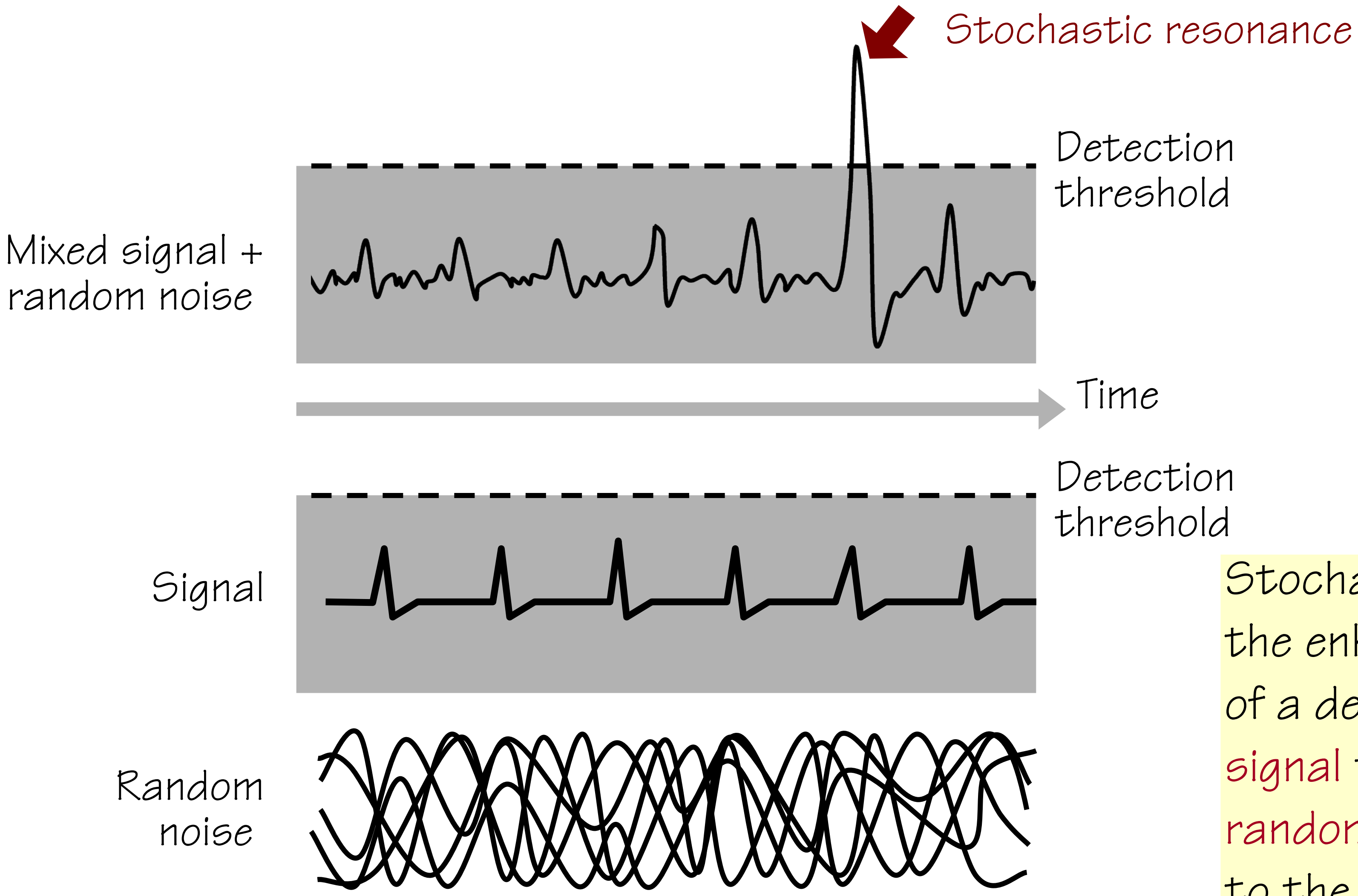
Final outcomes are (relatively) stable changes to some part of the system. Effects are 'real.'

Outcomes cannot be traced back to specific components or functions. Outcomes are emergent because the conditions that can explain them were transient.

IV – Functional resonance

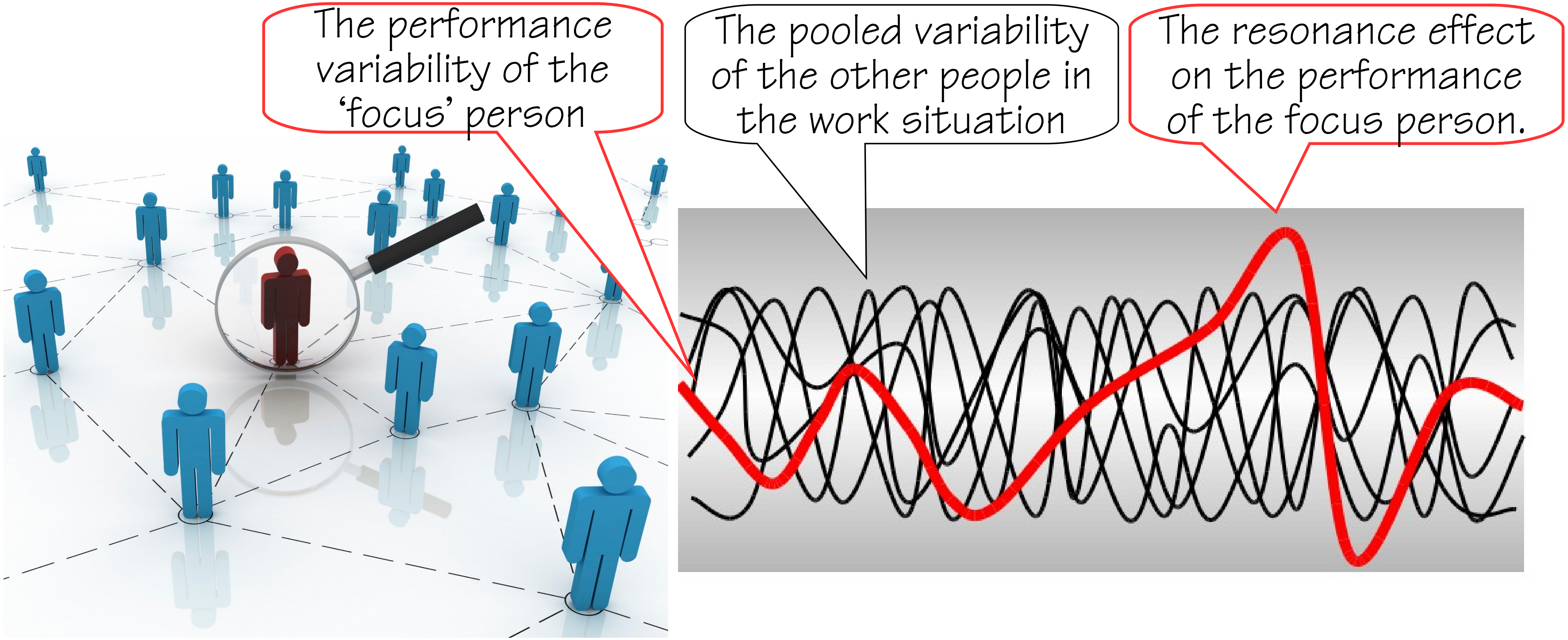


Stochastic resonance



Stochastic resonance is the enhanced sensitivity of a device to a weak signal that occurs when random noise is added to the mix.

Functional resonance

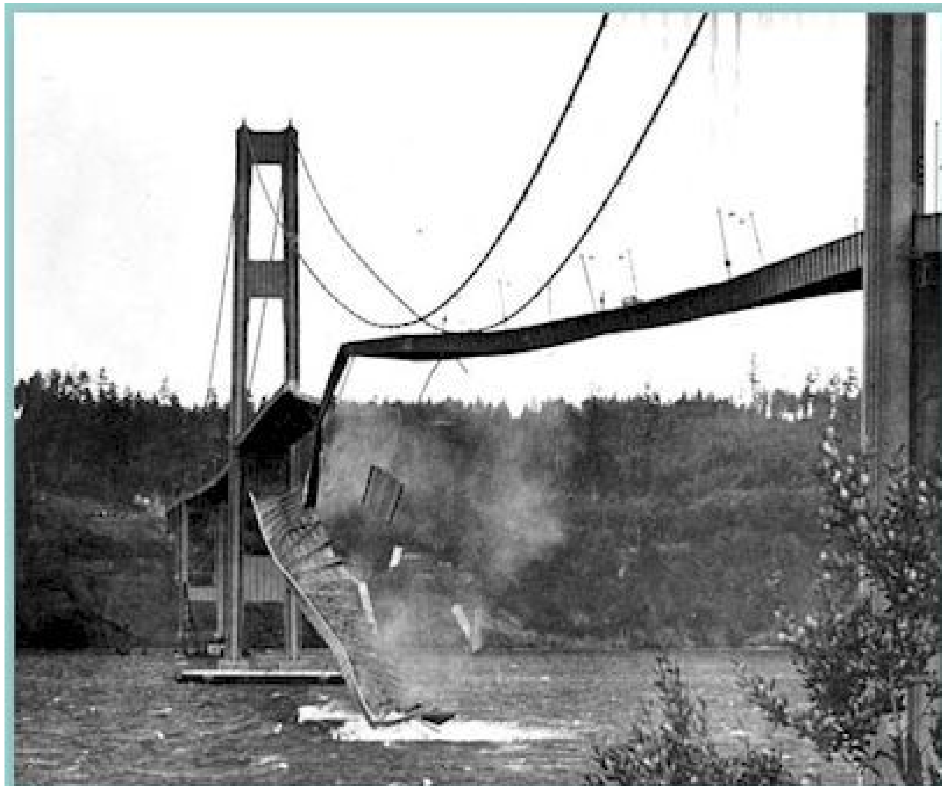


Functional resonance is the detectable signal that emerges from the unintended combination of the variability of many signals.

Tacoma Narrows Bridge

July 1, 1940

November 7, 1940

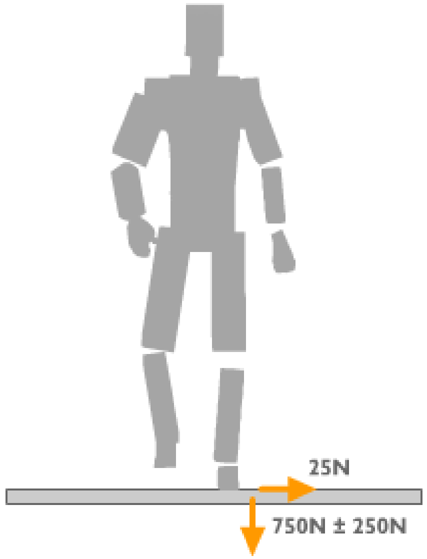


London Millennium Bridge

Opened June 10, 2000

Closed June 12, 2000.
Reason: bridge swayed severely as people walked across it.

Reopened after reconstruction, January 2002



Conclusions

Complex socio-technical systems cannot be modelled in terms of components and component interactions (structural models).

Model-cum-method: The method refers to an underlying model that defines components and how they are organised (levels).

The purpose of the method is to map the phenomenon onto the model.

The purpose of the model is to 'explain' what happens in terms of component characteristics.

Complex socio-technical systems should rather be modelled in terms of what they do – the functions and their relations (functional models).

Method-sine-model: The method does not refers to an underlying model but to basic principles for how functions can relate to each other.

The purpose of the method is to identify the relevant system functions, how they are (potentially) coupled, and how they can vary.

The model provides a basis for reasoning about how an event may develop.