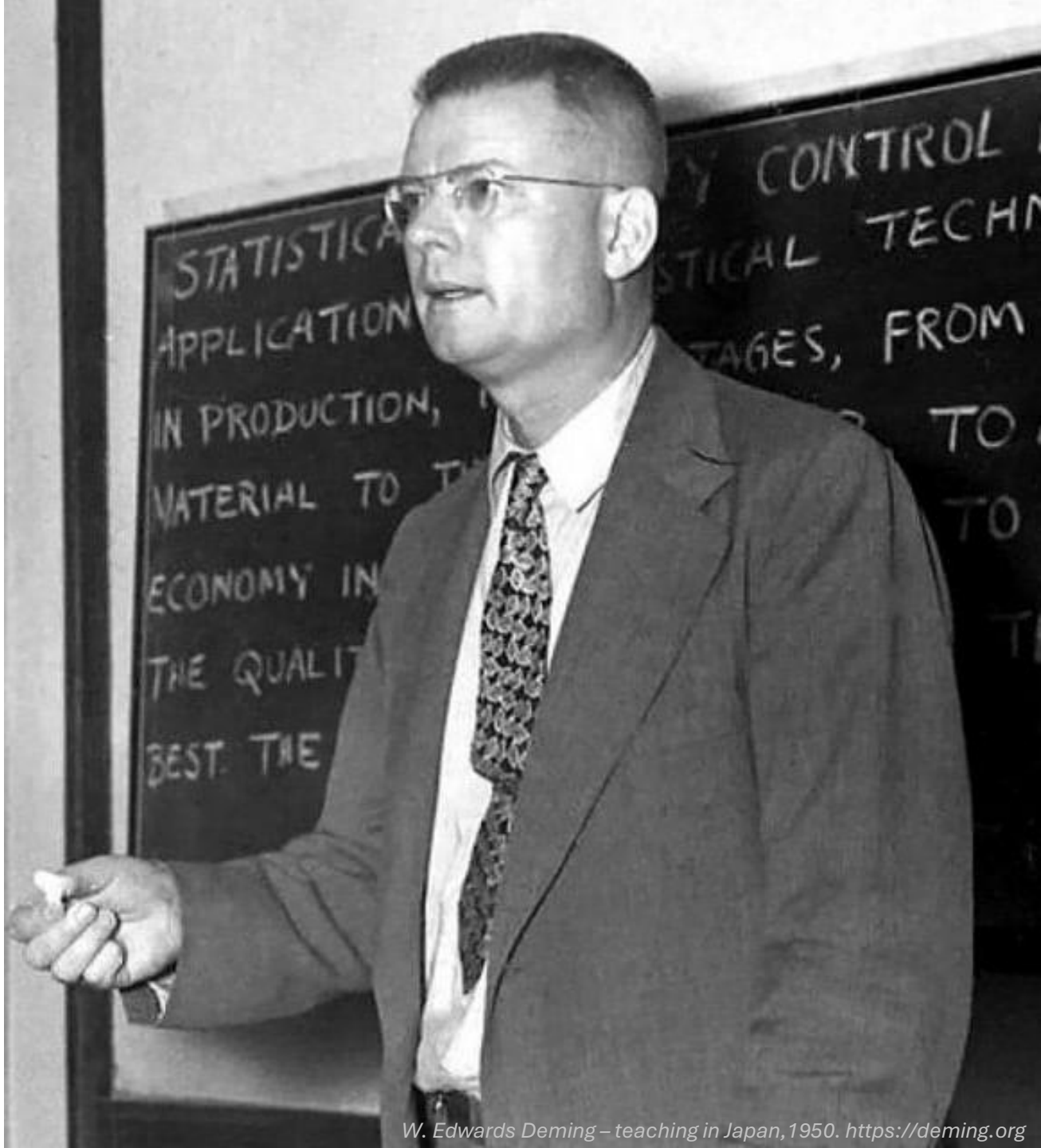
People and Systems

Understanding Cognition at Work

Richard Bye, Network Rail

“Every system is perfectly designed to get the result it gets.”

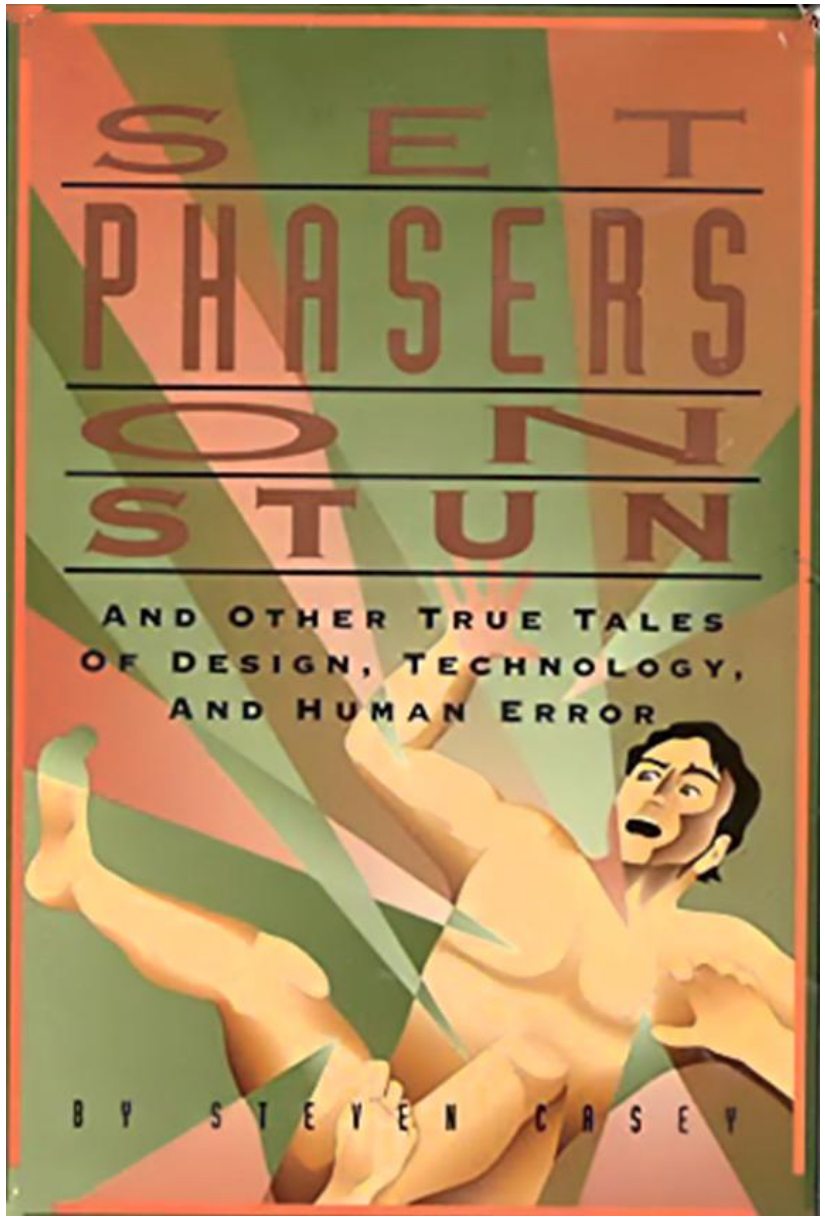
W. Edwards Deming



W. Edwards Deming – teaching in Japan, 1950. https://deming.org

“Structurally sound aircraft plummet to earth, ships run aground in calm seas, industrial machines run awry, and the instruments of medical science maim and kill unsuspecting patients, all because of incompatibilities between the way things are designed and the way people perceive, think, and act.”

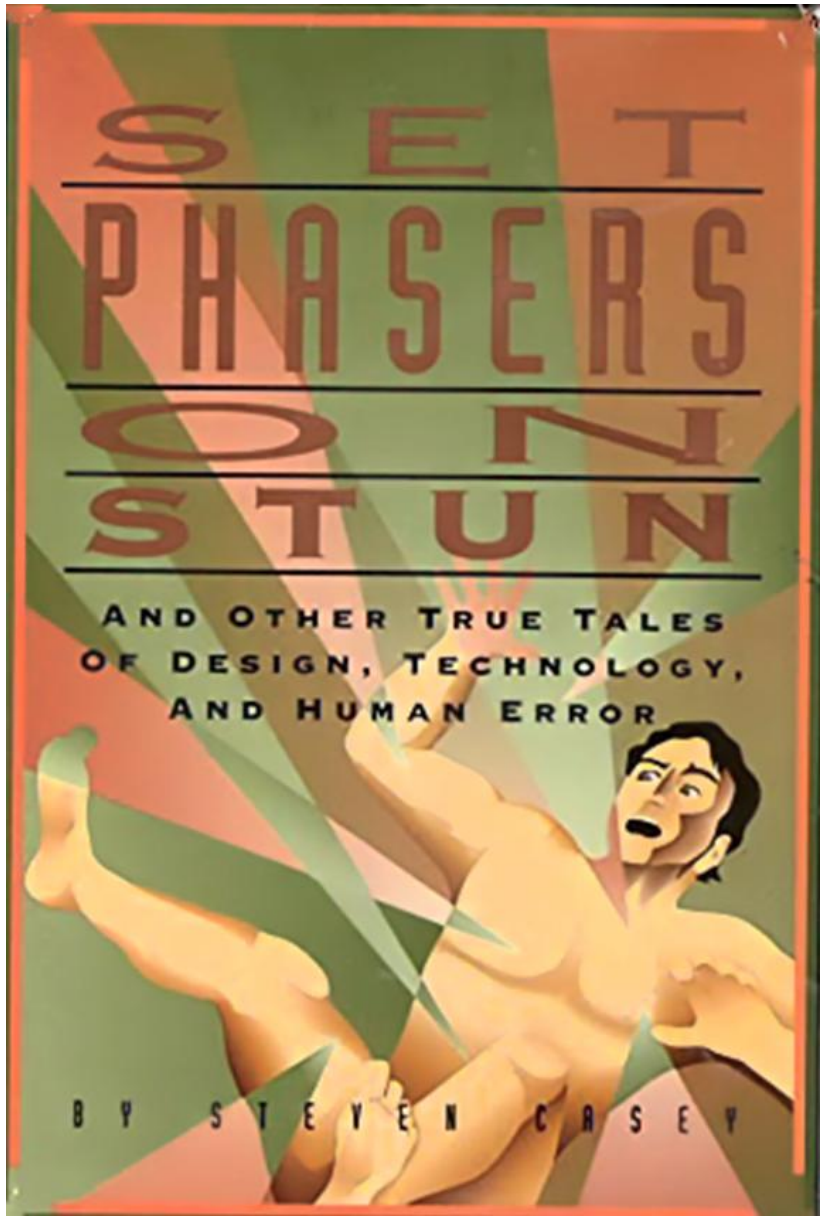
Steven Casey



Casey S. M. (1993). Set phasers on stun: And other true tales of design, technology, and human error. Aegean.

“Structurally sound aircraft plummet to earth, ships run aground in calm seas, industrial machines run awry, and the instruments of medical science maim and kill unsuspecting patients, all because of incompatibilities between the way things are designed and the way people perceive, think, and act.”

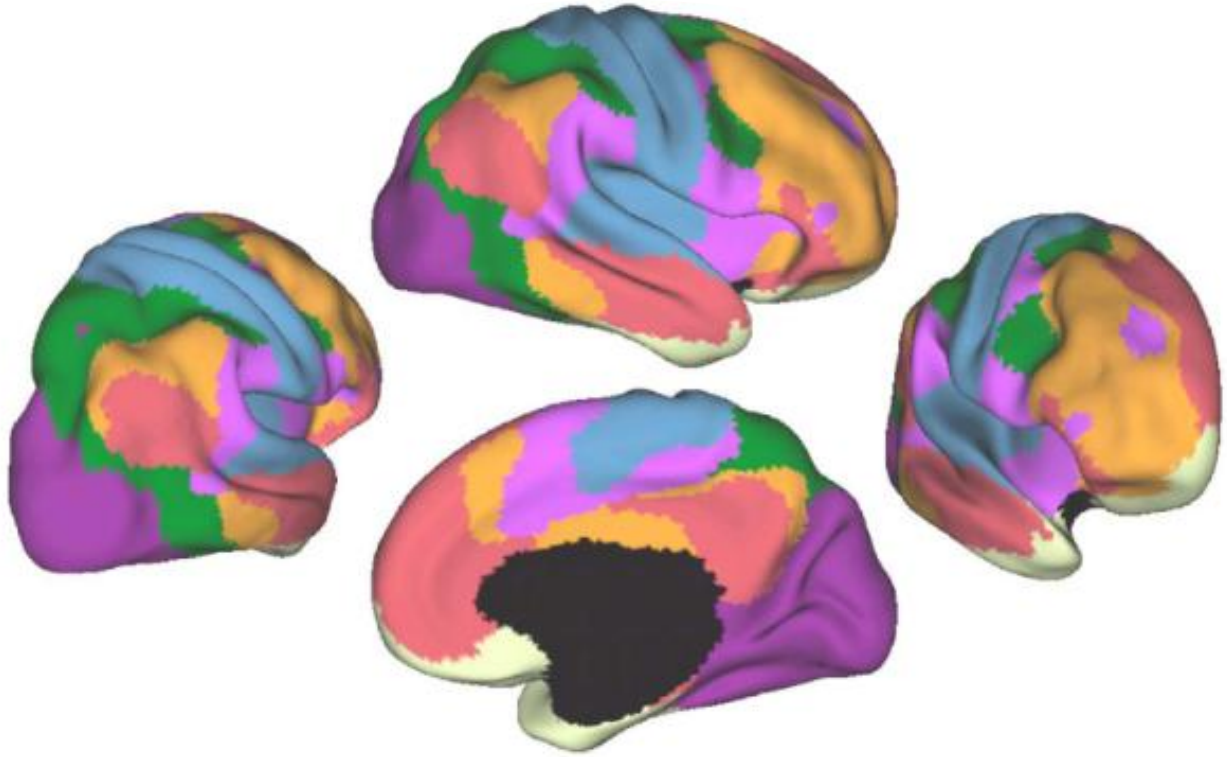
Steven Casey



Casey S. M. (1993). Set phasers on stun: And other true tales of design, technology, and human error. Aegean.

Brain Functions in the Cerebral Cortex

- *Visual Network*
- *Somatomotor Network*
- *Dorsal Attention Network*
- *Ventral Attention Network*
- *Limbic Network*
- *Frontoparietal Control Network*
- *Default Mode Network*



Adapted from Yeo, B.T. et al (2011). The organization of the human cerebral cortex estimated by intrinsic functional connectivity. Journal of neurophysiology.

Physical Senses

Sight *Hearing* *Balance*

Taste *Pain*

Touch *Smell* *Proprioception*

Temperature

Capabilities

Learning *Speed*

Accuracy

Strength *Reach*

Stamina *Empathy*

Stressors

Pressure

Fatigue

Uncertainty *Workload*

Emotional Response

Human Performance

Cognitive Processes

Mental Models *Cognitive Biases*

Reasoning

Situation Awareness

Judgement *Problem Solving*

Cognitive Functions

Perception

Attention

Memory

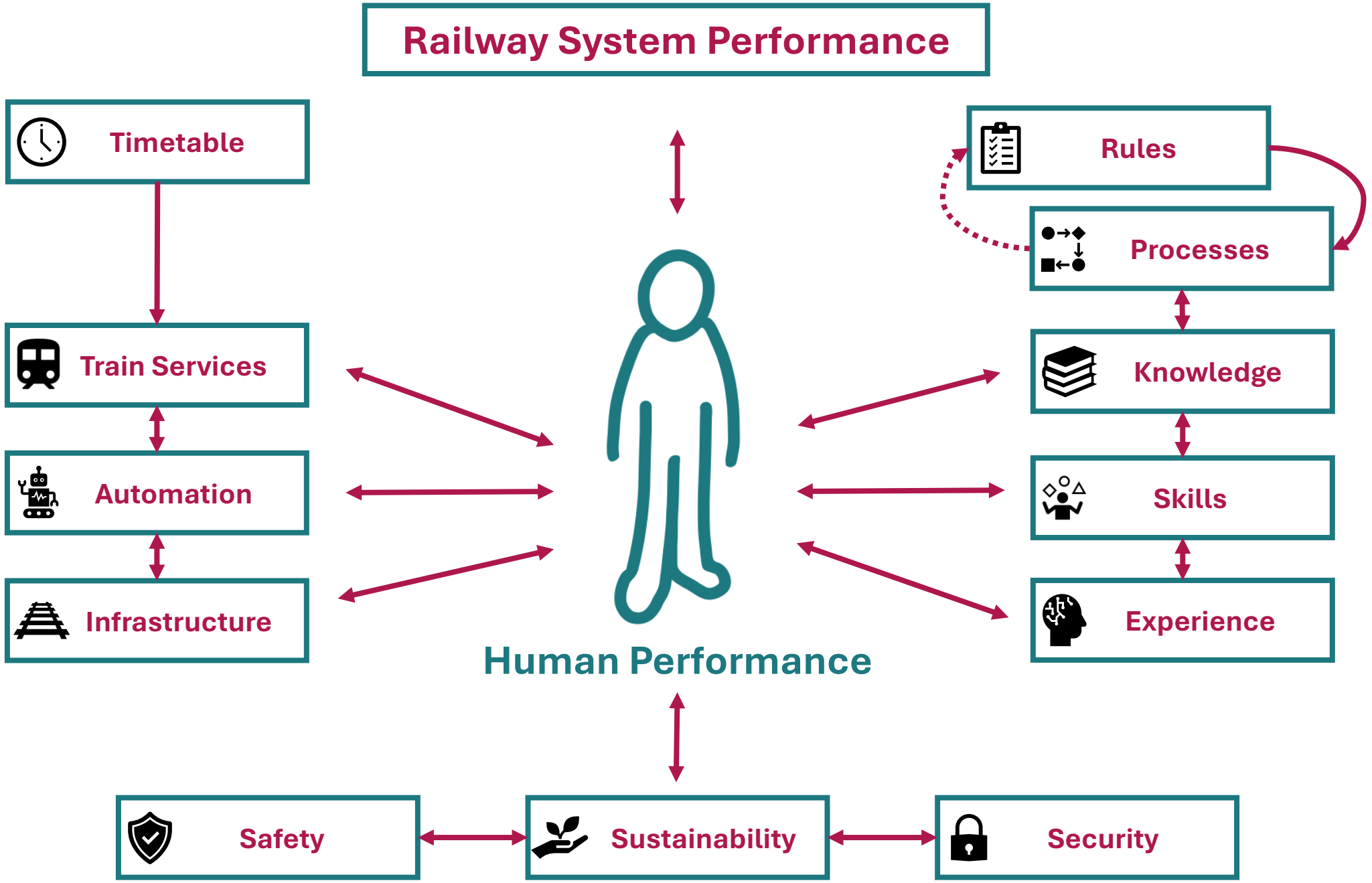
Vigilance *Monitoring*

Behaviours

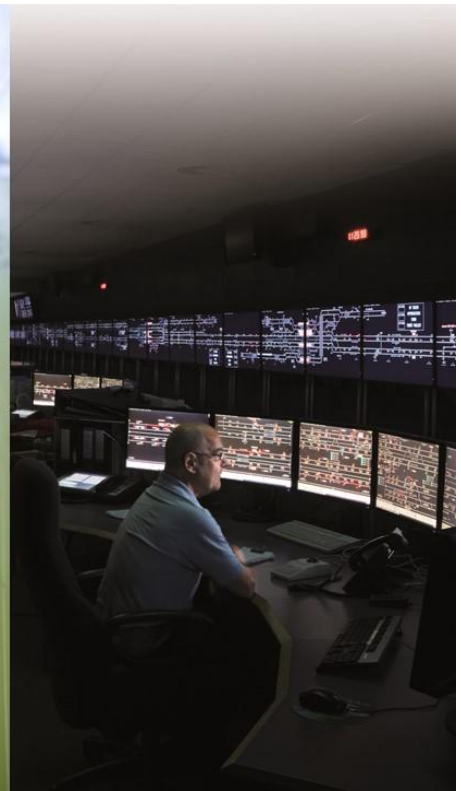
Automaticity *Decision Making*

Teamwork *Communication*

Slips and Lapses


Railway System Performance
Timetable
Train Services
Automation
Infrastructure
Rules
Processes
Knowledge
Skills
Experience
Human Performance
Safety
Sustainability
Security


MIND THE GAP



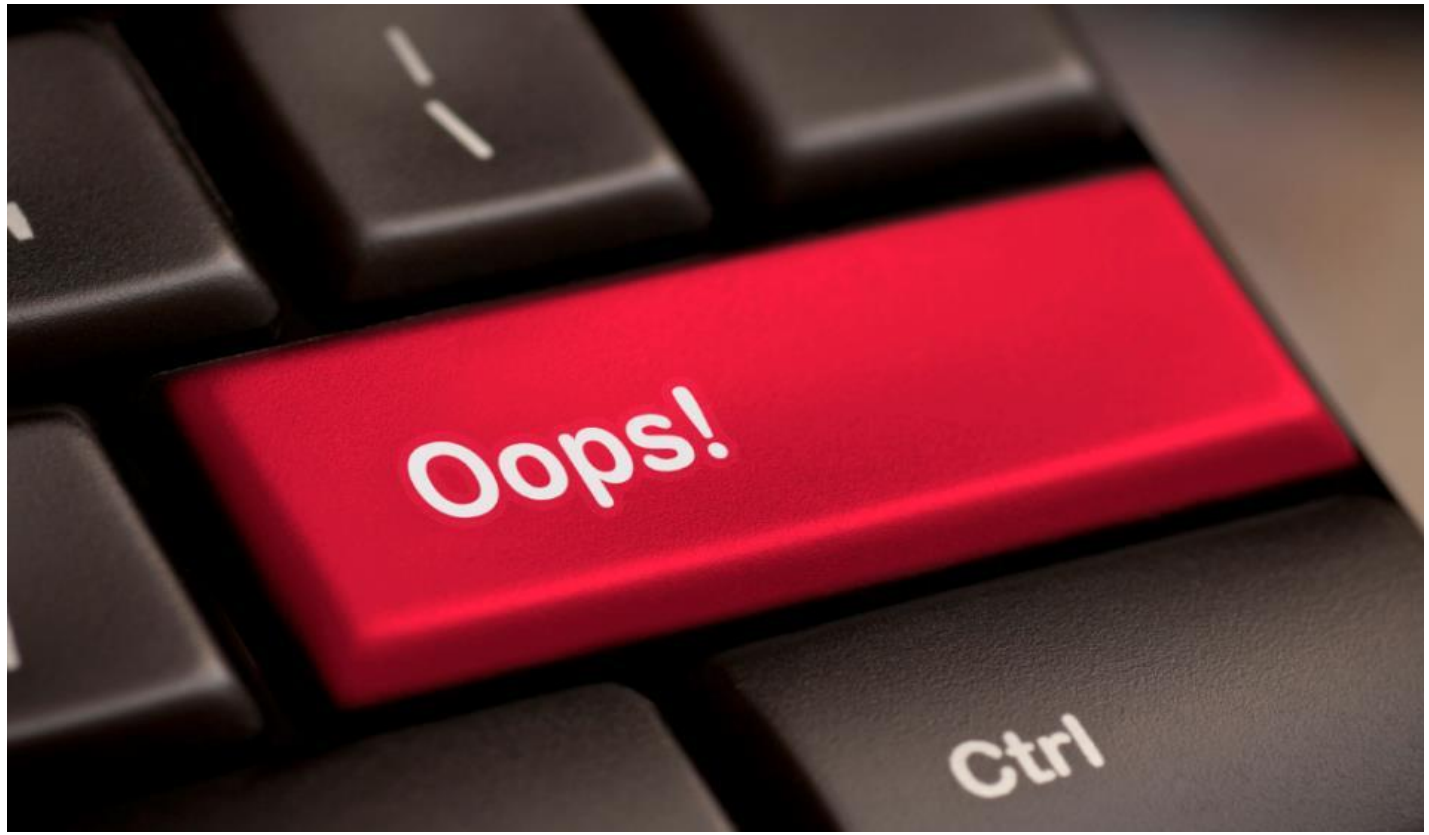

COFFEE PASTRIES TEA SANDWICHES
BENUGO


KEEP
CROSSING
CLEAR
DO NOT
STOP IN THE
YELLOW
BOX
DOING SO WILL
RESULT IN
PROSECUTION


GB Railfreight
69001


NetworkRail
NetworkRail

The Weakest Link?



What % of Railway Incidents are Caused by 'Human Error'?

0%?

25%?

75%?

100%?

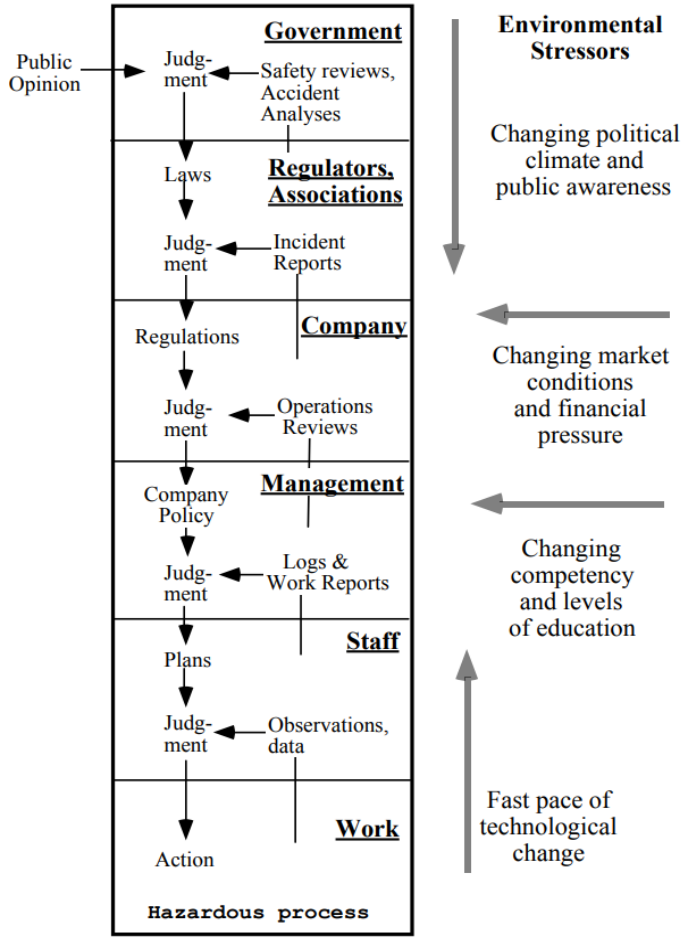
What % of Railway Incidents are Caused by 'Human Error'?

0%?

25%?

75%?

100%?



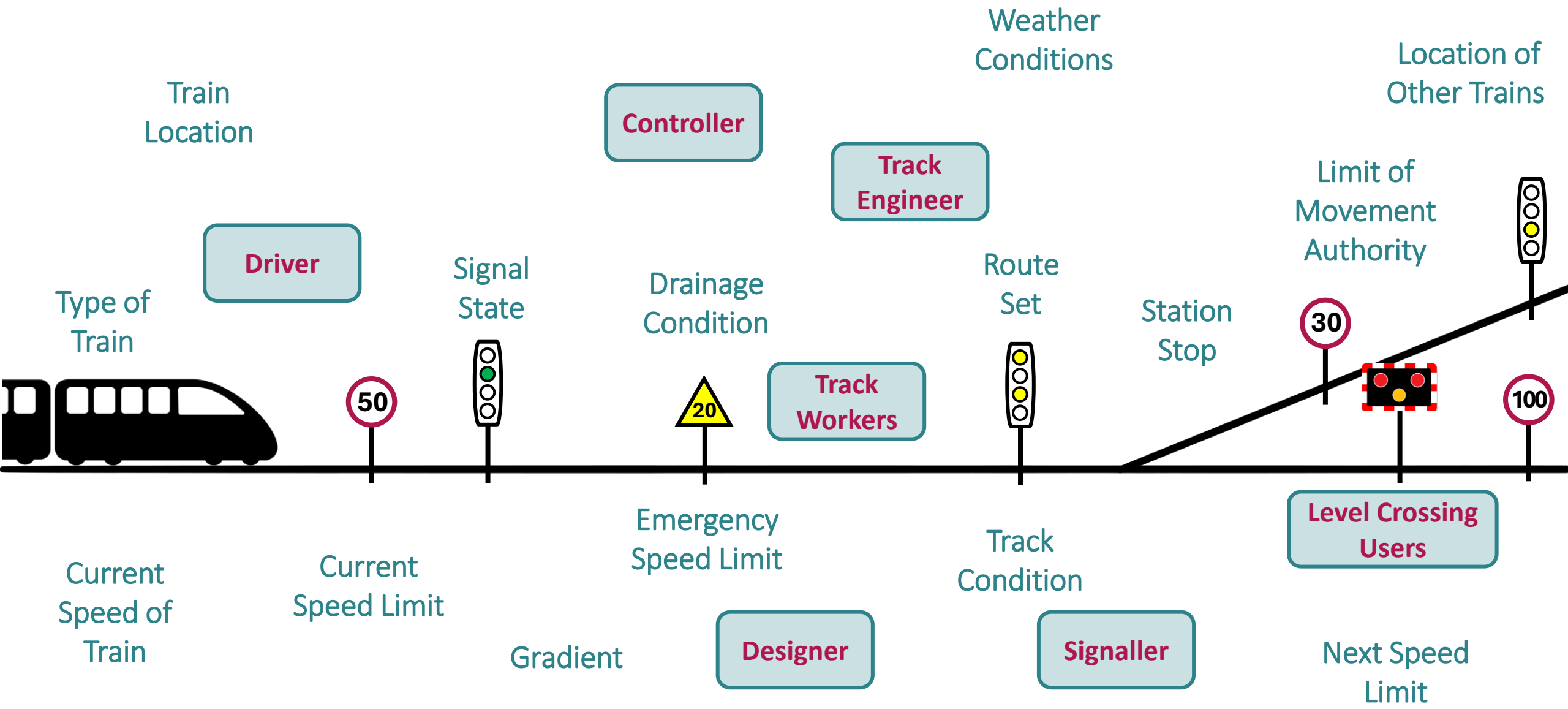
Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. Safety Science.

The Railway is a System

The Railway is a Cognitive System

The Railway is a Distributed Cognitive System

The Railway is a Distributed Cognitive System



Driver

Current Speed of Train

Gradient

Controller

Train Location

Current Speed Limit

Designer

Signal State

Type of Train

Track Workers

Limit of Movement Authority

Emergency Speed Limit

Track Engineer

Track Condition

Weather Conditions

Signaller

Location of Other Trains

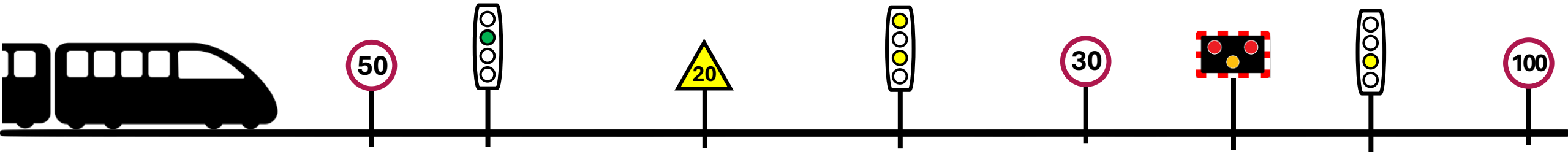
Station Stop

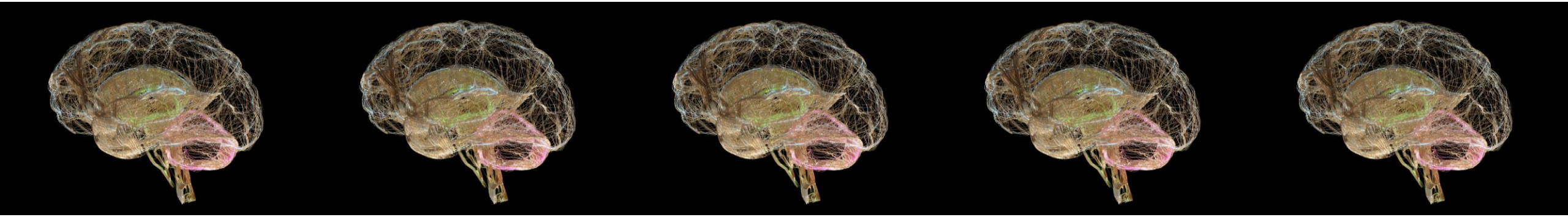
Level Crossing Users

Next Speed Limit

Route Set

Drainage Condition





Current Speed of Train

Train Location

Signal State

Limit of Movement Authority

Track Condition

Location of Other Trains

Route Set

Next Speed Limit

Current Speed Limit

Gradient

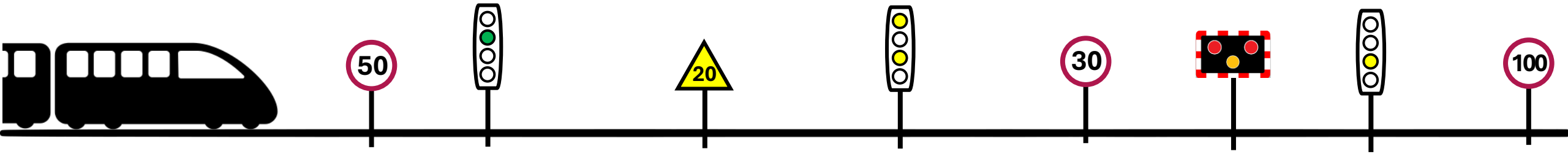
Type of Train

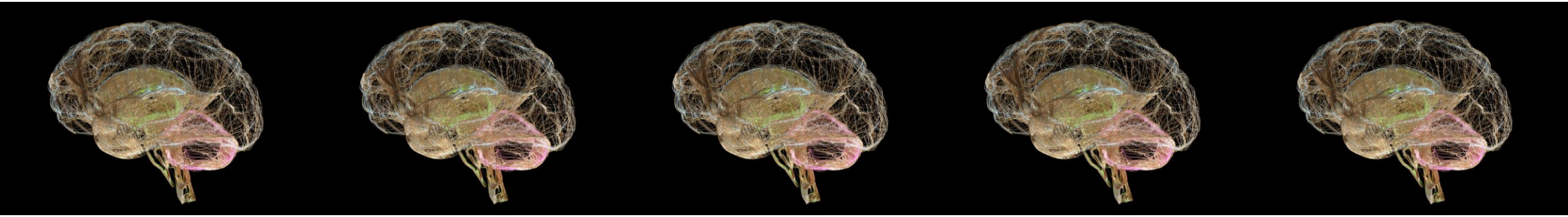
Emergency Speed Limit

Weather Conditions

Station Stop

Drainage Condition





Current Speed of Train

Train Location

Signal State

Limit of Movement Authority

Track Condition

Location of Other Trains

Route Set

Next Speed Limit

Current Speed Limit

Gradient

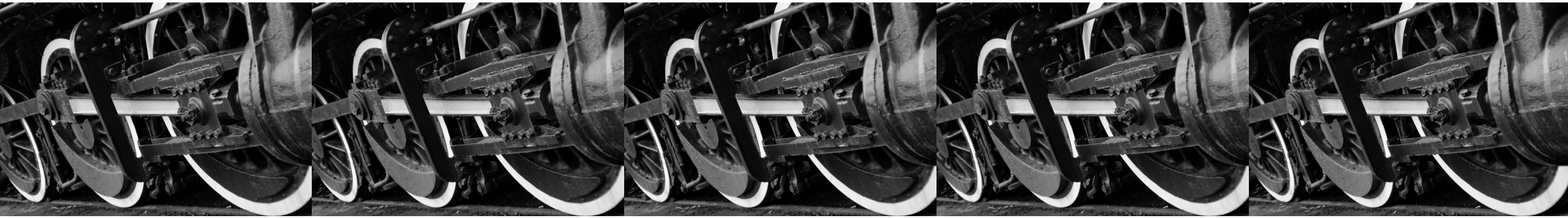
Type of Train

Emergency Speed Limit

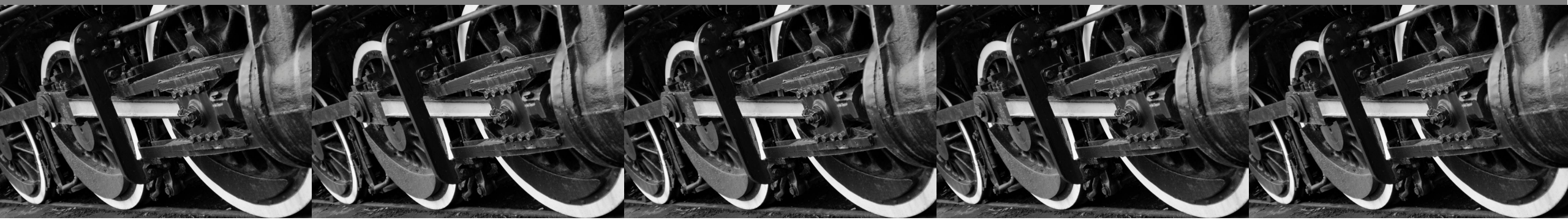
Weather Conditions

Station Stop

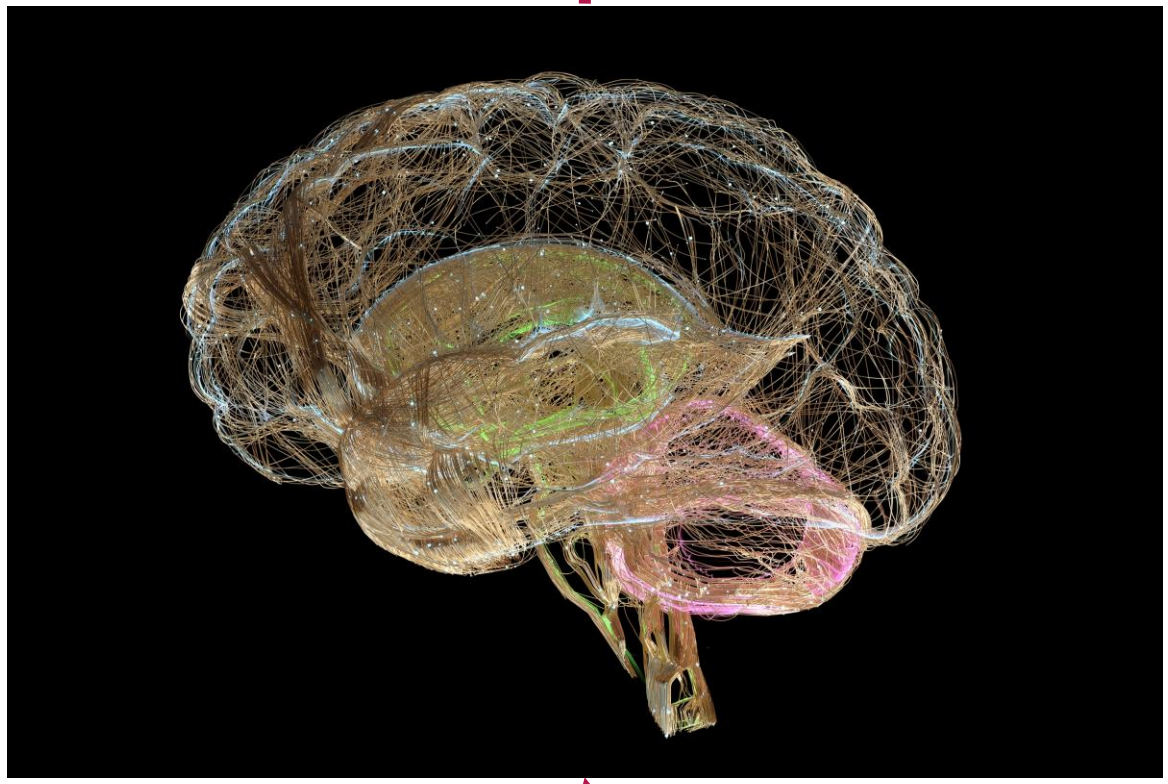
Drainage Condition

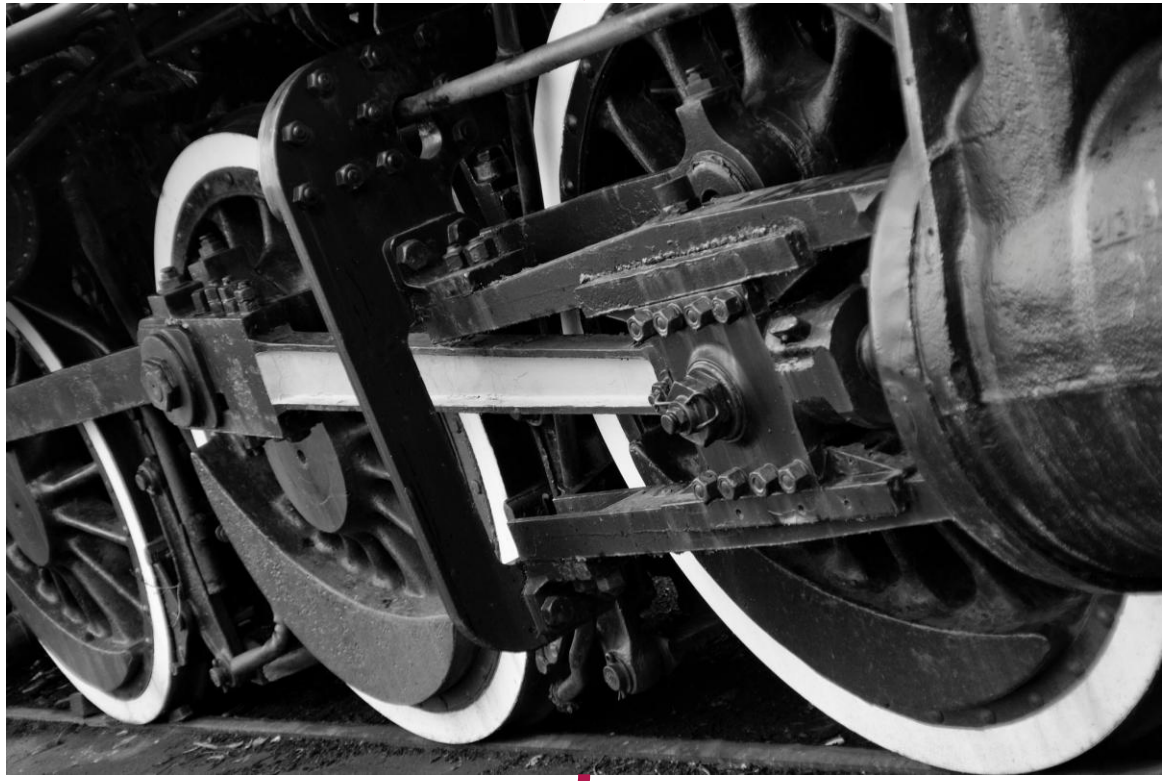


Operational Reality



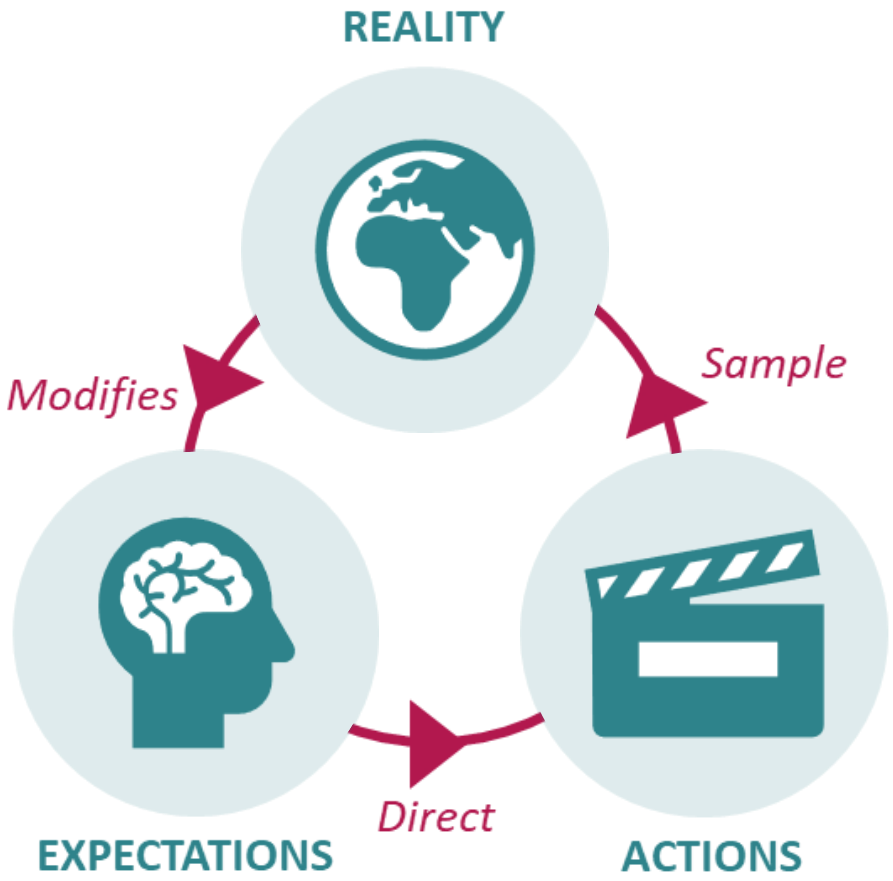
Expectations





Reality

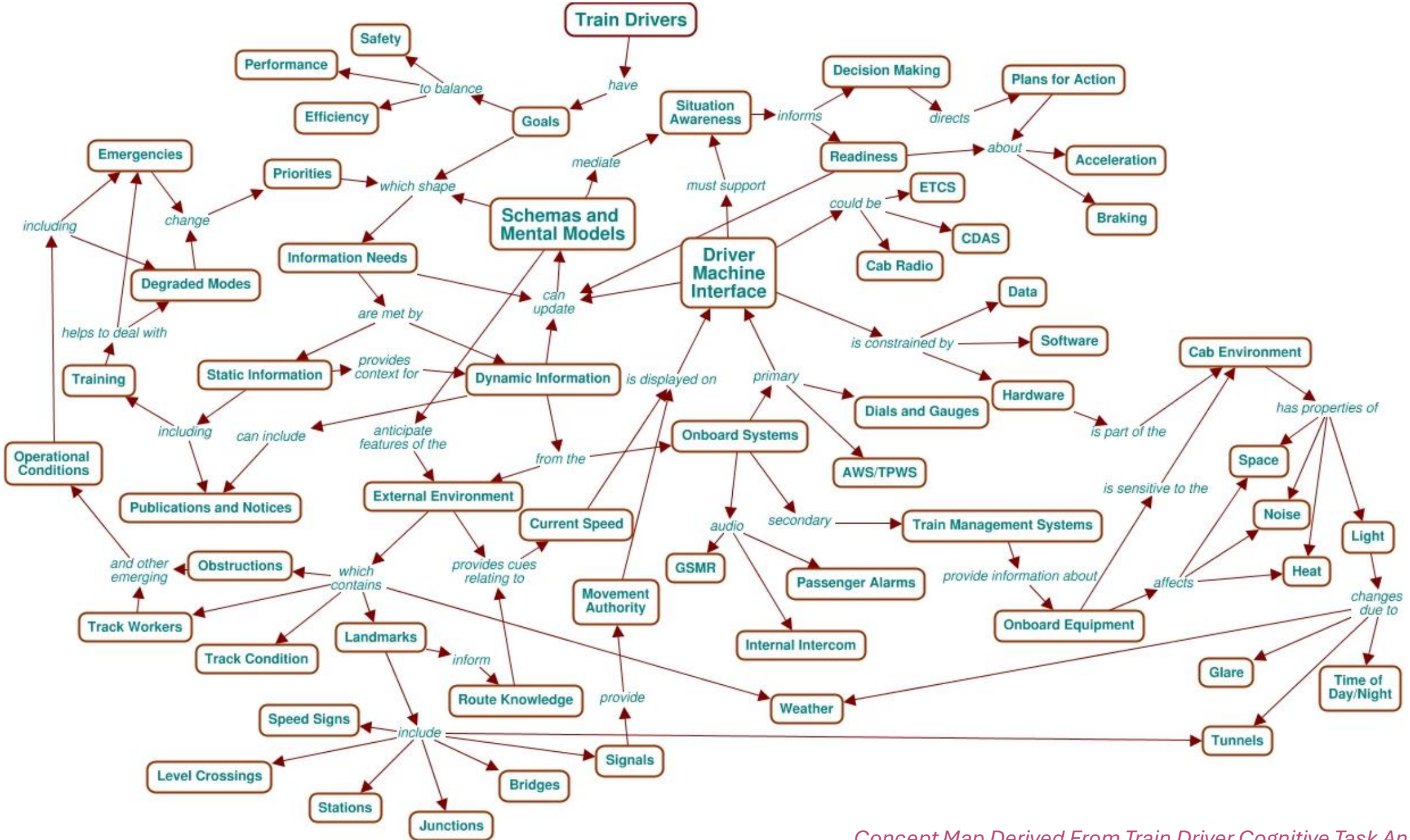
Aligning Reality With Expectations



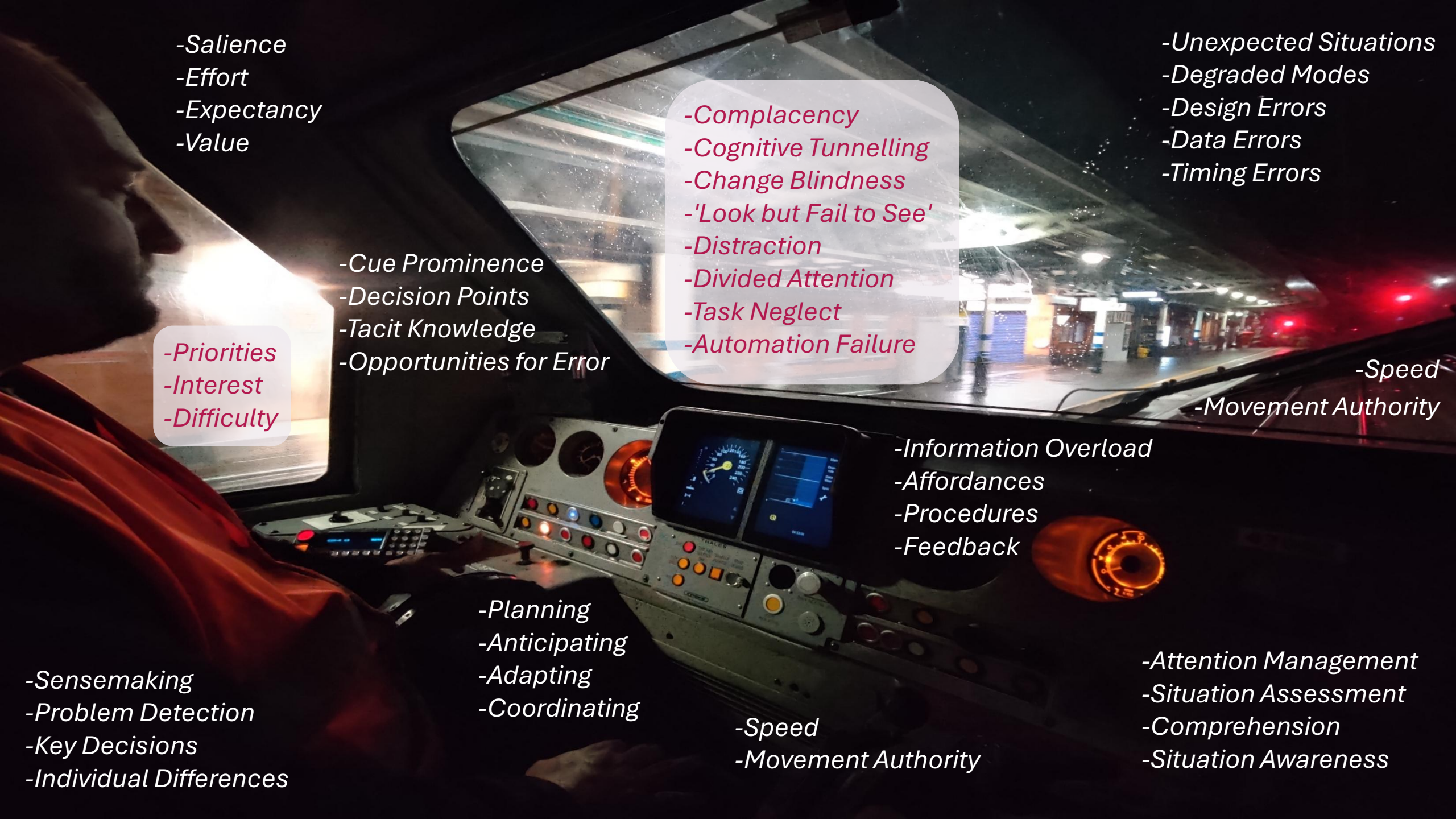
Adapted from Neisser, U. (1976). Cognition and reality. San Francisco, CA: W. H. Freeman and Company.

Learning From Incidents

Learning From When Reality Doesn’t Meet Expectations

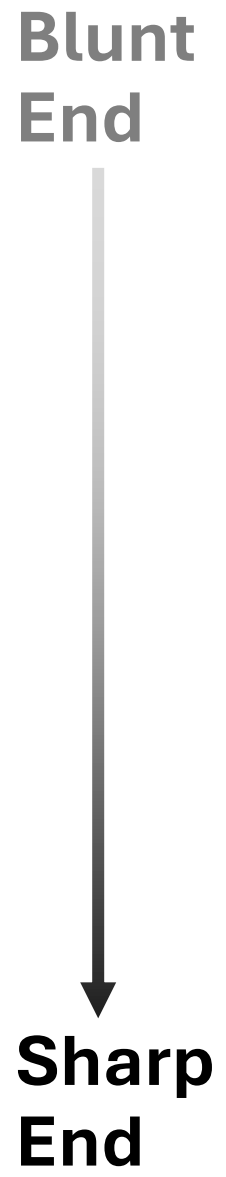


Concept Map Derived From Train Driver Cognitive Task Analyses


-Salience
-Effort
-Expectancy
-Value
-Unexpected Situations
-Degraded Modes
-Design Errors
-Data Errors
-Timing Errors
-Complacency
-Cognitive Tunnelling
-Change Blindness
-'Look but Fail to See'
-Distraction
-Divided Attention
-Task Neglect
-Automation Failure
-Cue Prominence
-Decision Points
-Tacit Knowledge
-Opportunities for Error
-Priorities
-Interest
-Difficulty
-Speed
-Movement Authority
-Information Overload
-Affordances
-Procedures
-Feedback
-Planning
-Anticipating
-Adapting
-Coordinating
-Sensemaking
-Problem Detection
-Key Decisions
-Individual Differences
-Speed
-Movement Authority
-Attention Management
-Situation Assessment
-Comprehension
-Situation Awareness

Levels of Abstraction and Their Functional Purposes

External Factors	*Establish goals, purpose and constraints*
Organisational Factors	*Set priorities, values and functions*
Work Design & Management Factors	*Determine processes and activities*
Events, Processes, Conditions & Decisions	*Define how work is done*
Work Outcomes	*Generate results*

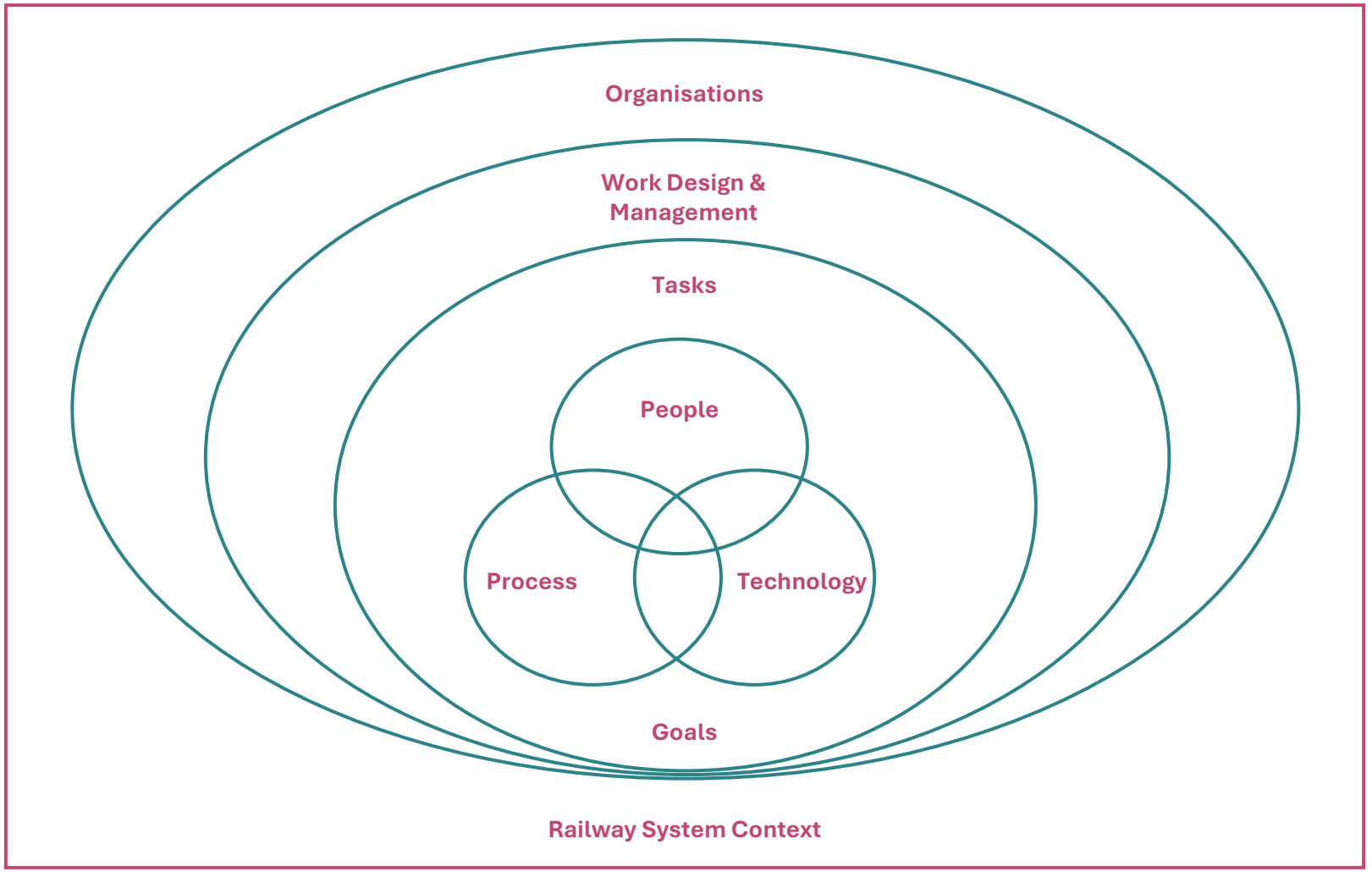


Adhesion Management

Infrastructure Faults

Conflict is Ubiquitous

Legal and Regulatory Frameworks



Resources are Finite

Financial Constraints and Priorities

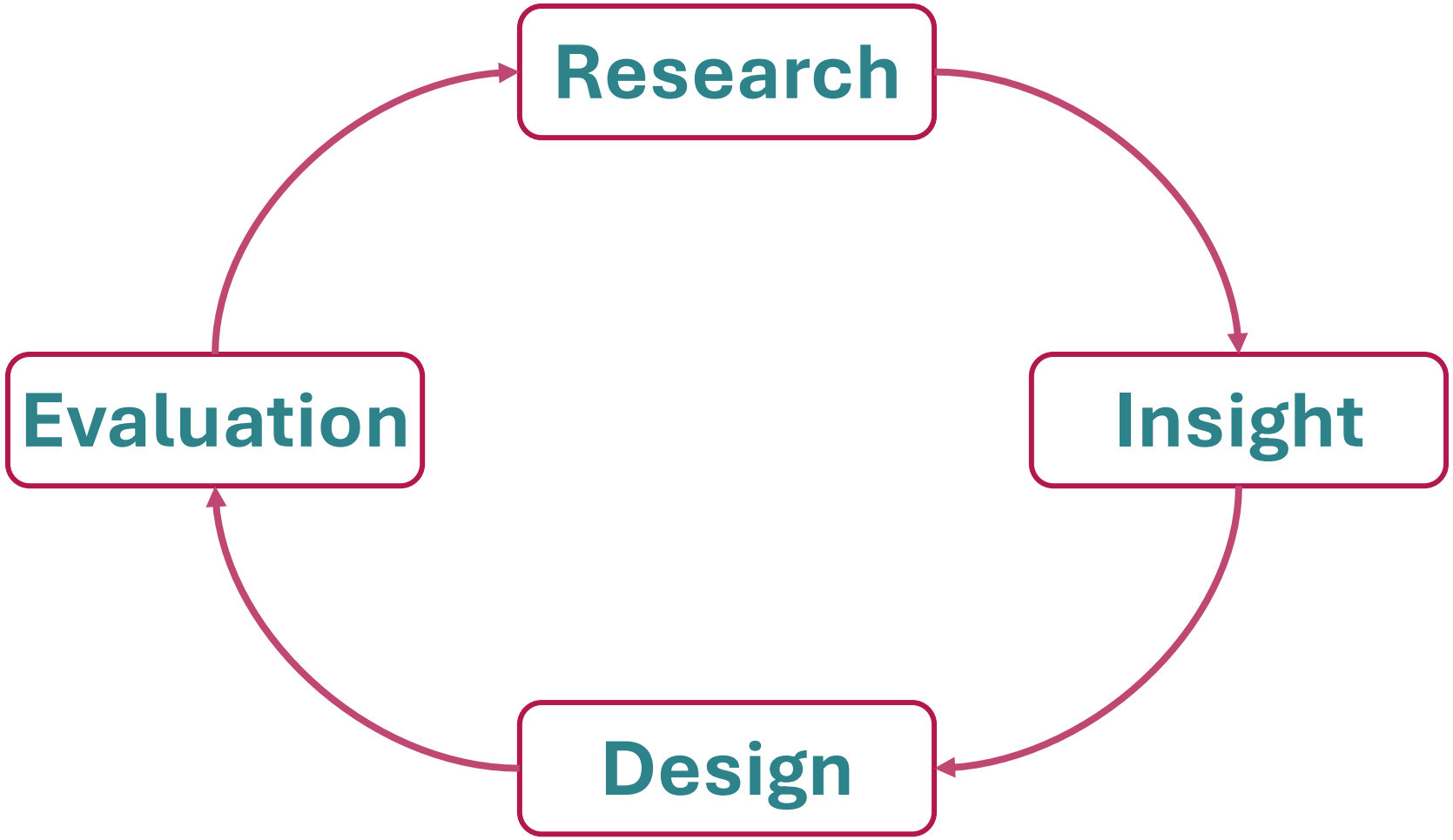
Technical Developments and Capabilities

Change is Continuous

Social Influences, Expectations and Norms

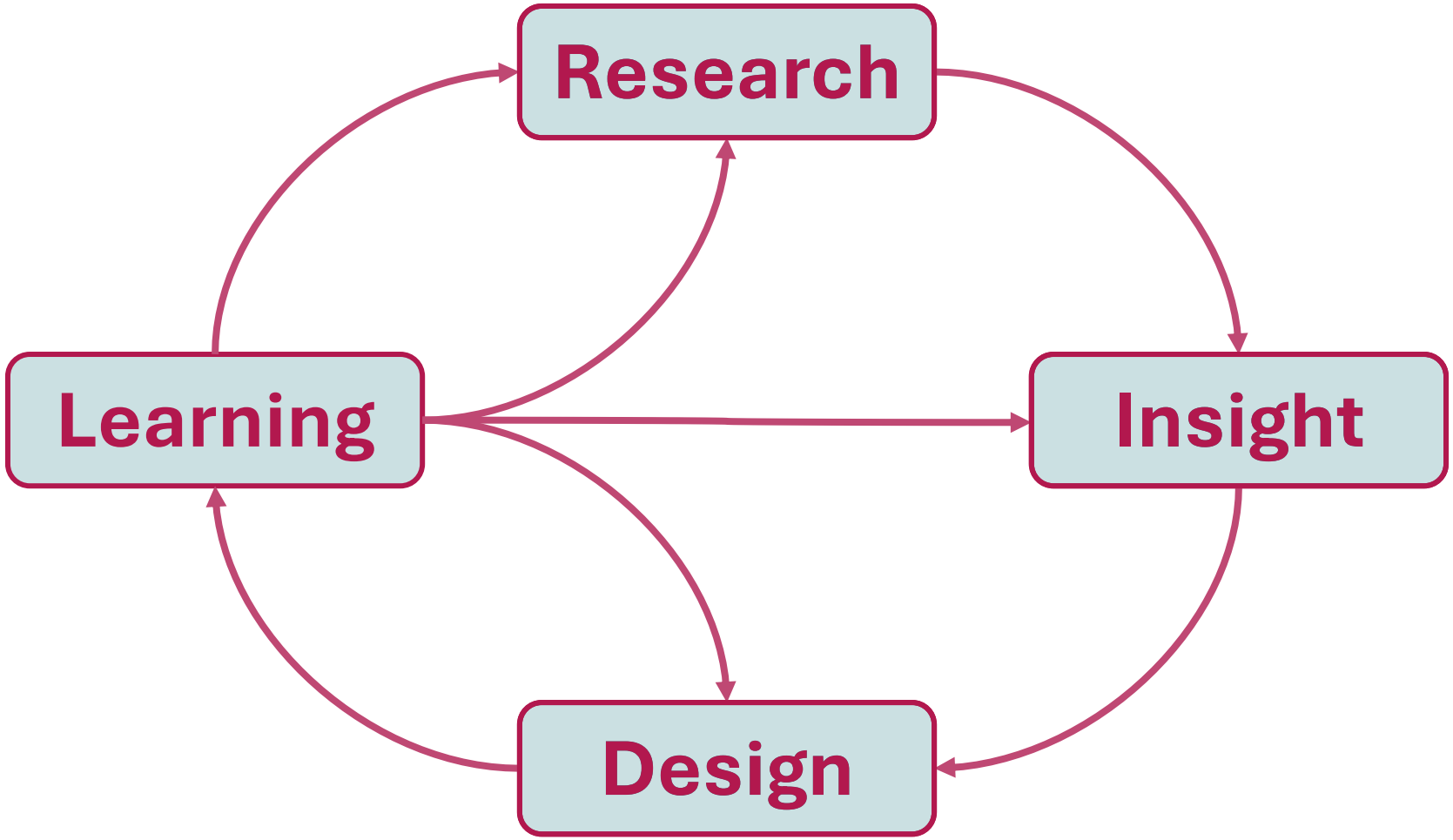
Models Become Stale

Updating Reality to Match Expectations



RIDE: Network Rail's Cognitive Systems Engineering Life Cycle

Updating Reality to Match Expectations



Network Rail Ergonomics

Human Factors-Centred Innovation