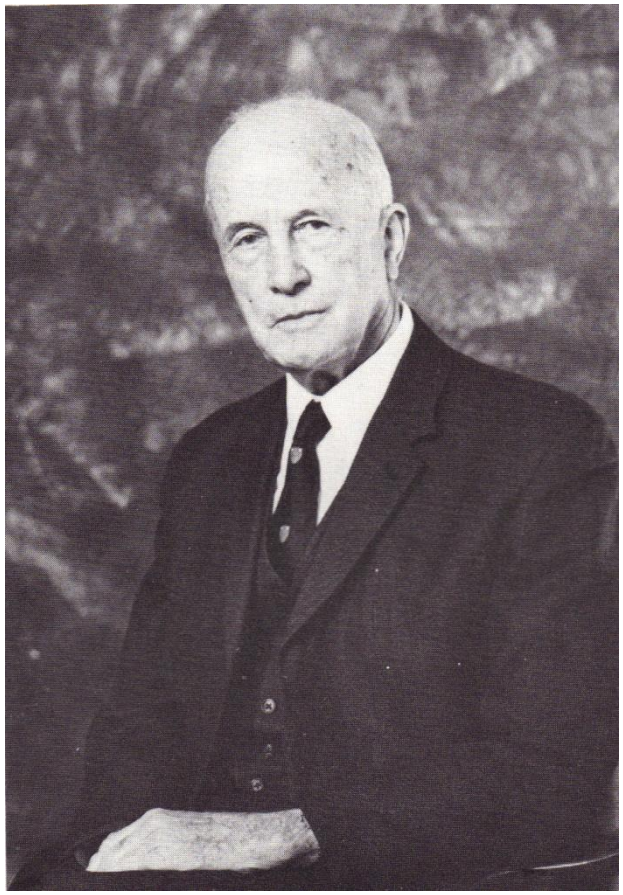
David Blockley

A Tale of Two Systems

It was the best of times, it was the worst of times……

2nd December 2010



Professor Sir Alfred Pugsley FRS, FREng
(1903 – 1998)
Chair of Civil Engineering 1945 -1968

Airship R101 - 1930
The Engineering Climatology of Structural Accidents
ICOSSAR Washington DC, 1969

Objectives

- To tell the story of how I came to systems thinking

- To argue that all hard systems are embedded in soft systems

Remark

It is my experience that Systems Thinking tends to polarise opinions!

Contents

1. The best of times…the worst of times…..
2. School – blissful discomfort
3. University – gradual awakening
4. Work – the shock of change
5. Bristol – keeping feet on the ground
   - fuzzy sets, uncertainty, incubating accidents/failures
   - **Systems thinking**
6. Conclusions

It was the best of times,
it was the worst of times,

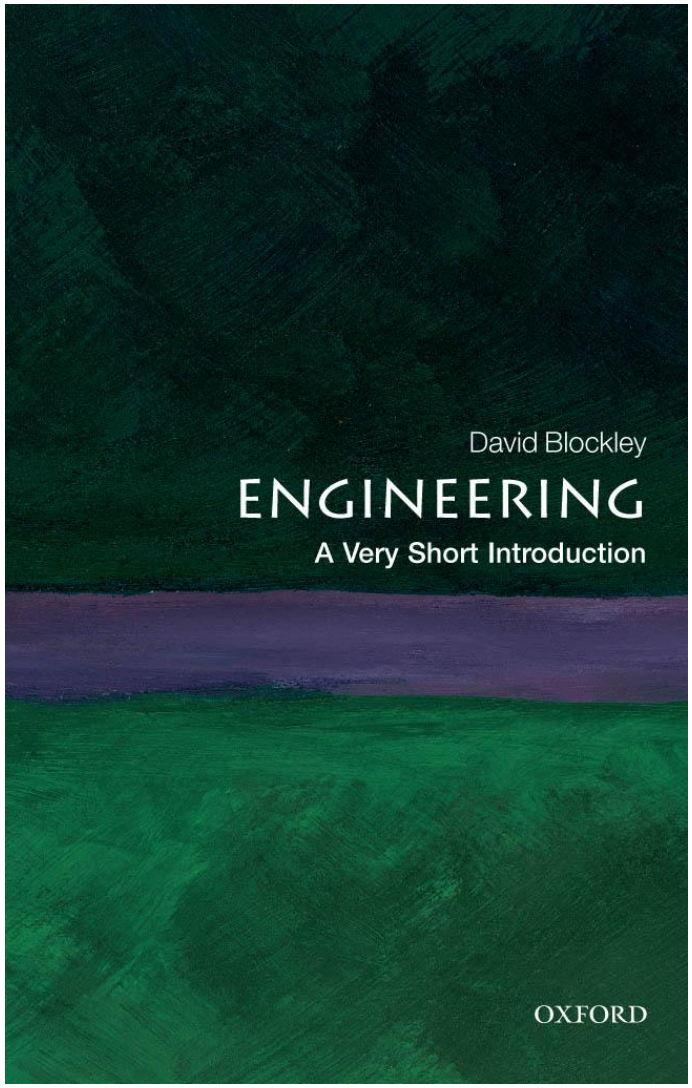
……

It was the spring of hope,
It was the winter of despair,

……

Combining the intimate and the epic
the local and the ‘big picture’
the tactical and the strategic

Stories at different levels



VSI Engineering

By David Blockley
Oxford University Press
2011

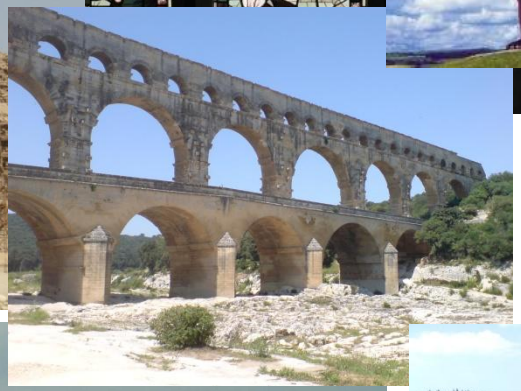
The 5 Ages of Engineering

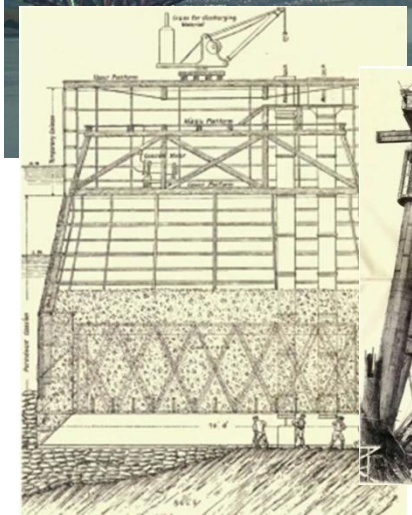
- Gravity
- Heat
- Electromagnetism
- Information
- Systems

Best of times – The Age of Gravity



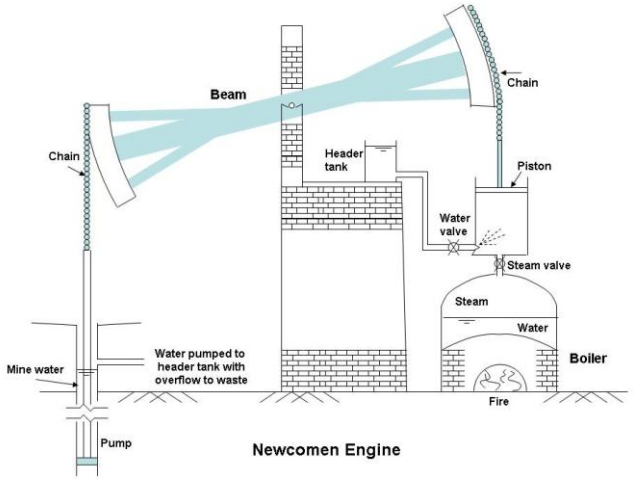




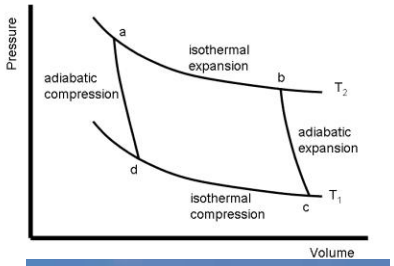


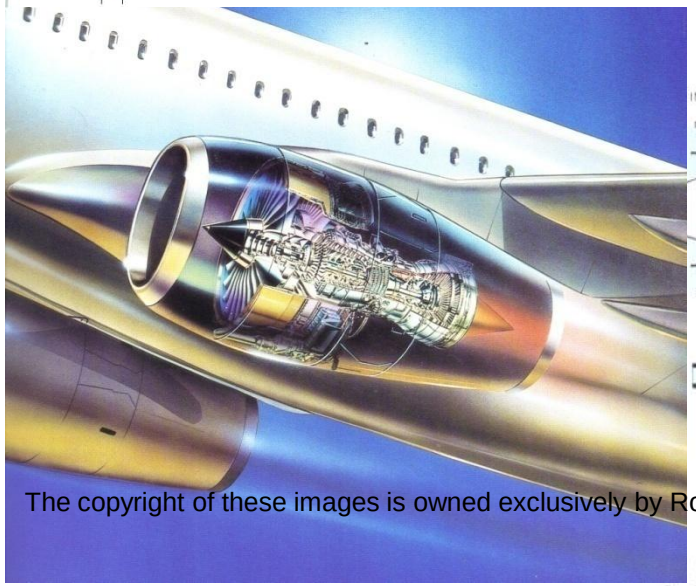


Best of times – The Age of Heat



Newcomen Engine





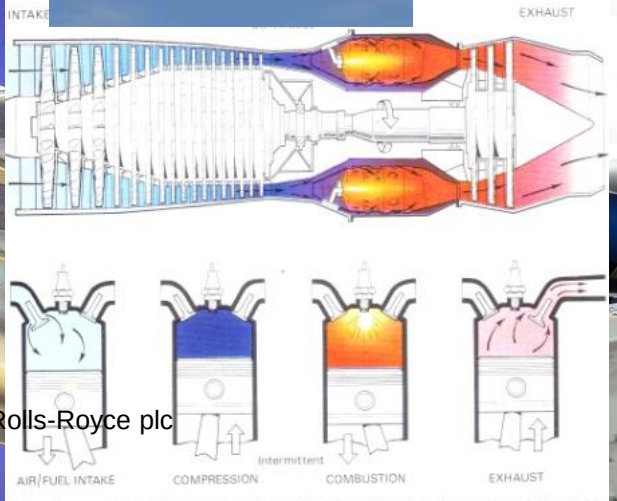
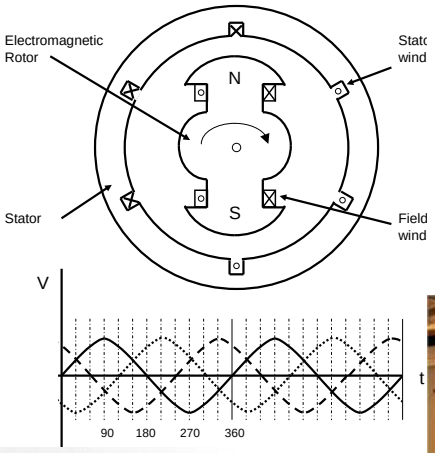
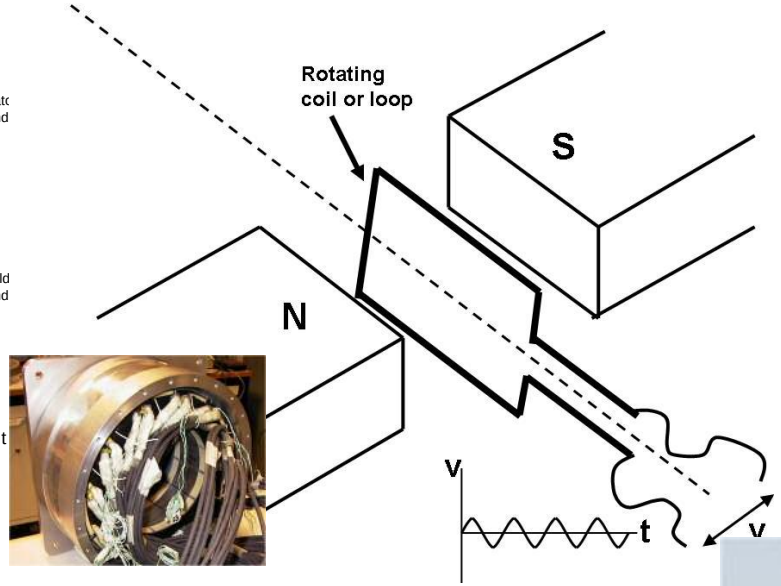


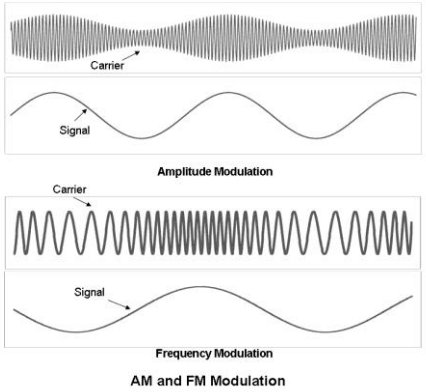
Fig. 2-1 A comparison between the working cycle of a turbo-jet engine and a piston engine

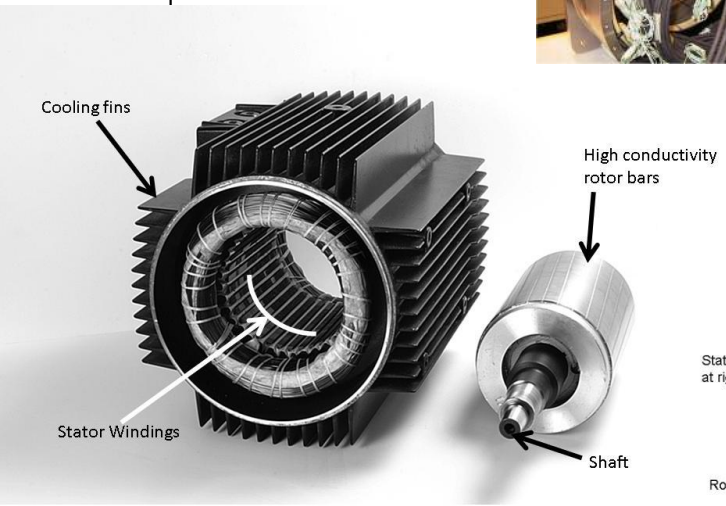
Suck, squeeze, bang, blow!

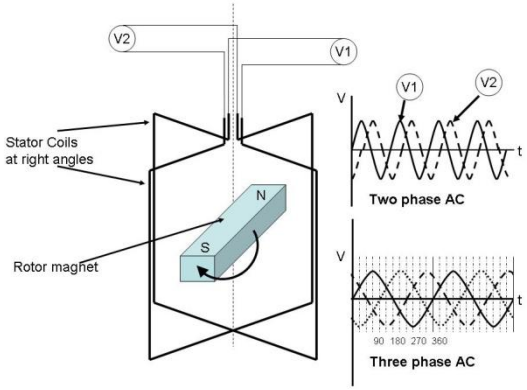
Best of times – Age of Electromagnetism



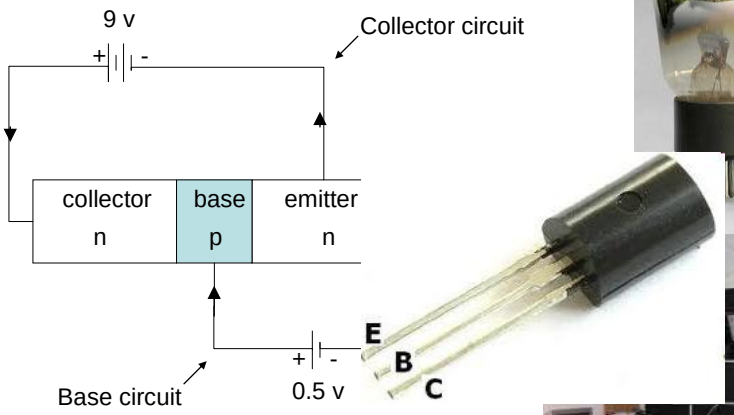


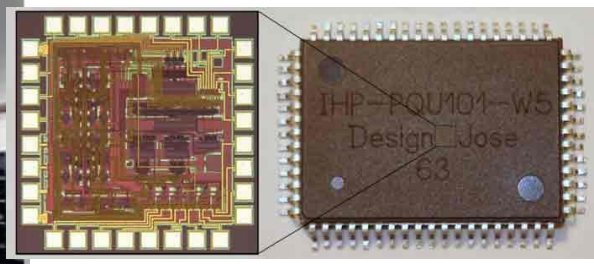


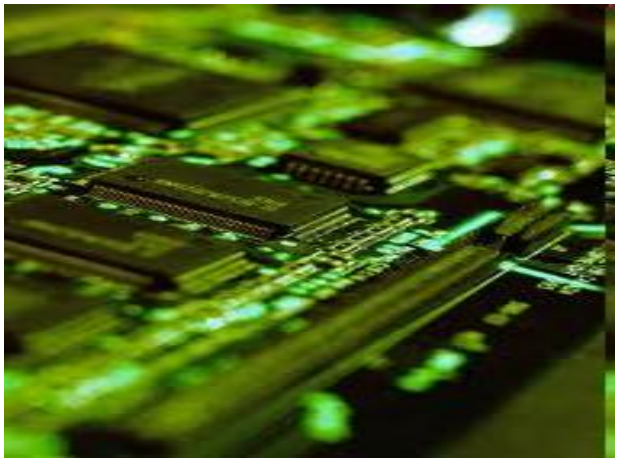


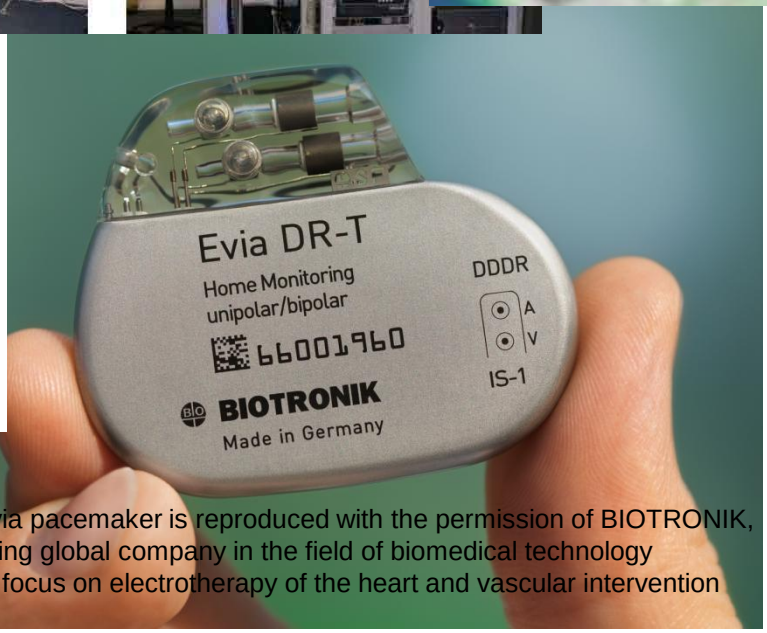


Best of times – The Age of Information





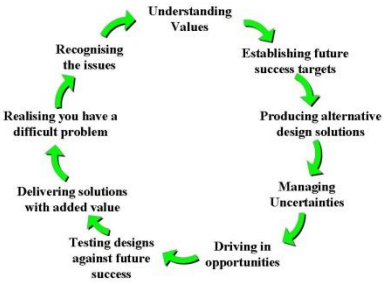


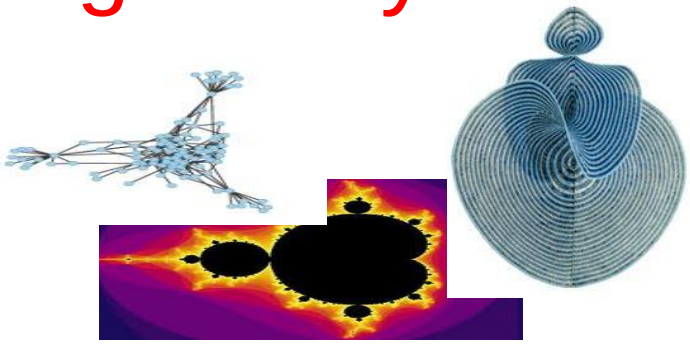


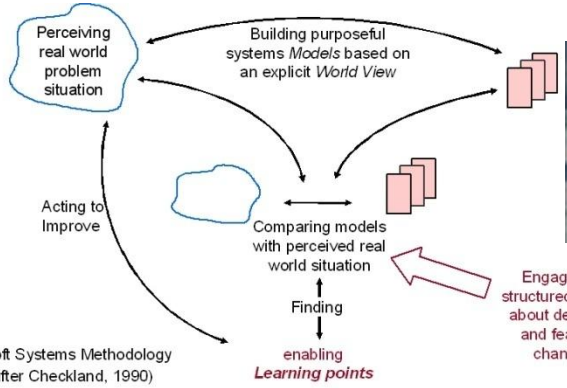
Single Chip Cloud Computer
- 1.3 billion transistors on a postage stamp

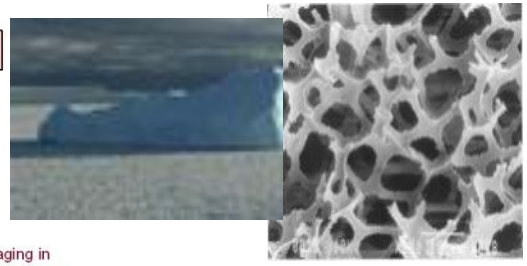
The Evia pacemaker is reproduced with the permission of BIOTRONIK, a leading global company in the field of biomedical technology with a focus on electrotherapy of the heart and vascular intervention

Best of times – The Age of Systems







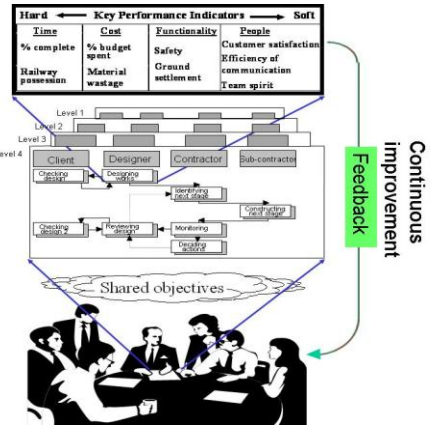


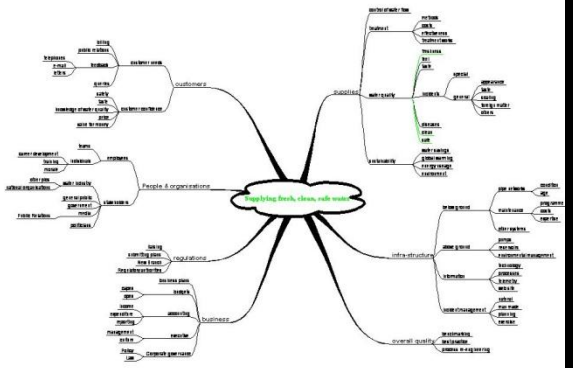
Benchmarking

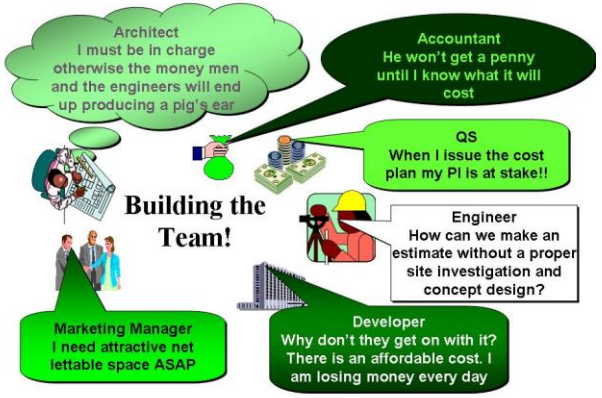
Integrated processes and teams

Value Management

Partnering



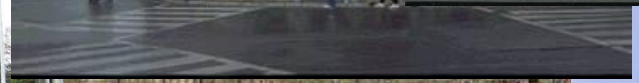




Worst of times










Worst of times

Widespread fear of – technology, complexity, disaster, the unknown
Too many engineers are technically narrow and narrowly technical
We have allowed ourselves to be intellectually dominated by science
There is a gulf between theory and practice, industry and academia
Theory undervalues judgement and ‘soft’ evidence
We tend not to communicate very well

As a Result ⟶

Worst of times

Engineering is significantly undervalued by wider society

With the consequence -
too many people perceive that

- engineers are highly specialised,
- the clever bits of engineering are science
- the high art is architecture,
- engineering is not relevant to anything but itself,
- engineering services can be bought – like a product,
- there is little value in consulting engineers on wider issues,
- engineering is rather boring – not an exciting career.

Language is the key

to coping with

Risk, Uncertainty & Complexity

Systems thinking

is about

Integration & synergy

dealing with unknown & unintended consequences

- some bad and some good

Let me tell you a story…….

about two systems

Hard & Soft

in their many **styles** & guises

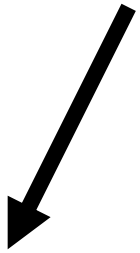
Science & Art
Objective & Subjective
Practice & Theory
Doing & Knowing
Logos & Mythos

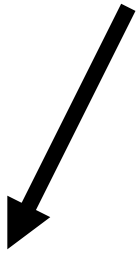
C. P. Snow Two Cultures
remarked on a hostility between
science and the humanities

Technology is […] a queer thing.
It brings you gifts with one hand, and
stabs you in the back with the other

School - blissfully unaware

Physics	Cricket boxes
Maths	Cancelling the ds
Chemistry	Explosive news

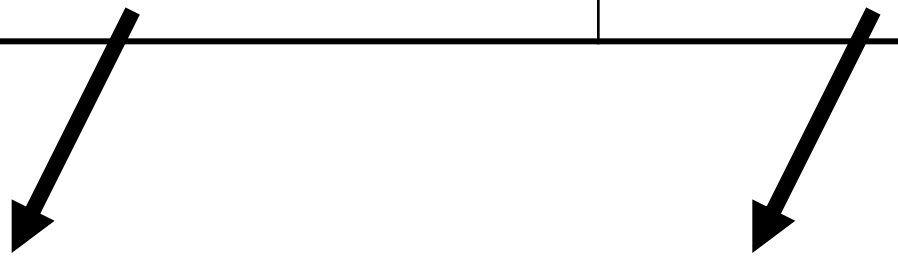




Hard	Soft

University – gradual awakening

Wind & **Models**	Methodology
Writing	Many versions, many languages of 1 idea
Experimenting	Working with others - people



Hard	Soft

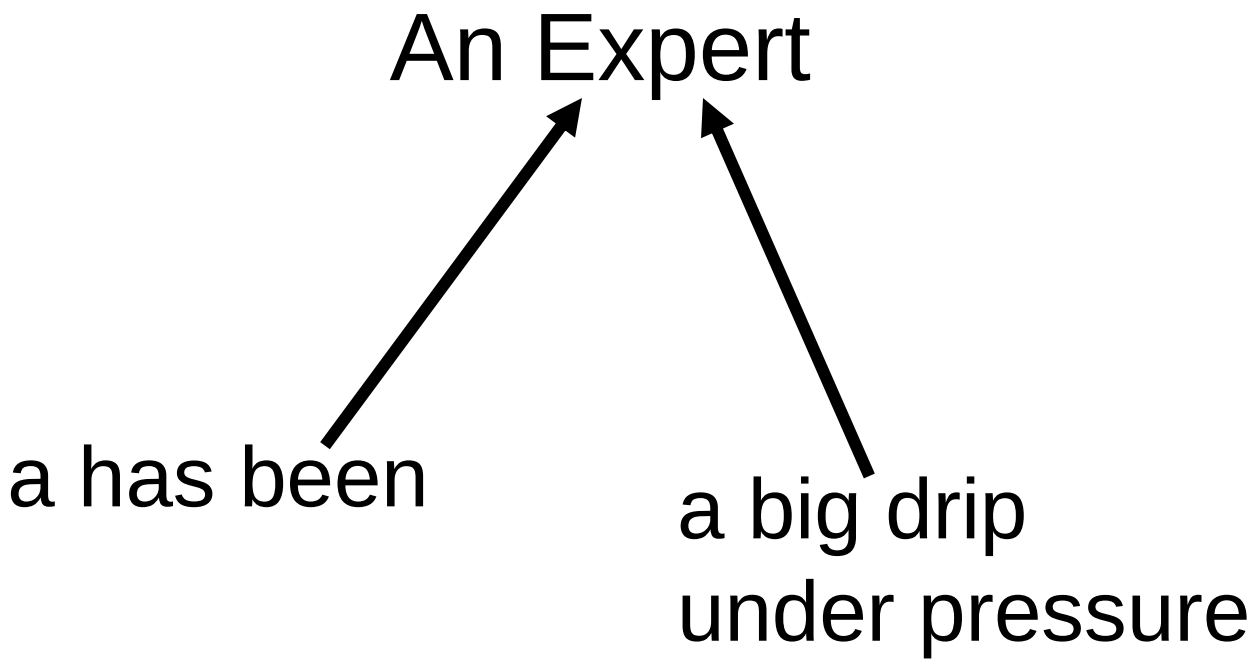
Remember you are unique

Just like everyone else

Work – the shock of change

Portal frames & optimisation	Manufacturing efficiency
Box girders	Complexity of failure
Commuting & life in a London office	Office politics & the man in a bowler hat

Hard	Soft


An Expert
a has been
a big drip
under pressure

Bristol – keeping feet on the ground

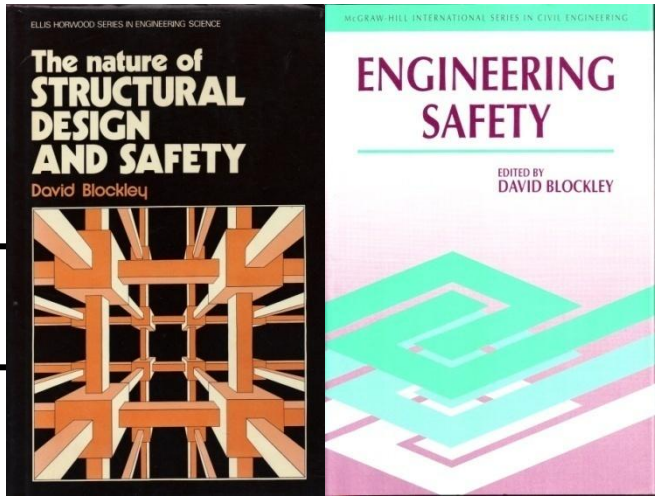
Continuous or discrete	Modelling
Virtual work	Thought experiment
Institution of Structural Engineers – 7 hour design exam	Exam technique

Hard	Soft

Bristol – The nature of structural design and safety

Function limit states	**Form** structure /aesthetics
Cost first, affordability	**Safety** site, structural
Reliability maths, modelling	**Risk** maths, failures

Hard	Soft



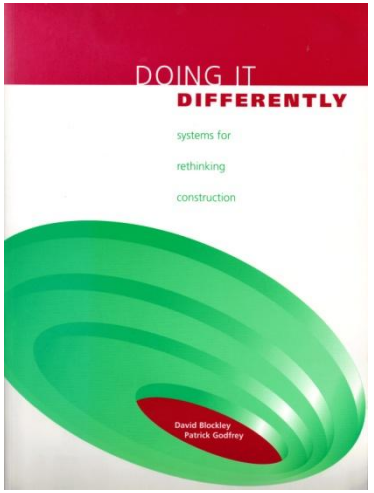
There are differences between

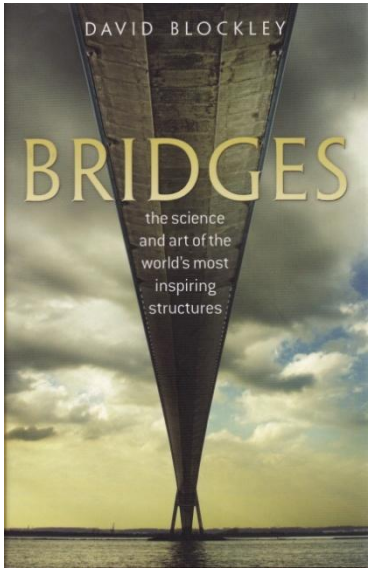
- **what we know**
- **what we do and**
- **why things go wrong**

Engineering:

is a **science and an art**:

- quality is key
- decisions are uncertain
- we work in teams
- failure may be complex



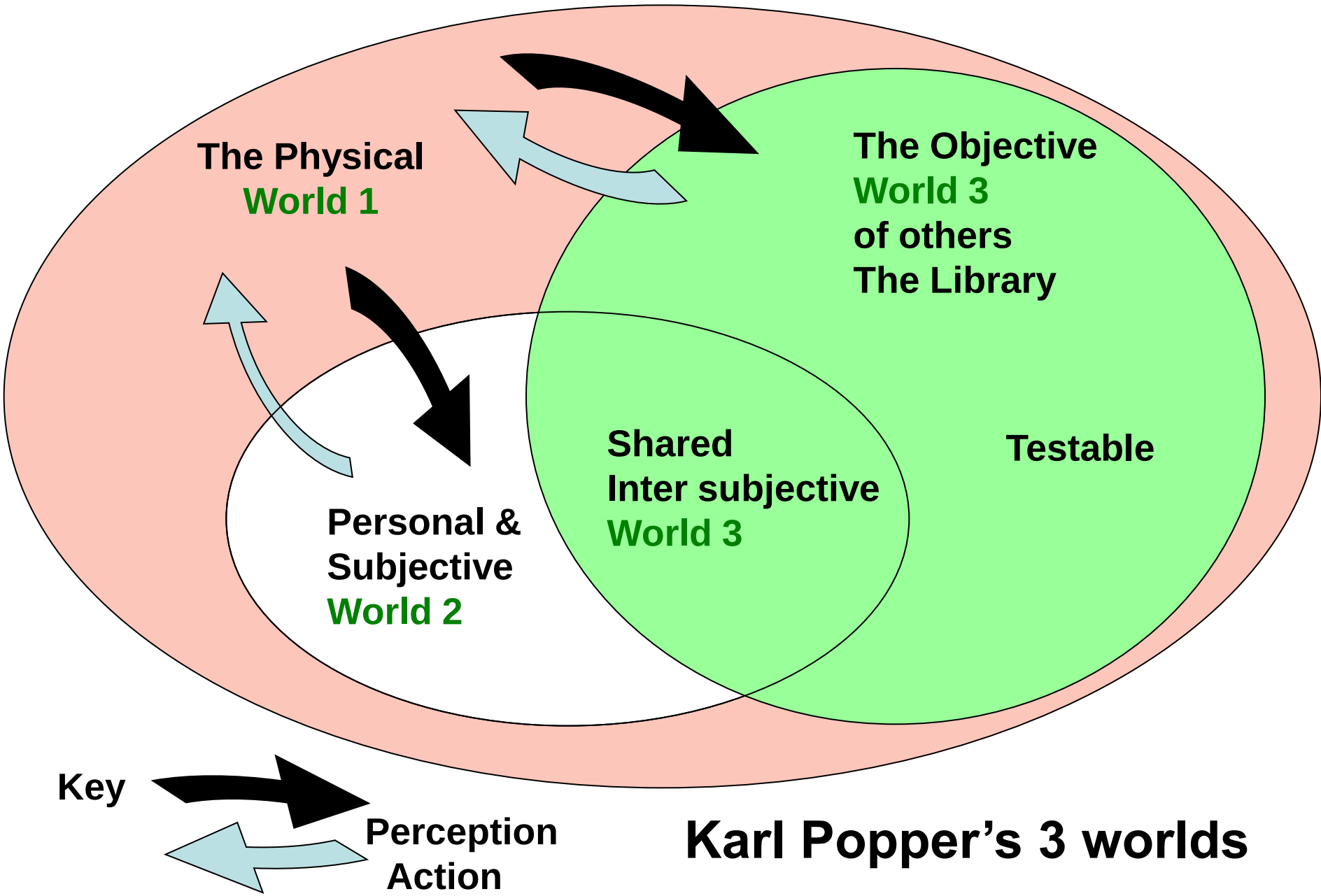


Hard & Soft

In their many guises

Science & Art
Objective & Subjective
Practice & Theory
Doing & Knowing
Logos & Mythos

Objective & Subjective



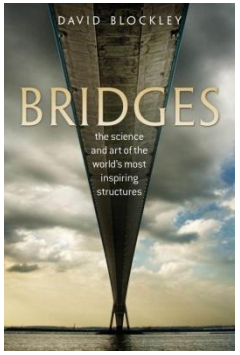
Karl Popper's 3 worlds

Practice & Theory

Engineering is turning an idea into a reality

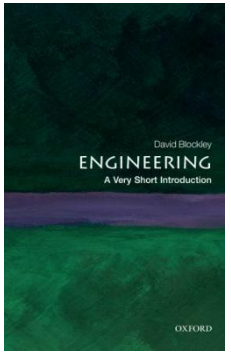
- creating and using tools to fulfil a purpose

Engineering is a form of living
since ‘doing’ or **practice** is prior to knowing
but knowing and **theory** inform better practice



Blockley, David (2010) Bridges, OUP
Blockley, David (2011) VSI to Engineering, OUP

Crawford Matthew, 2009, The Case for Working with Your Hands, Viking, London



Doing & Knowing

Man’s ability to make tools is remarkable.

But it his ingenious ability to make sense of the world and use his tools to make even more sense and even more ingenious tools, that makes him exceptional

Non-Darwinian evolutionary leapfrogging

Logos & Mythos

Logos is rational and factual but says nothing about the meaning of life

Myths are socially powerful traditional stories
– Professor Richard Buxton

What would it be like if…….there were life after death
Myths are unverifiable – require faith but little use to science

Logos & Mythos deal with different aspects of **being human**

Armstrong Karen (2004), The Battle for God, Harper Perennial, London

Faith & Trust

We have to have faith that:

- there is a real world outside our minds;
- which is structured in an orderly and intelligible way;
- this rational order is contingent,
  cannot be deduced in advance by logical reasoning
  but has to be discovered
- it is accessible to us: we are adequate to the task

How important is experience?

Experience helps you
to recognise a mistake
when you make it again.

How do we close the gaps
between what we know,
what we do and
why things go wrong?

Systems Thinking?

Systems Thinking

- ‘Joined up’ thinking

- Getting the right information (what) to the right people (who) at the right time (when) for the right purpose (why) in the right form (where) and in the right way (how)

- A lack of ‘joining up’ is where a message, any message, doesn’t get sent or received or is poorly formulated, incomplete, misleading or is without adequate justification.

Hard Systems Analysis

System	Potential	Flow	Impedance
Elec.	Volts	Amps	resistance, capacitance, inductance
Mechanics	Velocity	Force	damping, mass, flexibility
Water pipes	Pressure head	Flow	drag, open tanks/reservoirs, closed tank
Traffic	Need	Flow	on-street parking, off street parking, route changes

Systems thinkers do it holistically 

Systems thinkers do it in layers 

Six Important Moves

We need to move from thinking that

1. **complex problems can be 'solved'**
   - **rather they may be managed to some kind of success**

2. **'happenings' or occurrences are events**
   - **rather they are part of ongoing processes**

3. **linkages are linear**
   - **rather they are networks (Kirchoff's Laws apply - flow balances across a cut & and potential balances around a loop)**

Six Important Moves (continued)

We need to move from thinking that

4. **the deeper we go the more fundamental we get**
   - **rather we choose an appropriate level for our purpose**

5. **rigour can only come by being 'pure'**
   - **rather we must recognise and nurture 'practical rigour'**

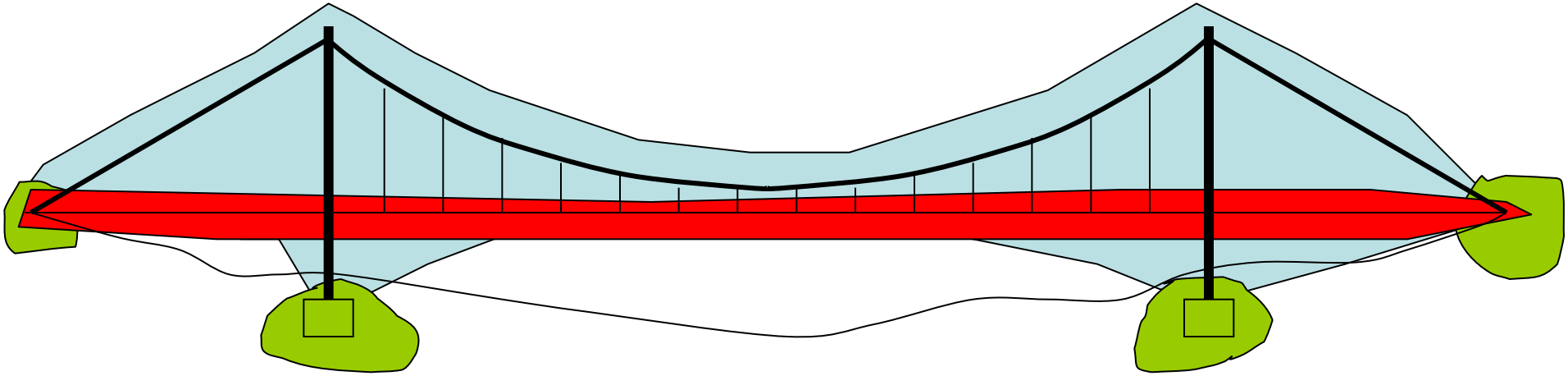
6. **values are self evident**
   - **rather we need to be explicit about our values and work to find those we have in common**

Systems Thinking

(not a subject, not a discipline but a way of thinking)

- **Thinking in layers**
  - evolutionary holism (Smuts)
  - **holons** (parts and wholes Koestler), holarchy
- **Thinking in loops**
  - 'joined up' thinking - interdependence
  - connectivity – interaction, **emergence**
- **Thinking about processes**
  - potential, flow, **impedance**
- **Thinking about basics**
  - worldview, various models
  - **hard & soft**
  - integration and synergy

Thinking in layers



Chapters (sub-structure)	**Suspension**	**Deck**	**Foundations**
Paragraphs (sub-sub-structure)	Towers, chains, suspenders, saddles	Girders, cross beams, deck surface	Anchors, abutments, piles, bearings
Sentences (components)	Cable (wires), blocks, plate, bars, welds, rivets	UBs, rebars, angles, channels	Individual blocks, piles, UBs, rebars etc
Words (materials)	Masonry, steel, concrete	Steel, concrete	Steel, concrete + rock, soil
Letters (constituents)	Sand, cement, aggregate, iron, minerals	Sand, cement, aggregate, iron, minerals	Sand, cement, aggregate, iron, minerals

Thinking in loops - emergence

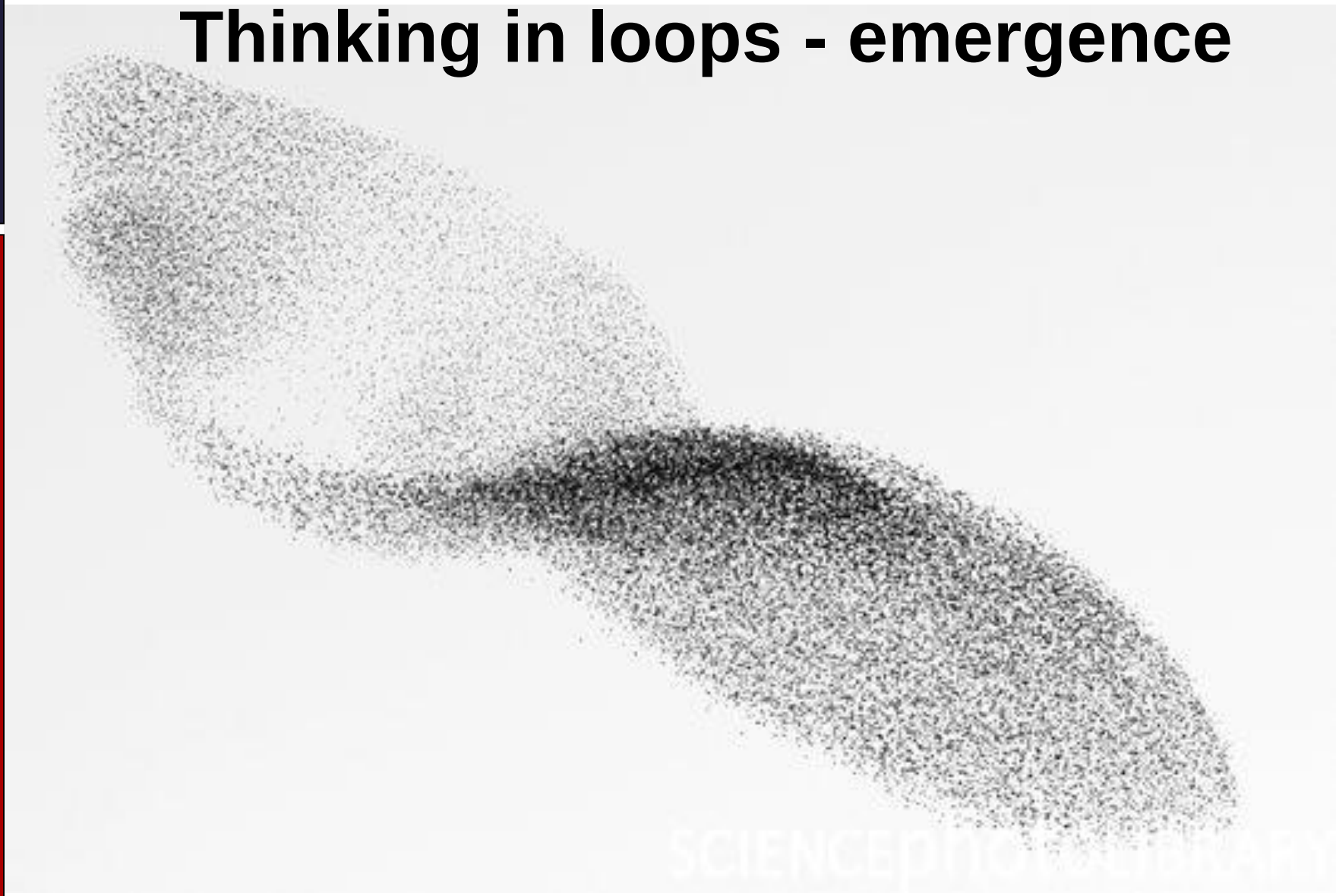
Salginatobel Bridge
Switzerland 1930

Bridges:

The harmony of beauty & function

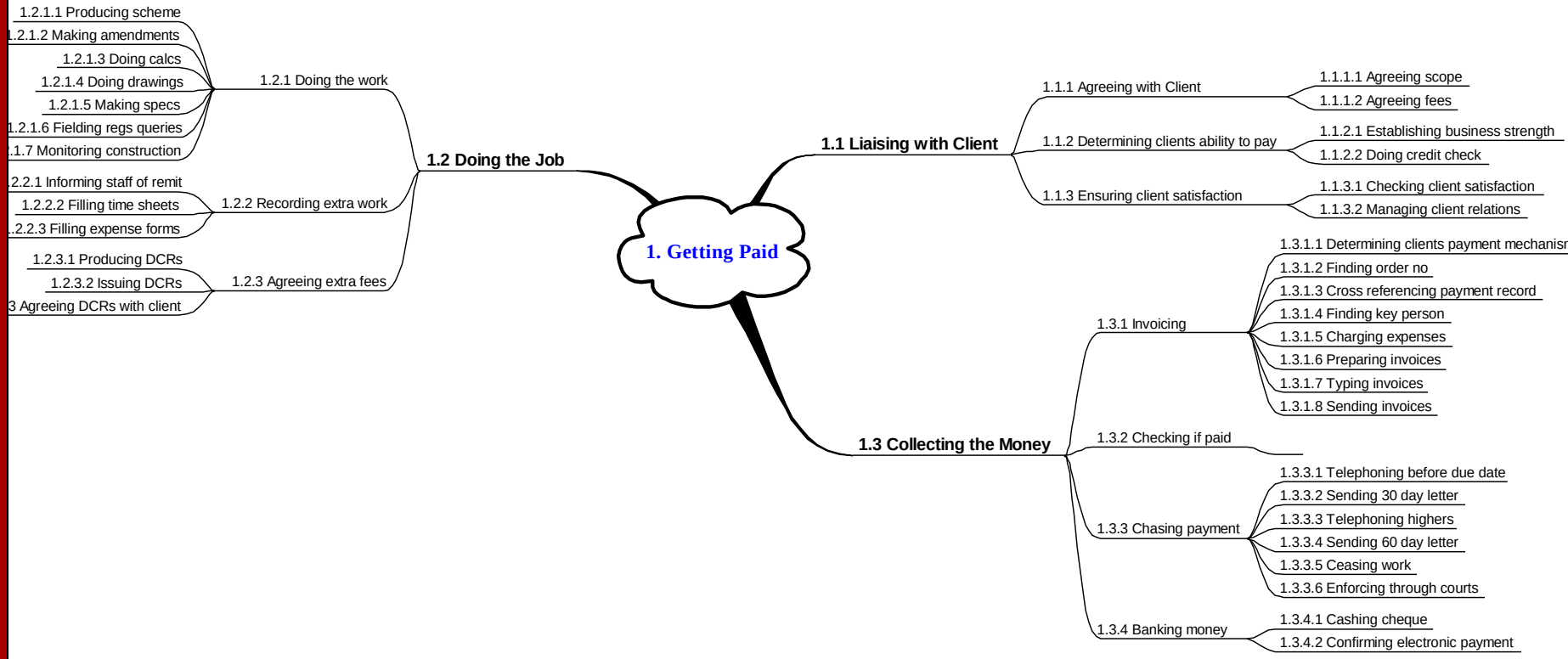
Millau Viaduct
France 2004

Thinking in loops - emergence



http://www.bbc.co.uk/nature/species/European_Starling#p005lnwt

Thinking in layers of processes – using mind maps



Why do we need systems thinking?

- To minimise the worst of times

  Monitor to minimise risk of both hard and soft system failures

- To maximise the best of times

  Promote human flourishing – well being

  (happiness is an emergent property!)

Hard and Soft Systems

Hard

- Related to physical and technical issues
- Objective content
- Uses deterministic and statistical information
- Expressed using traditional mathematics
- Have measurable data
- Reasonably predictable

Soft

- Related to human and organizational issues
- Subjective content
- Uses vague and imprecise information
- Expressed in natural language
- Have little measurable data
- Difficult to predict

I want a language in which

we can unify

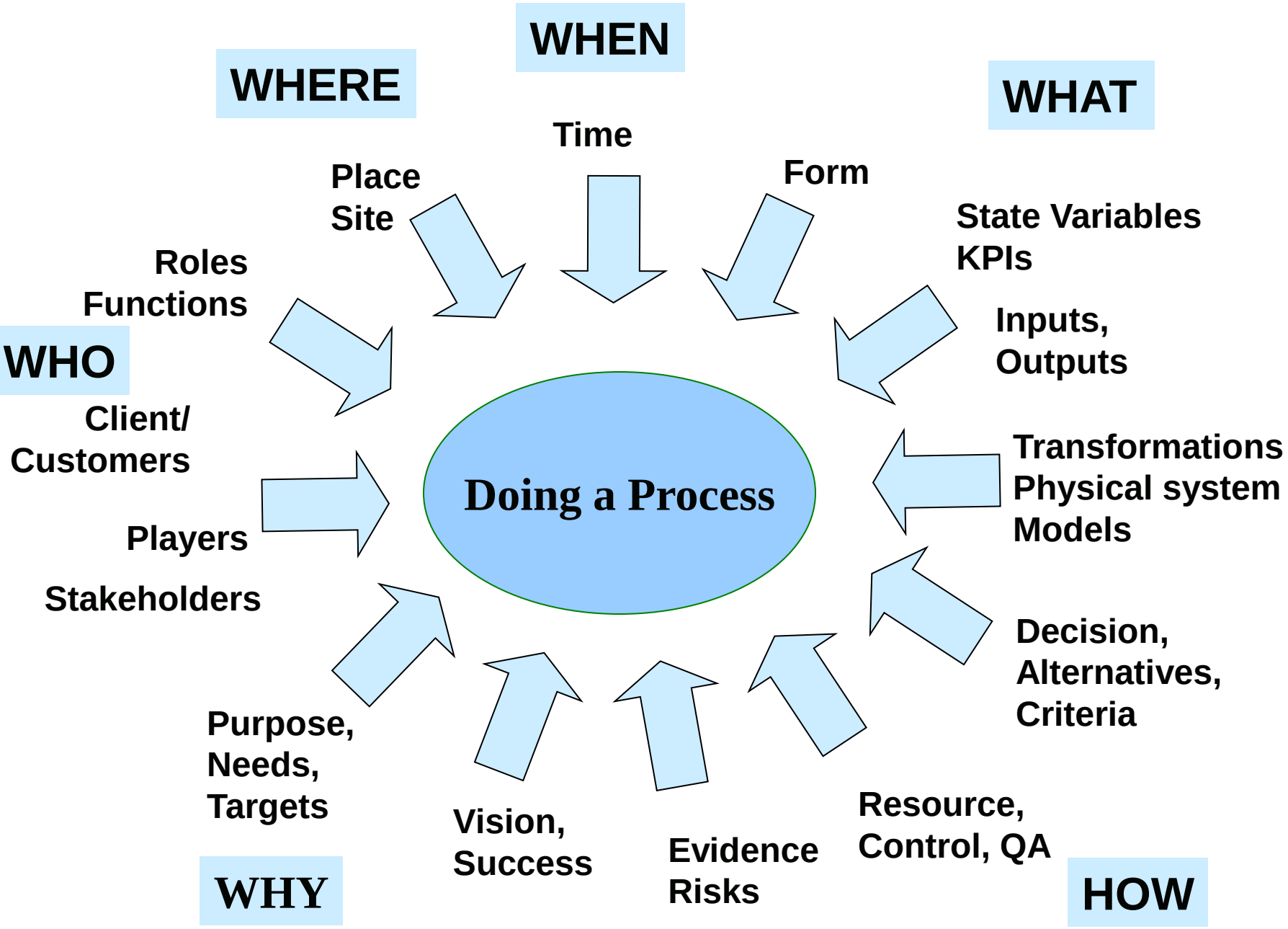
People, Purpose & Process

Change driven by Purpose

Hard systems are embedded in soft systems

- We do what we do
  through what we understand
- Understanding and action is a soft process
- Designed hard systems have a function or role
- Natural systems play a role in environmental processes – as far as we understand
- ‘Save the planet’ is misleading
  rather save ‘life as we know it’ – the planet will continue!

System	Potential	Flow	Impedance
Elec.	Volts	Amps	resistance, capacitance, inductance
Mechanics	Velocity	Force	damping, mass, flexibility
Water pipes	Pressure head	Flow	drag, open tanks/reservoirs, closed tank?
Traffic	Need	Flow	on-street parking, off street parking, route changes
'Soft'	**Why – creative tension**	**(Who, What, Where, When)**	**ambiguity/conflict, capacity to perform, capacity to adapt/innovate**



Thinking about processes – new view

The **Potential** drives the **Flow**

Why = How (who, what, where, when)

The **function** or **method** that makes the **change** and which includes the **impedance.**

Impedance is opposition to flow and includes
Resistance – dissipation of energy
Capacitance – storage of potential - accumulator
Inductance – storage of flow - delay

Thinking about processes – new view

VALUES

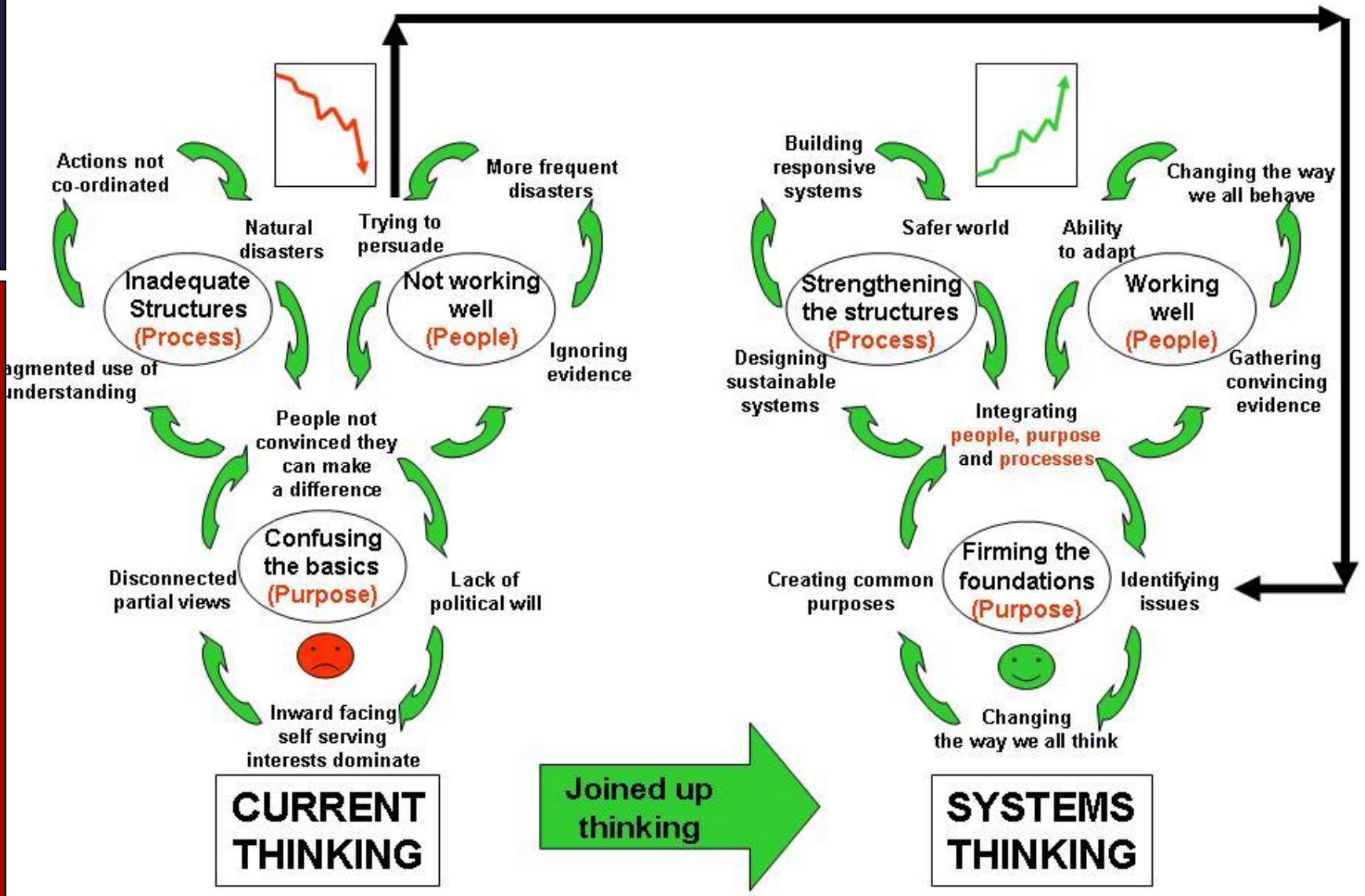
- We make decisions based on preferences
- Preferences are based on values
- Values are the **worth** we give to something
- Quality is degree of excellence which is the state of having the highest value
- Quality for science is precise **truth**
- Quality for engineering is **fitness for purpose**

Practical Rigour & Practical Intelligence

- logical rigour necessary but not sufficient
- *making it work*
  - **designing - vision to reality**
  - **delivering a system valued in a variety of ways**
  - **managing 'creative tension'**
- *appropriate models* - ***sensible approximations***
- *judgement -* **diligence & duty of care**
- *creative foresight* - **imagine what might happen**
- dependable evidence - *testing*
- feedback & *learning*

Truth is to knowledge as risk is to action

Knowledge	Action
Intention of ***knowledge*** is to achieve ***understanding***	Intention of ***action*** is to achieve ***outcome***
Truth/dependability is attribute of correspondence of understanding with ***'facts'***	Risk is attribute of (lack) of correspondence of outcome with ***consequences***
Degree of truth/dependability between ***True & False***	Degree of risk between ***Failure & Success***


Actions not co-ordinated
Natural disasters
Trying to persuade
More frequent disasters
Inadequate Structures (Process)
Not working well (People)
agmented use of understanding
Ignoring evidence
People not convinced they can make a difference
Confusing the basics (Purpose)
Disconnected partial views
Lack of political will
Inward facing self serving interests dominate
CURRENT THINKING
Joined up thinking
Building responsive systems
Safer world
Ability to adapt
Changing the way we all behave
Strengthening the structures (Process)
Working well (People)
Designing sustainable systems
Gathering convincing evidence
Integrating people, purpose and processes
Firming the foundations (Purpose)
Creating common purposes
Identifying issues
Changing the way we all think
SYSTEMS THINKING

Where is Systems Thinking Needed?

- Just about everywhere!
- Sustainable engineering
- Joined up Government
- Social services - Victoria Climbié etc
- NHS
- Criminal justice system
- Managing terrorism
- Climate change

What are the ‘Grand Challenges’?

Infrastructure

Lifelines, transport, water, food, ‘smart’ energy

Economics

Growth & sustainability, secure personal freedoms

Wellbeing

Happiness, health, caring for the vulnerable

Grand Meta-challenge

Systems thinking

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Conclusions
The benefits of Systems Thinking

- Promotes ‘Joined-up’ thinking
- Integrates to provide synergy
- Goes beyond science
- Addresses complexity
- Promotes practical rigour
- Improves rigour in ‘soft’ issues
- Shows hard systems embedded in soft systems

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David Blockley

A Tale of Two Systems

It was the best of times, it was the worst of times……

THANK YOU FOR LISTENING

2nd December 2010

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