The Barriers to Systems Thinking

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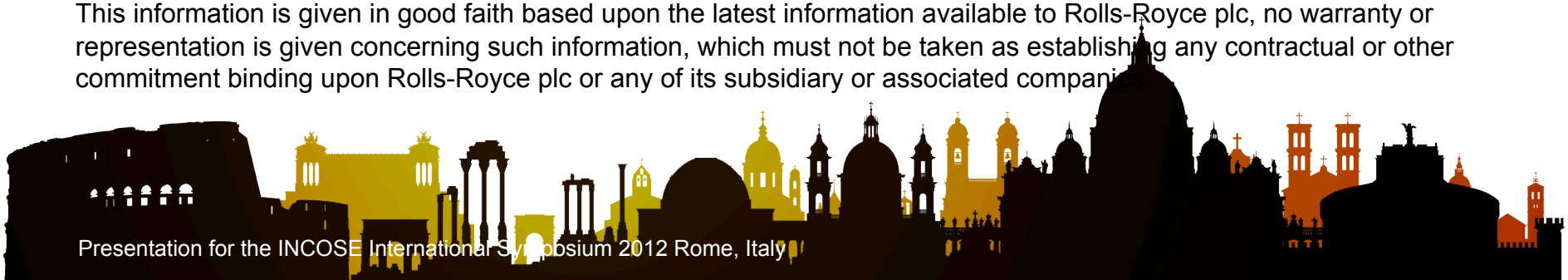


Contents

- **Systems Thinking**
  - What is it?
  - Why is it important?
- **Barriers to it**
  - Human nature (the human mind)
  - Organisation / engineering
- **Overcoming the barriers**
  - Knowing the problem – what needs to be done to overcome
- **Concluding remarks**

Systems Thinking

- Systems Thinking critical to effective Systems Engineering
- Rolls-Royce definition of Systems Engineering and Thinking
  - *Systems Engineering* is applying the **concept of a system** to a situation in order to gain insight and understanding (Systems Thinking), in a **systematic and repeatable** manner.
  - *A System* is connected components forming a whole, **showing properties of the whole**, rather than the components. A system has **systemic properties** and characteristics used to understand the problem / situation under investigation.
- Apply properties of a system to problem, even when it isn't an actual system, to get understanding
- Systems Thinking to be a core competence across RR Engineering

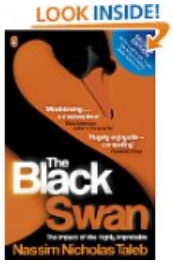
Balance thinking and process

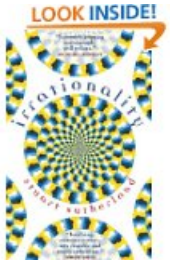
Being Systematic		Poor Systems Skills	Good Systems Skills
	Good process	**No invention / rework** No real thinking, Systems process methods "by the numbers" methods, ineffective Systems Engineering	**A very good chance** The right understanding of problem – skilled and appropriate use of process and method
	Poor Process	**No chance** Cannot handle complexity and unlikely to do well!	**No control** Individuals "uninterested" in process –no control, critical things missed, reinvention, some "mavericks"
		Being Systemic	

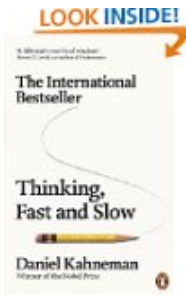
Human Behaviour barriers to Systems Thinking

- The way the human mind works is one of the biggest barriers to Systems Thinking
- Specific barriers are
  - Levels of activity in the human brain – e.g. Koestler "Ghost in Machine" describes
    - **Autonomous** (e.g. Breathing)
    - **Limbic / reactive** ("Horse's kick", "fast thinking")
    - **Cognitive / reasoned** – often very analytical and "reductionist" – but thoughtful "slow thinking"
  - Jumping to conclusions – and the "availability error" (see later slide)
  - "What you see is all there is"
  - Difficulties with dynamics

Key references for human aspects







- The paper draws heavily on 3 “popular press” publications – recommended for further reading
  - Taleb, Nassim, 2007 *The Black Swan* – first half!!
  - Sutherland, Stuart, 1992. *Irrationality*,
  - Dorner, Dietrich; 1996 *The Logic of Failure* (Original in German in 1989)
- Since writing the paper my thoughts have been reinforced by reading Kahneman, Daniel, 2011 *Thinking, fast and slow*
  - Fast thinking is the default – instinctive, jump to conclusion
  - Slow thinking is rational / analytical (not Systems Thinking) and biased by fast thinking preconceptions

Availability Error

Natural drive to jump to conclusions as soon as possible compounded by **"the availability error"**

Assertion – "A card with Letter **A** on one side always has a **3** on the other"

Task – you are given 4 cards – which **two** do you turn over to test the assertion?

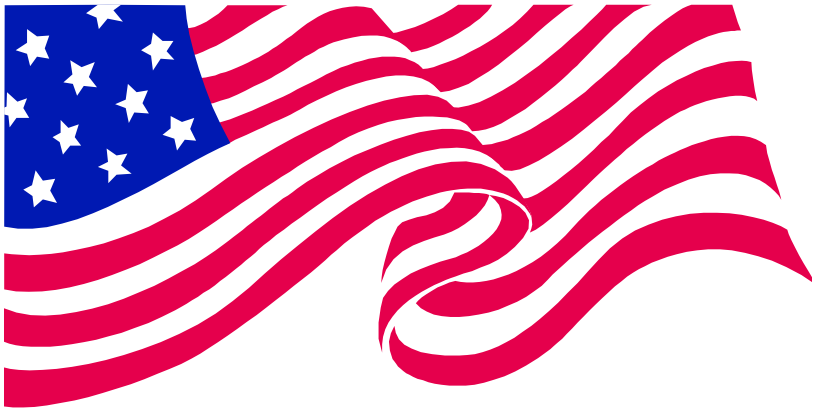
A D 3 7

A – most chosen and sensible – no 3 shows assertion is wrong

D – least chosen – and least chosen

3 – popular choice**– irrelevant to assertion – but 3 is available**

7 – rarely chosen **– but very relevant –** an A disproves assertion



The United States of of America

Difficulties with looking and dynamics

- *"Understanding how to act under condition of incomplete information is highest and most urgent human pursuit"*

Karl Popper 1972

But ..

- Our "jump to (plausible) conclusion" mindset prevents us wanting to look
- When we do look – focus is on known problems
- A little extra information increases confusion – and destroys "safe" assumptions

Dynamic Situations even worse

  - Failure to comprehend momentum (see Dorner)

Organisation and engineering itself

- There are specific issues from the nature of organisations and the nature of Engineering
  - Changing is hard (see Kotter change model)
  - Drive for progress
  - Engineering as a discipline
  - Systems Engineering – and the way it is described / sold
  - Large / diverse organisations

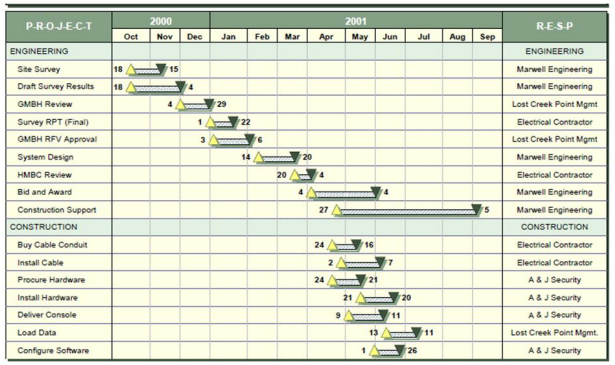
The drive for progress

- A desire for progress is natural human behaviour
- Shakespeare summarises it ...

And thus the native hue of resolution
Is sicklied o'er with the pale cast of thought,
And enterprises of great pitch and moment
With this regard their currents turn awry
And lose the name of action…

Hamlet Act 3 Scene 1

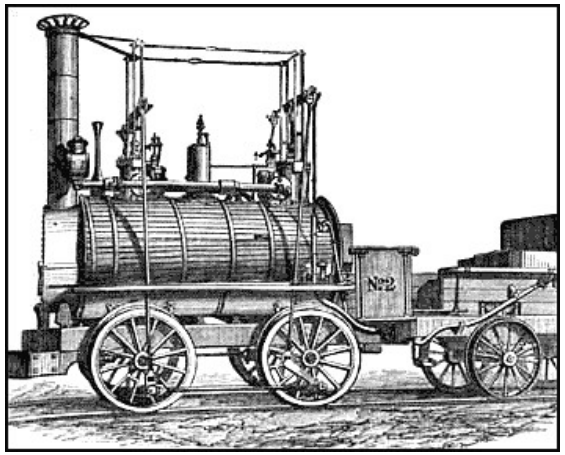
- Progress needs to be tangible / visible
  - Understanding of problem isn't
- Time on plans one way – no iteration



Beware the "Curse of the Gantt chart"

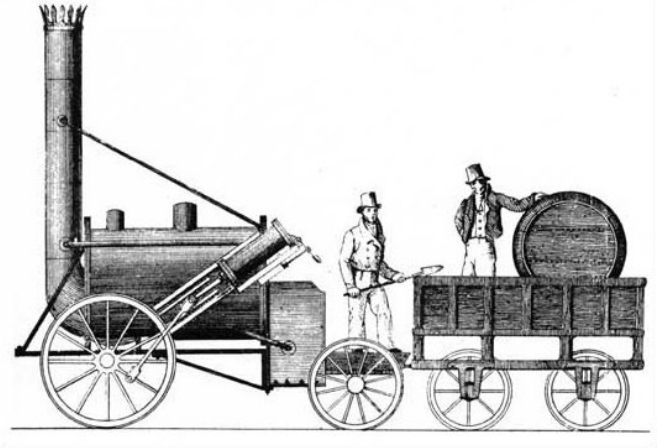
Engineers as practical

George Stephenson, 1778 - 1848



Blucher engine – designed and built by George Stephenson 1814

- Problem with escaping steam
- Flowing through chimney **DOUBLED POWER OF ENGINE**



- Blucher innovations lead to high performance of the Rocket **in 1829**, and without steam blast, and locomotives would still be dragging themselves along at 5 or 6 miles an hour (written 1874)
- Performance principles of the combustion aerodynamics theoretically understood at Purdue University **in 1908**

- Sources – Samuel Smiles on “the lives of the Engineers”, and for theoretical understanding (Purdue) Wikipedia article of George Stephenson

Engineering and Systems Engineering

"Systems Engineering is just good engineering with special emphasis"

From Introduction – Systems Engineering and Analysis – Blanchard and Fabrycky 2005)

"Are you saying I'm not a good engineer?!!"

- Heroes fix problems, don't prevent them
- Engineering process not set up for "wicked" problems
- Systems Engineering language can be a barrier
- Systems Engineer as "glue / integrator" seen as overhead (want one task per person)
  - But what's point in Sys Engineer understanding what the System Designer with solve

Beware Systems Engineering being seen as a new breed of magic

So....

- "*You've got to accentuate the positive Eliminate the negative*"

Johnny Mercer, 1944

- *"Describing barriers is important to understand, but negative on journey – we need to be thinking of solution scenario (and what its like) rather than eliminating problem, which keeps us fixating on problem and so we lose confidence*"

Relationships made easy, David Fraser, 2010

- Let us not give up hope – and focus on ideas to improve / enable Systems Thinking – based on understanding barriers

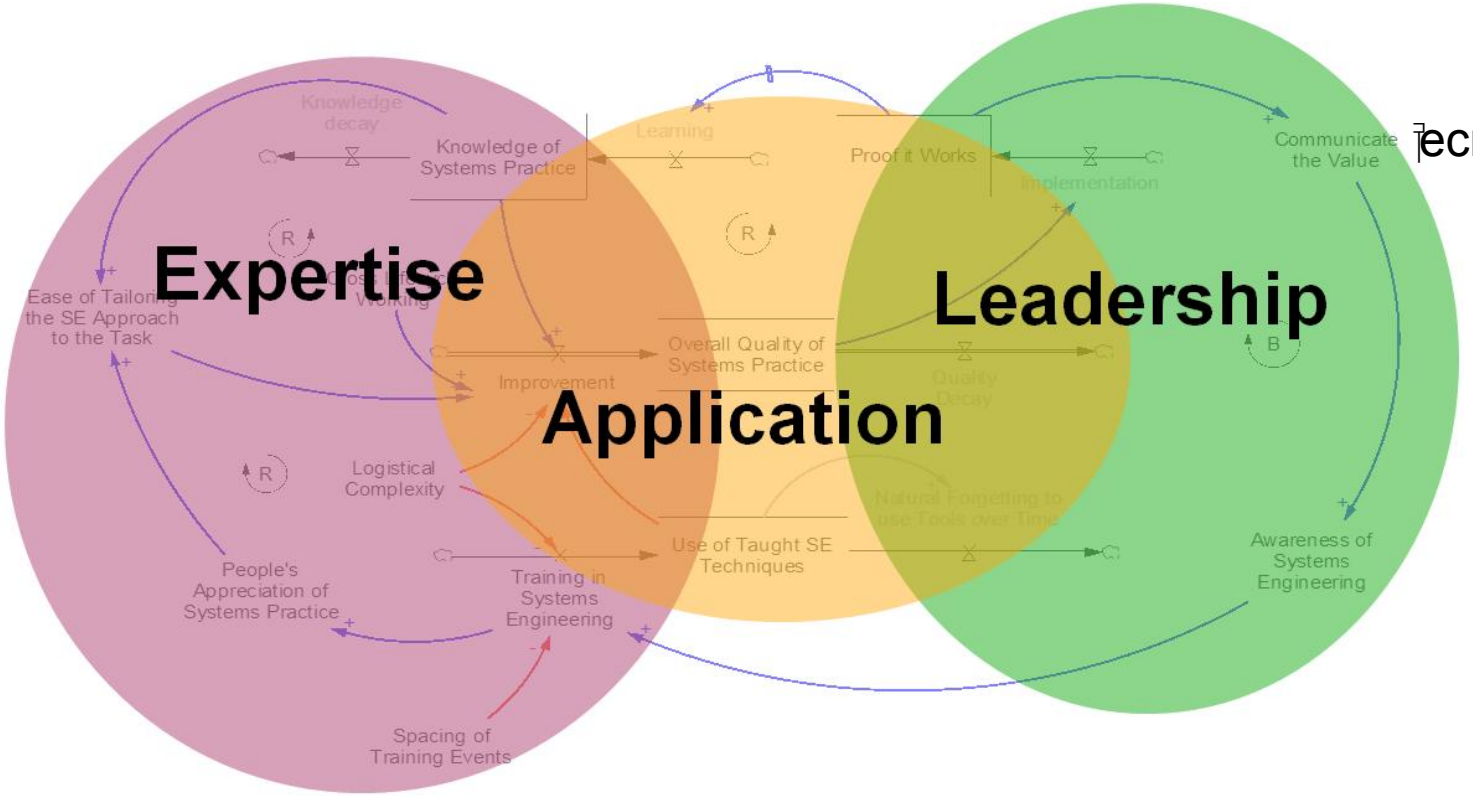
How to Develop Systems Thinking

1. Make it a **core** engineering skill

   Systems Engineering to be the way RR does engineering

2. Identify the best way to learn –
   - Basic training necessary but not sufficient
   - Davidz / Nightingale (2008) emphasise
     - Experiential learning
     - Right supportive environment
     - Identifying specific supporting behaviours
3. Behaviours
   - UK dstl highlight “emotional intelligence”
   - NASA focus on “human dynamics”

Model for developing / enabling Systems Practice



From on-going EngD work at Bristol Systems Centre by Charlotte Dunford

ecneulfnI
margaid
gnithgilhgih
ot sreirrab
gnimocrevo
ot sreirrab
gnitiolpxe
smetsyS
hcaorppA

Training alone not enough – so need

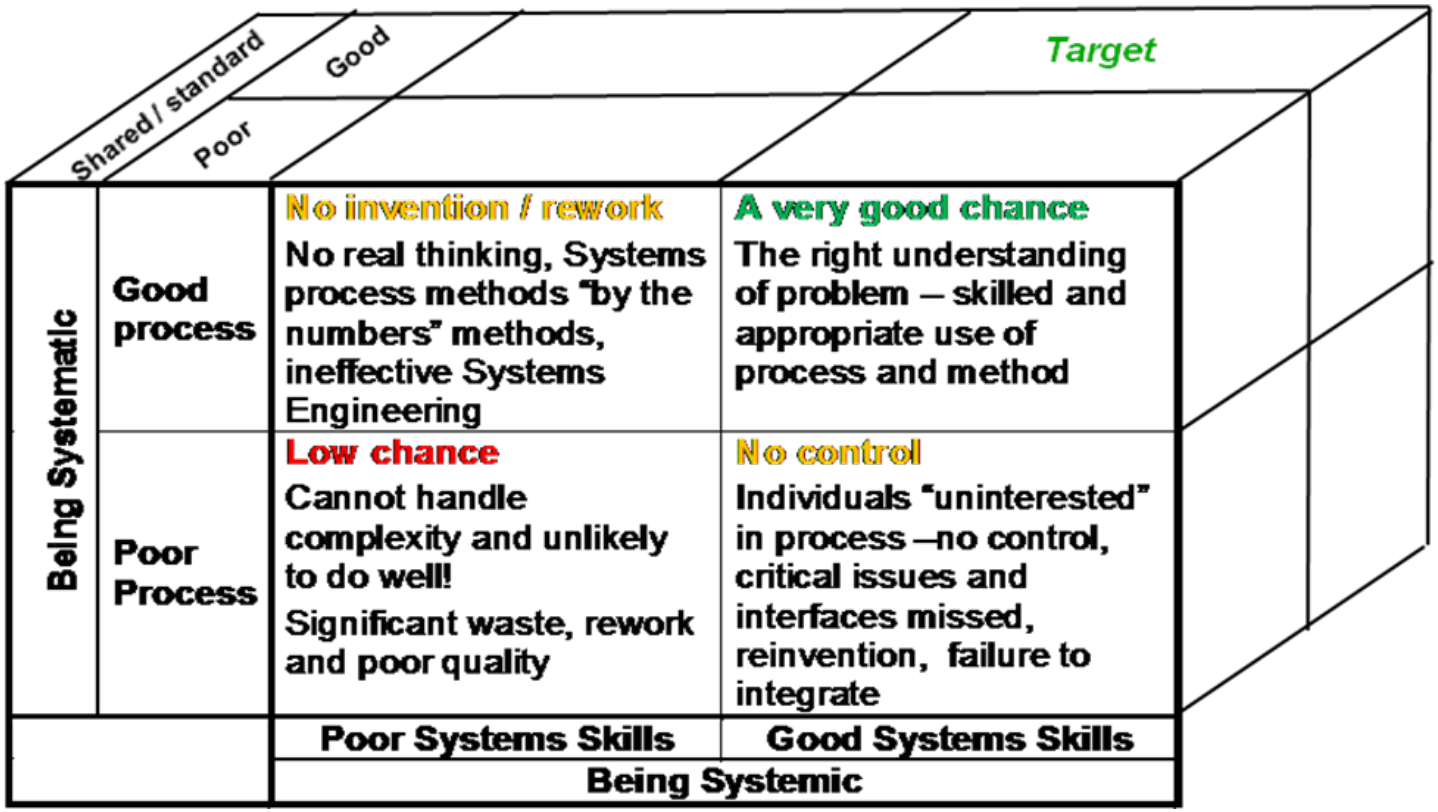
- Right coaching / support (to embed)
- Opportunities to apply
- Leadership pull to expect / pull for Systems Practice

Ne

Learning trajectory for Systems Thinking

Project Type	**Real world**	**Resolving in-service problems** Quicker results and faster appreciation of power of approach	**Major projects** The highest value from SE, but not the place to learn
	Pedagogical	**Simple** Introduction / learning tools and concept, but low domain applicability	Large case study worked examples Insufficient benefit in return for the case
		Short, Simple	**Long, complex**
		Project Duration and Complexity	

Standardise and Share



Conclusions

- Systems Thinking important, but (for many reasons) hard to do
- Key to success is wanting to do it, and recognising that the key to successful development is personal experiential learning
- This needs to be supported / nurtured by leadership
- Make SE core (understanding is a team sport)
- Develop the behaviour characteristics to support
- **Don't give up** – the benefits of Systems Thinking are too great to miss

Last word

The Last Judgement, Michelangelo, Sistine Chapel, Rome (1534-1541)

"The great danger" for most of us lies NOT in setting our aim too high and falling short, but in setting our aim too low, and achieving our mark"

- **Michelangelo Buonarroti Simoni** (1475 –1564)

QUESTIONS?

Reliability, integrity, innovation