32nd Annual INCOSE international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

Institutional Change and the Evolution of Systems Engineering

www.incose.org/symp2022

The Plan

- Panelists from Australia, US and Great Britain have varied backgrounds to explore, through conversation, the opportunities for systems engineering to contribute to sustainable lifecycles, building trust in institutional change processes while evolving the art, science and expertise of systems engineering.

The Who

- Professor Michael Henshaw, Loughborough University, UK
- Meaghan O'Neil, Systems Practitioner
- Professor Duncan Kemp, UK Ministry of Defence
- Dr. Barclay R. Brown, ESEP, Assoc. Director AI Research Collins Aerospace
- Dr. Richard Hodge

Michael Henshaw

EVERY GOOD REGULATOR OF A SYSTEM MUST BE A MODEL OF THAT SYSTEM
Roger C Conant and W Ross Ashby, Int. J. Systems Sci., 1970, vol. 1, No. 2, 89-97

- A rather erratic paper with many unrelated examples of control models that, nevertheless, makes some profound points of significant relevance to modern systems.
- It is focused on mathematical predictive models
- From a cybernetics point of view, the argument follows from Ashby's Law of Requisite Variety, that the control model for a system must have sufficient degrees of freedom to fully respond to system changes (otherwise it cannot control the system).
- The paper attempts to convince the reader that systems thinking is a natural science that obeys generalisable laws. It unnecessarily includes maths (in a form of group theory) to support the arguments more convincingly than the narrative. Based on the arguments concerning models, the authors assert (in 1970) that we could begin to measure the efficiency with which the brain works.
- However, the paper has some important implications:
  - That the brain must model it's environment – i.e. we all think in models all the time. This implies that our understanding of the environment is determined by the extent to which our brains can model the environment.
  - In the modern age, as engineered systems become increasingly complex, then eventually the only model of the system that is available is the system itself. This implies that even our most sophisticated models will not allow us to accurately model the system behaviour and our only recourse is to stimulate a system and measure its response to determine its behaviour.

Meaghan O'Neil, Systems Practitioner

18+ years design and delivery experience in safety critical systems

Meaghan O'Neil

Director, Systems Consultant
System Design and Strategy Ltd
Bristol, United Kingdom
Meaghan@incose.net
www.systemdesignandstrategy.co.uk

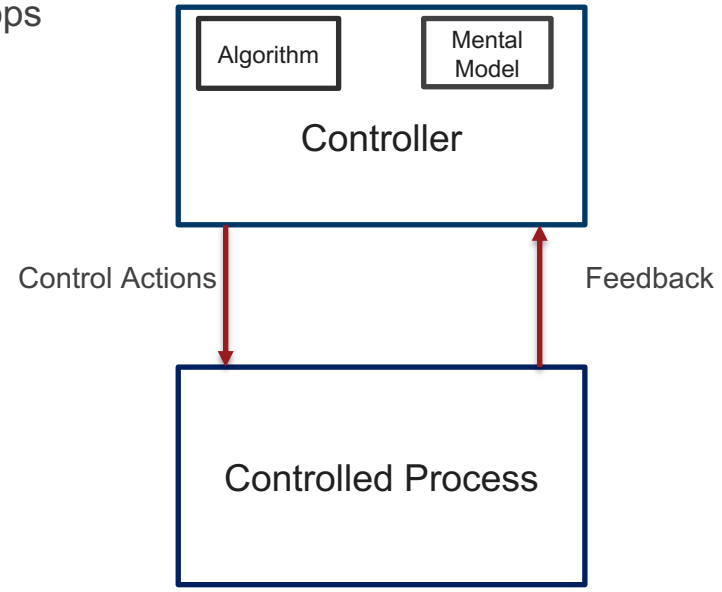
- **System Safety experiences with systems including products and services** Medical Device, Healthcare Services, Power Generation, Fire Fighting PPE and control systems, Infrastructure, Manual and Automated Manufacturing, Visual Inspection, Automotive, Aerospace
- **Provide extensive systems consulting experience.** Founder of System Design and Strategy Ltd, previous experience at Accenture and Cambridge Consultants. Experience providing systems consulting and training to a wide range of industry sectors worldwide.
- **Contribute internationally to progress the state of the practice of system safety and system engineering practices.** Leader (10+ years) International Council on Systems Engineering (INCOSE), Co-chair International Systems Safety Working Group, Elected International Treasure/Officer INCOSE Board, Co-chaired International Biomedical Working Group.
- **Education and research background.** Chemical Engineering Bachelors (Cornell University), System Design and Management Masters (Massachusetts Institute of Technology), dissertation on System Safety Approaches Applied to Healthcare Adverse Events.
- **General Aviation Pilot:** FAA Commercial Single Engine License, Instrument Rated, Advanced Ground Instructor

Systems Perspectives on Institutional Change

- Approach based on Systems Theory and System Control Theory (STAMP)
- Why this is hard in practice
- Practitioners experience and lessons learned

Systems-Theoretic Accident Model and Process (STAMP) offers a hierarchical control view of systems

Control Loops



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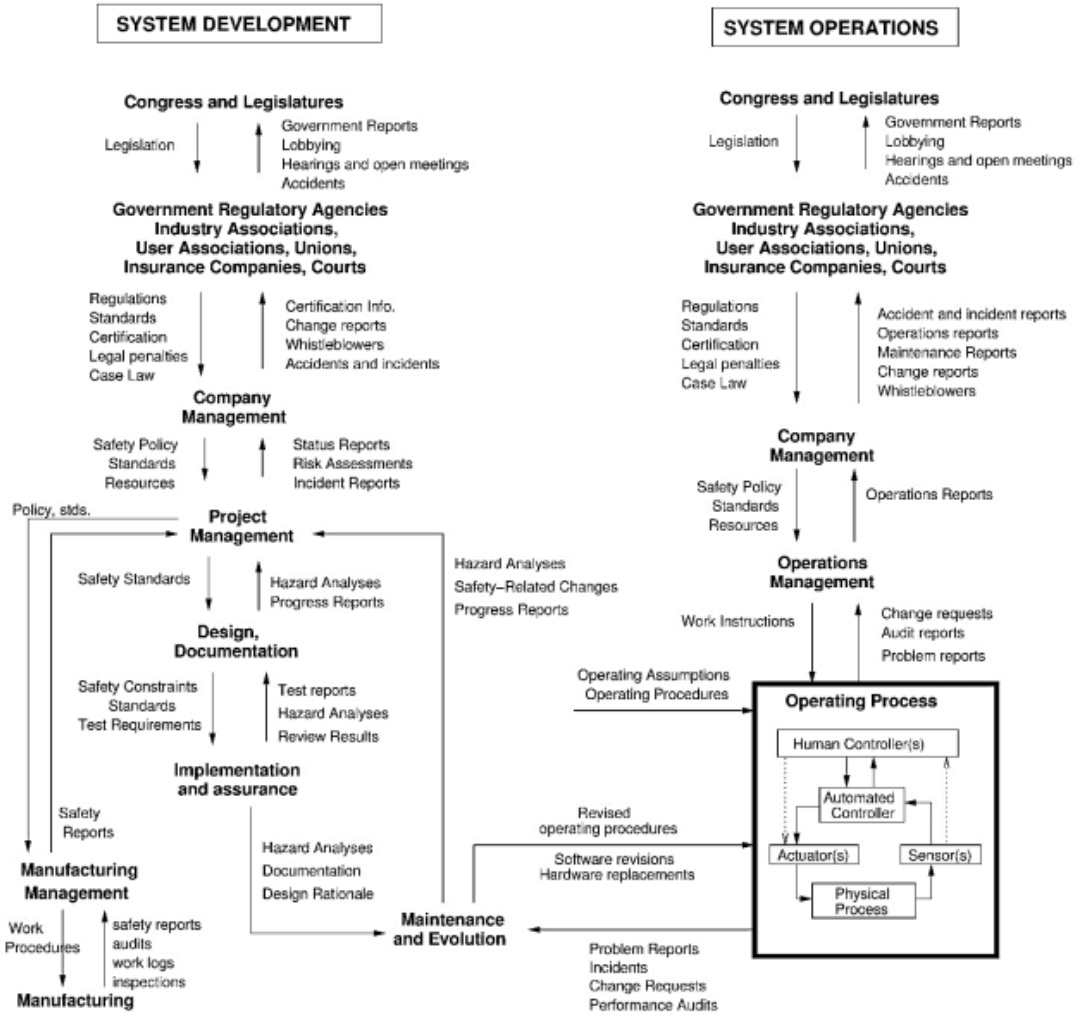

Figure 3.2: An Example Safety Control Structure

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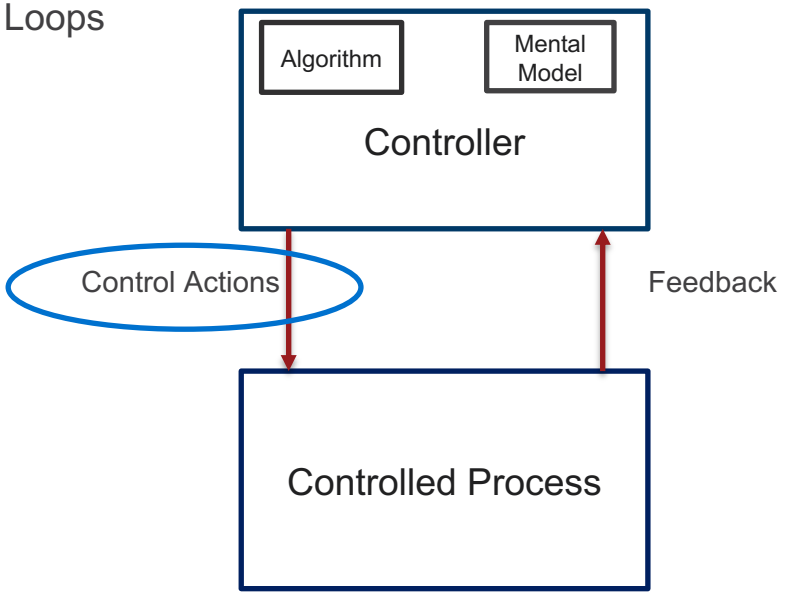
STAMP can aid in understanding why

Institutional Change is hard in practice

Actions (aka “levers”) are limited

Control Loops



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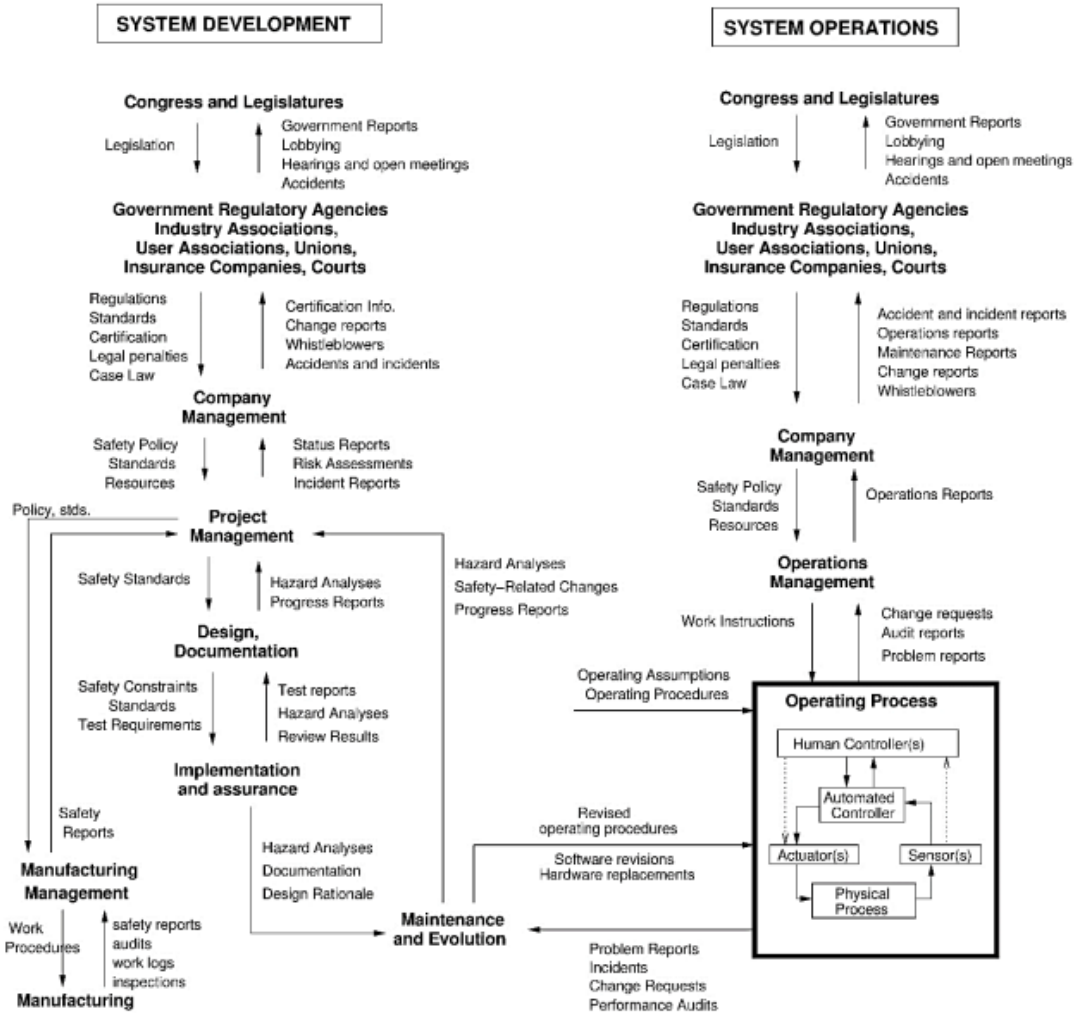

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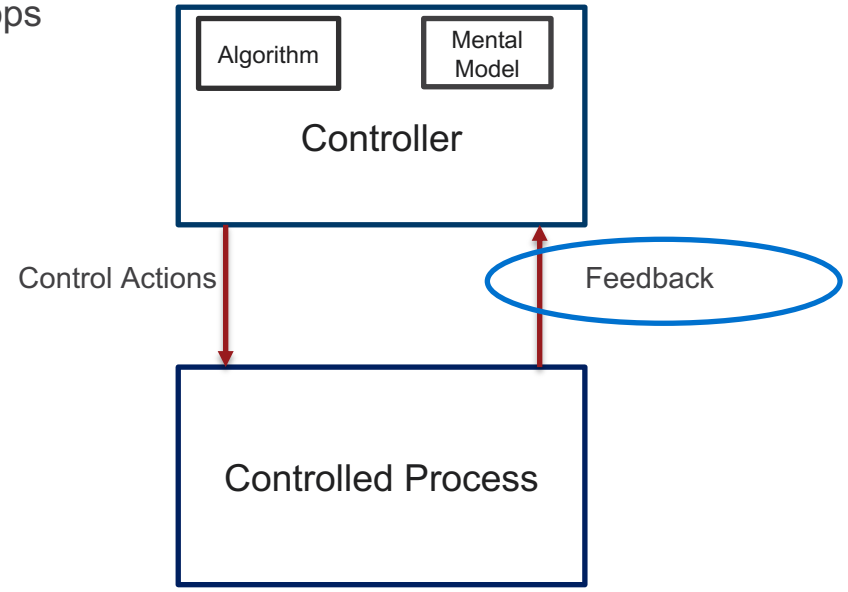
Common Feedback Challenges include: missing, limited, delayed, incorrect…

Control Loops



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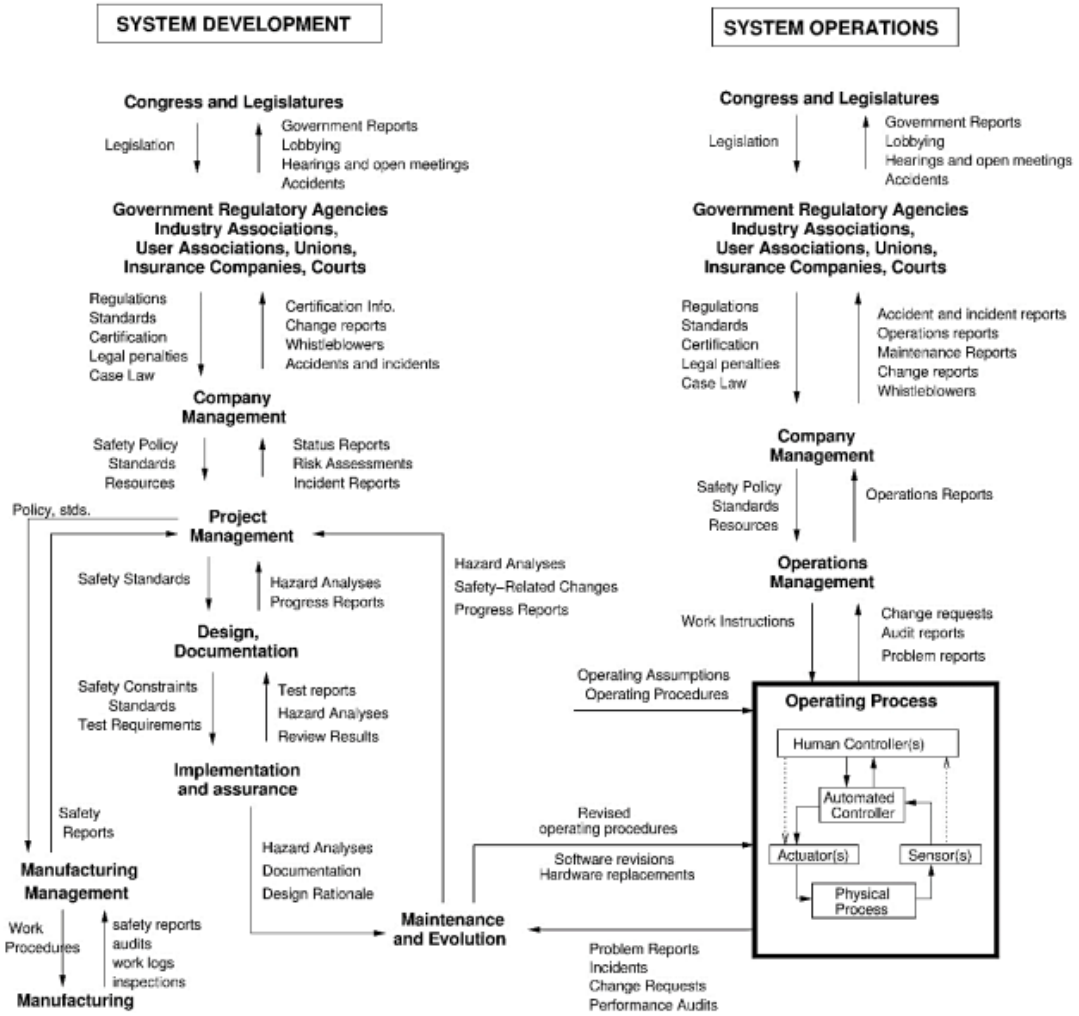

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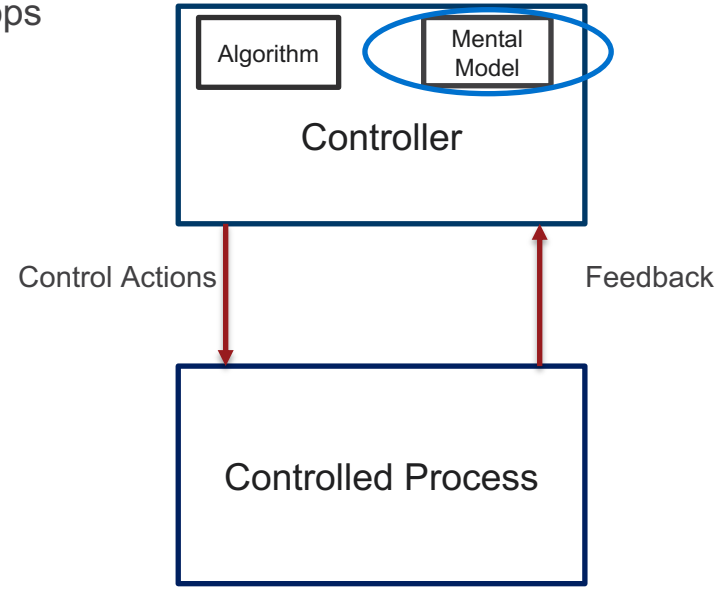
The human mental model attempts to interpret the received feedback which then affects the decision making (algorithm)

Control Loops



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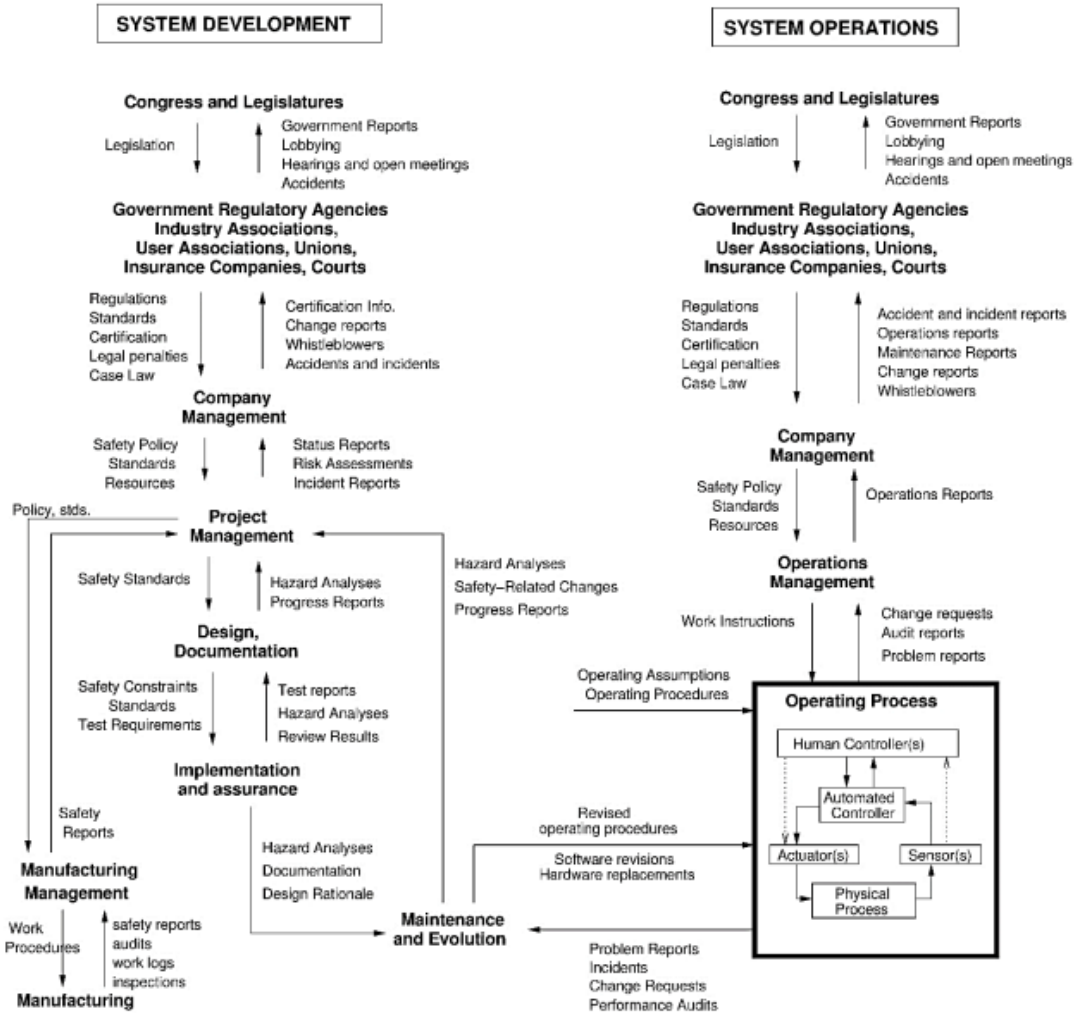

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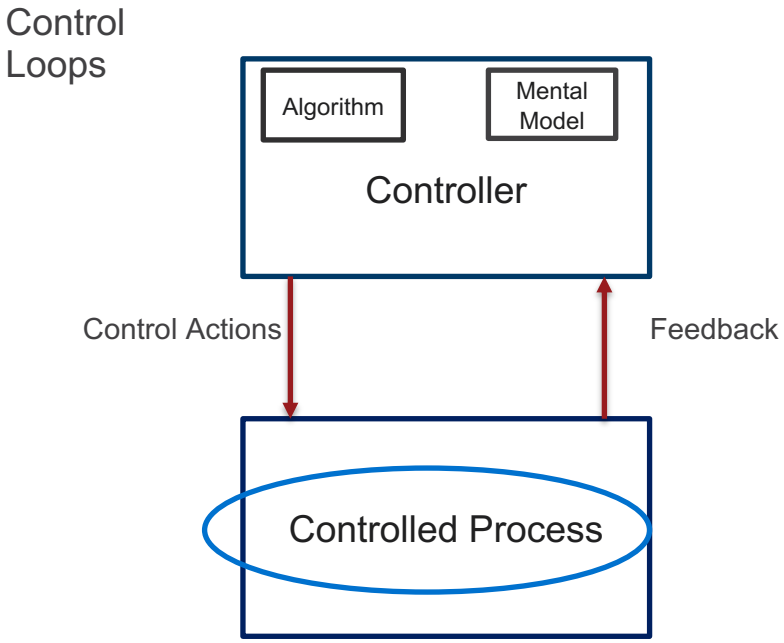
Dynamic Feedback is one cause of complexity
Result is separated in space and or time from the action



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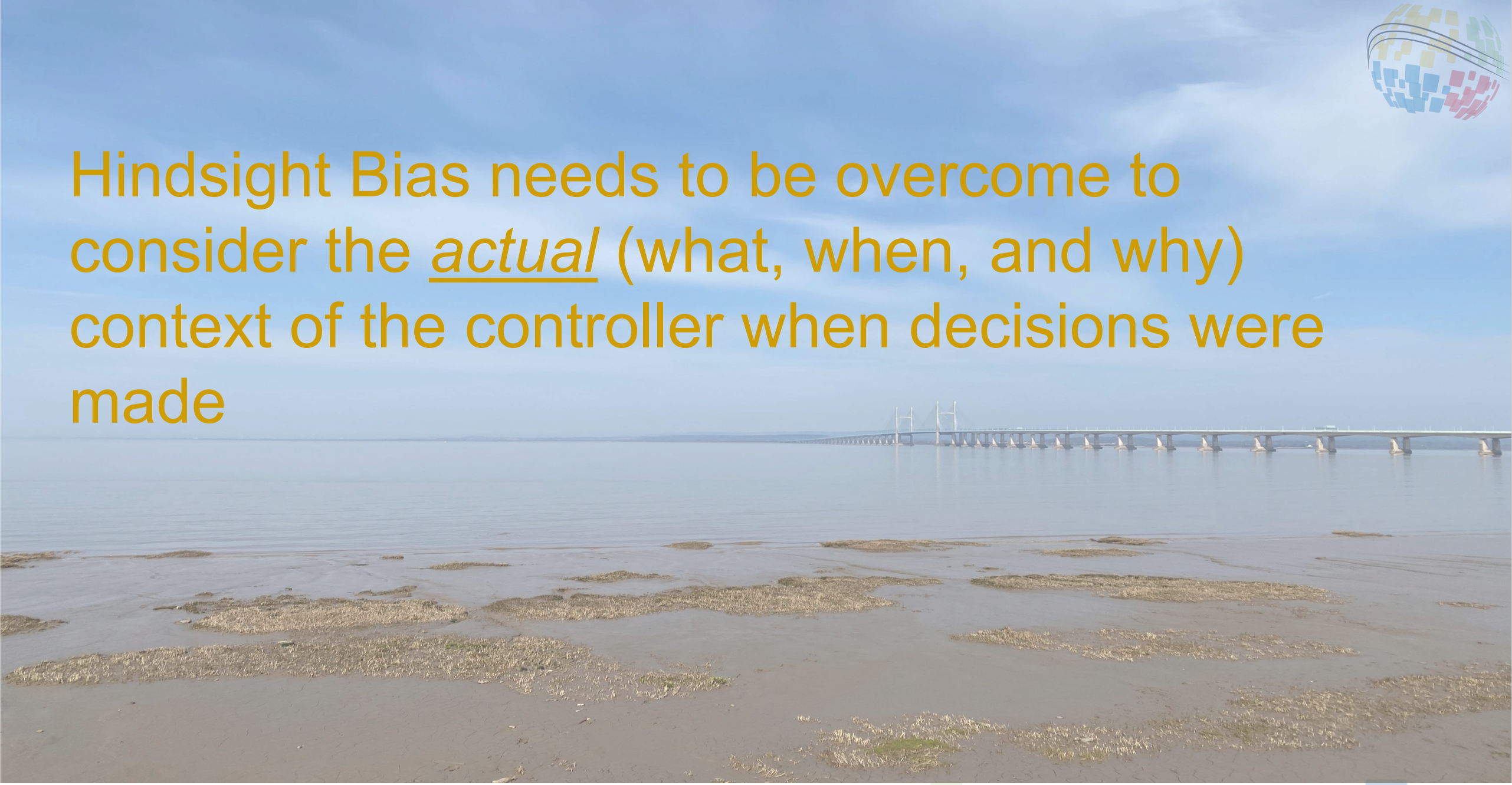
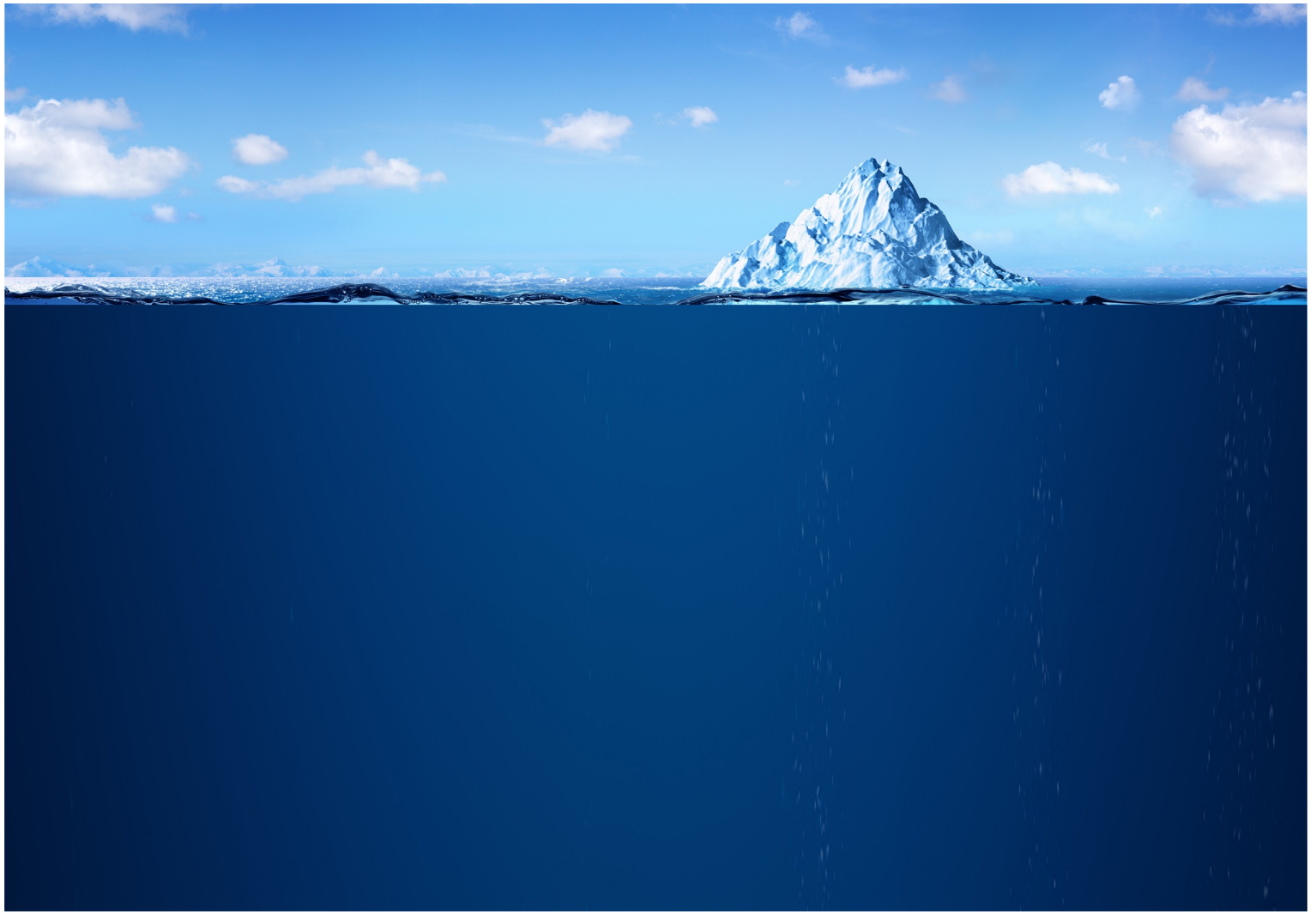
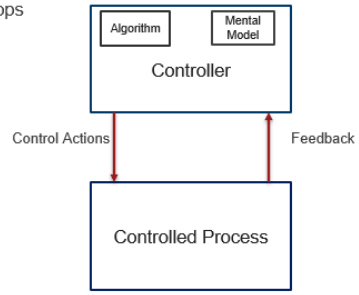


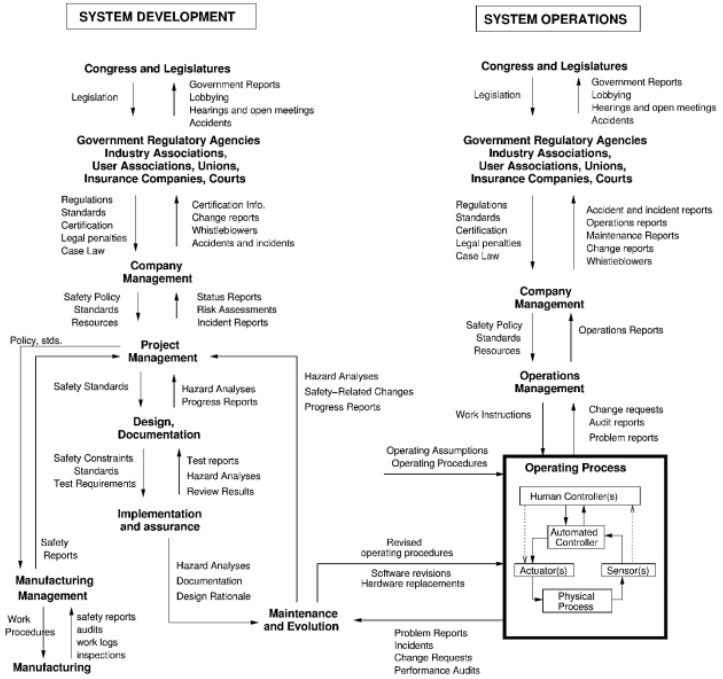
Hindsight Bias needs to be overcome to consider the *actual* (what, when, and why) context of the controller when decisions were made



Summary

Control Loops





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Managing diverse mental models

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Duncan's background

Professor Duncan Kemp, CEng FIET, INCOSE Fellow

DE&S Fellow for Systems Engineering
Internal Technical Support Team Leader
Engineering Group
Abbey Wood South, BS34 8JH
Tel: +44 (0)7966 146 724

1984 – Joined MoD as Student Engine
1989 – Graduate E
Technical Discipline Lead for SE
2019 – Senior Fellow for SE
2022 – Digital Engineering Implementation TL

And …

- Chair of the INCOSE System Safety working group
- Published 20 peer reviewed technical papers, including several on System Safety
- Presented DE&S Maritime Safety Refresher, MOD 1* Boot camp
- Guest lectured at Birmingham, Loughborough and Bristol Universities, MIT, USMA West Point
- Visiting Professor for Systems Thinking at Loughborough University
- INCOSE Fellow

What is your preferred approach?

You have been headhunted to fill a prestigious and high profile leadership role based upon your experience. A day after starting one of your team explains that a situation has occurred that requires your full attention. It is exactly the type of situation that you were brought in to manage. If you get this right, you will have justified your recruitment. Get it wrong and you will be sacked. Do you:

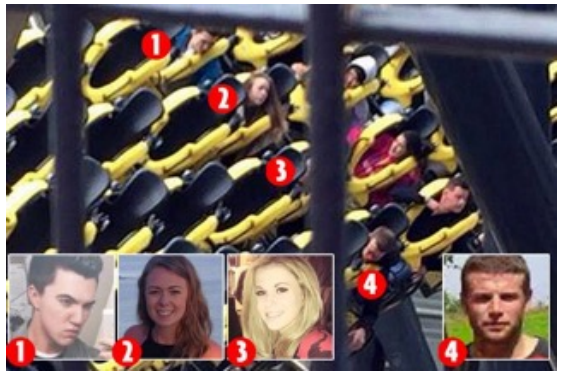
A. Make a quick decision and communicate it clearly to everyone. The real situation will be more complex than your initial understanding – but quick decisive coherent action is better than over analysing the situation

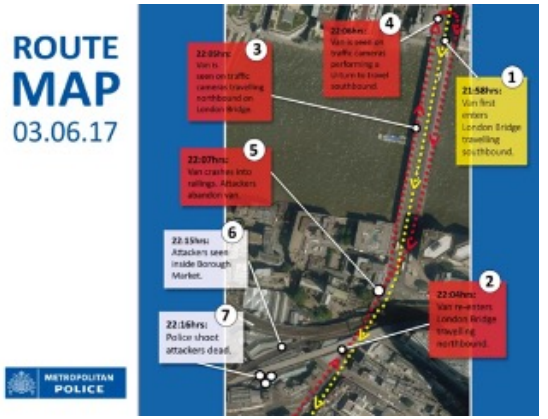
B. Initiate several teams to implement different solutions. Not all of them will succeed, but you can roll-back the failures and reinforce the successes. You didn't get where you are by putting all your eggs in one basket!

C. Commission a detailed analysis of the situation, gather all the facts and then make a measured judgement call based upon your experience. Communicate your decision to everyone so they can implement things. Difficult problems require expert judgements.

D. Get everyone to follow the process, but don't intervene personally. It may feel uncomfortable, but that is what the process is for. Coach them and advise them. You are their leader – but it is their job.

What is your preferred approach?





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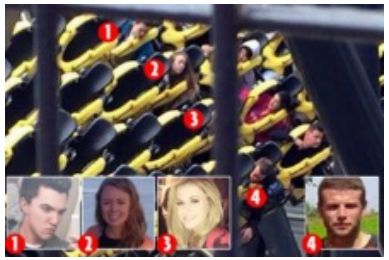
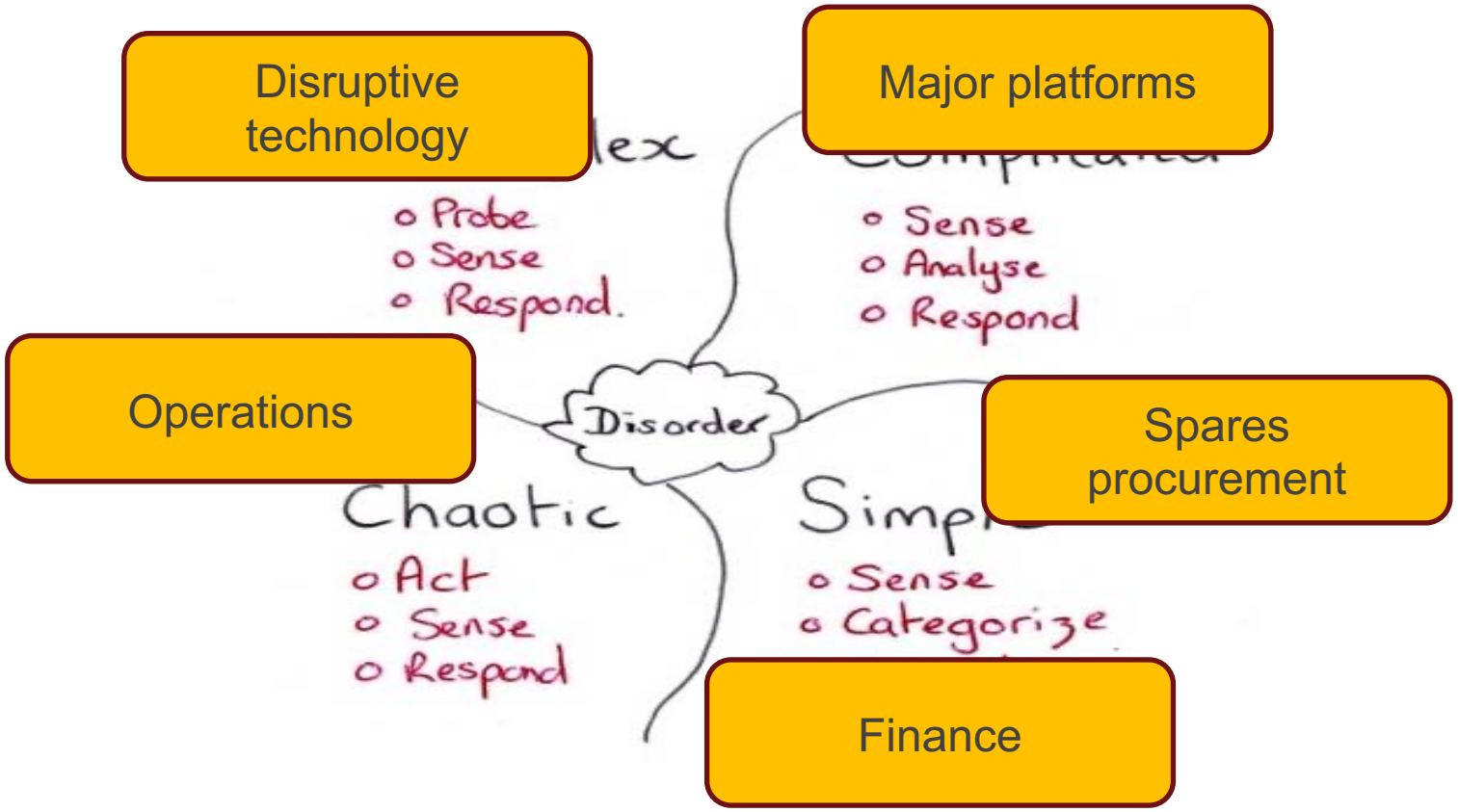
Key lessons



- Take initiative *and* strictly follow process
- Take as long as it takes *and* take quick decisive action
- Follow the experts diagnosis and plan *and* change plan as operation evolves
- Single coherent approach *and* diverse strategy
- Listen to the diverse views *and* tell people clearly what we are going to do

There is no way to follow all of the 'lessons' … they are contradictory

So what?



- Am I using the right approach, or my preferred approach?
- How do I convince someone to use a different approach to their preference?

Barclay

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MBSE as Data

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Barclay R. Brown, PhD, ESEP

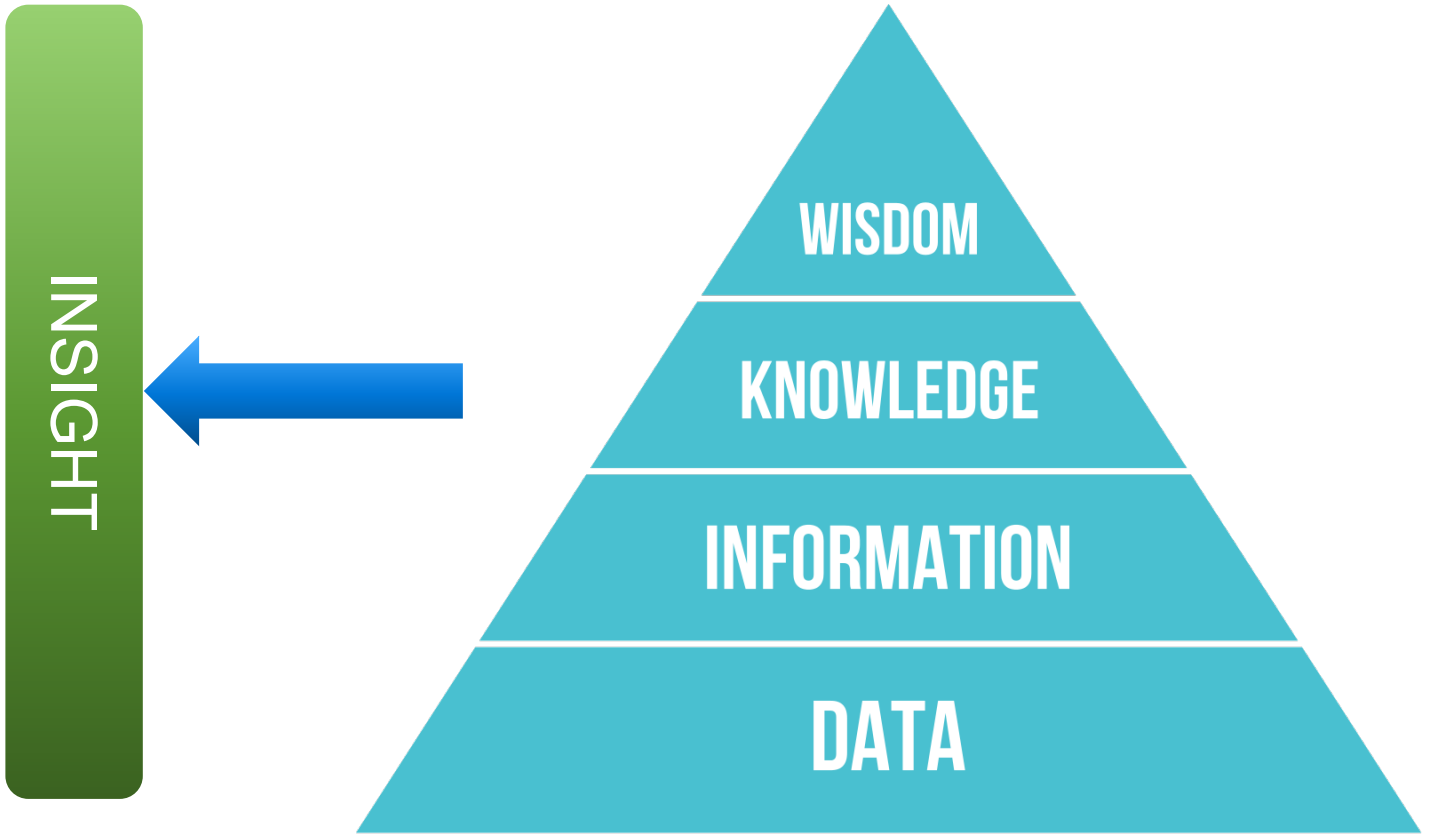
- Barclay R. Brown is Associate Director for Research in AI at Collins Aerospace, a division of Raytheon Technologies.
- Before joining Collins, he was an Engineering Fellow in Raytheon Missiles and Defense, focusing on MBSE, and prior to that he was the Global Solution Executive for the Aerospace and Defense Industry at IBM, and lead systems engineer for some of IBM's largest development projects.
- Dr. Brown holds a bachelor's degree in Electrical Engineering, master's degrees in Psychology and Business and a PhD in Industrial and Systems Engineering.
- He is author of "Engineering Intelligent Systems" to be released by Wiley in Winter 2022 and is a certified Expert Systems Engineering Professional (ESEP), certified Systems Engineering Quality Manager, and CIO of INCOSE for 2021-2023

Thinking in Reverse

AI and Machine Learning IS:

Deriving Insight from Data

But, MBSE is usually already expressing information or even knowledge



Data/Information in Most Organizations

- MBSE is just one more data silo
- Silos often map to data formats
  - Application-specific
  - Language-specific, e.g. SysML
  - Office, e.g. Word, Ppt

Application Integration:
Perhaps NOT the Answer

- Millions are often spent in an attempt to integrate all applications
- Or, to integrate all data into one master repository
- But what are we really trying to accomplish?

https://youtu.be/ZwNXAzOlF6E

How to use the Internet

- First, copy the entire Internet to your computer so that it's all integrated in one place. Convert it to a universal format.
- Then, find and use the information you need.
- Rinse and repeat anytime you need to use the Internet.

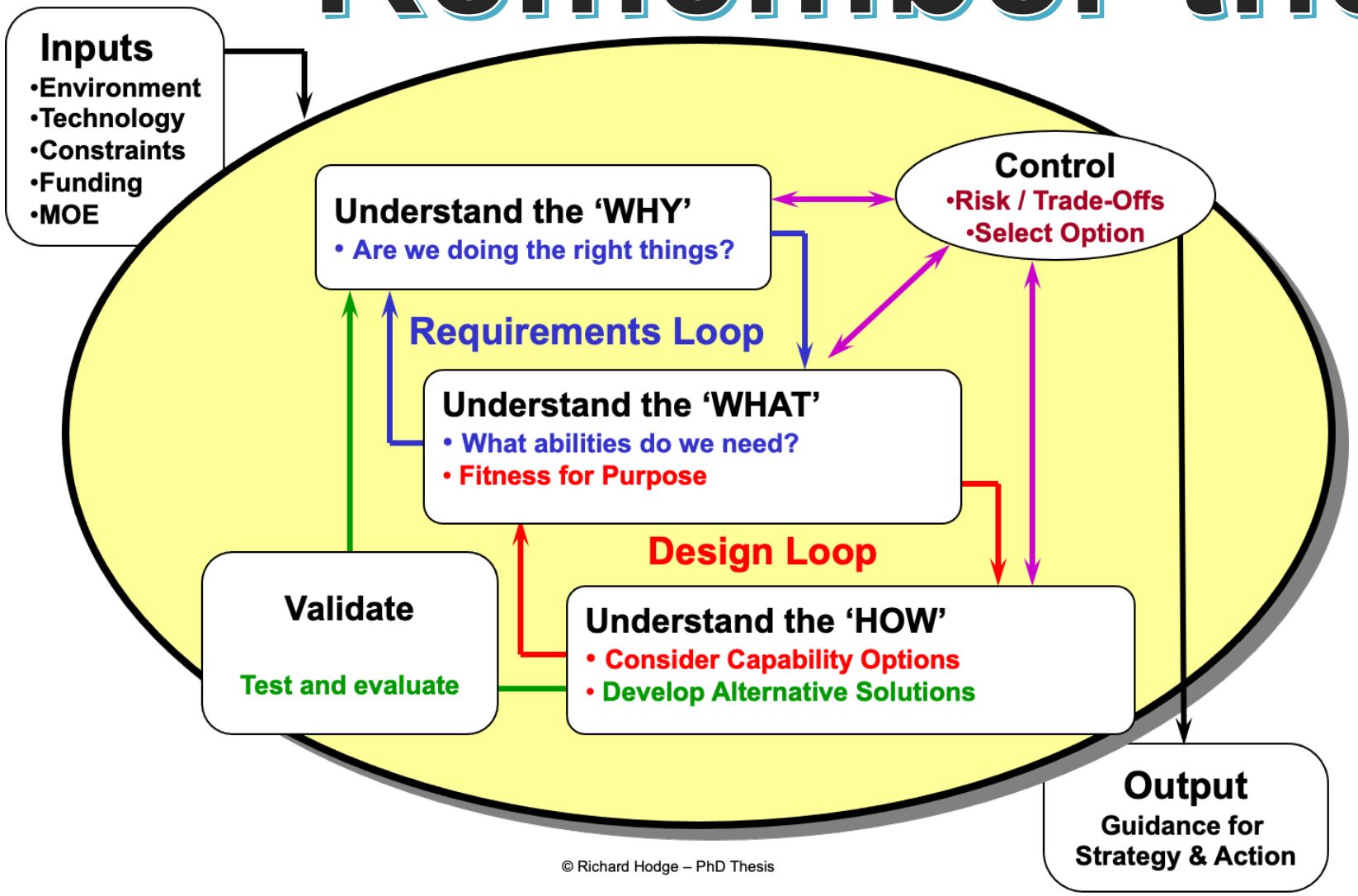
With apologies to Abraham Lincoln…

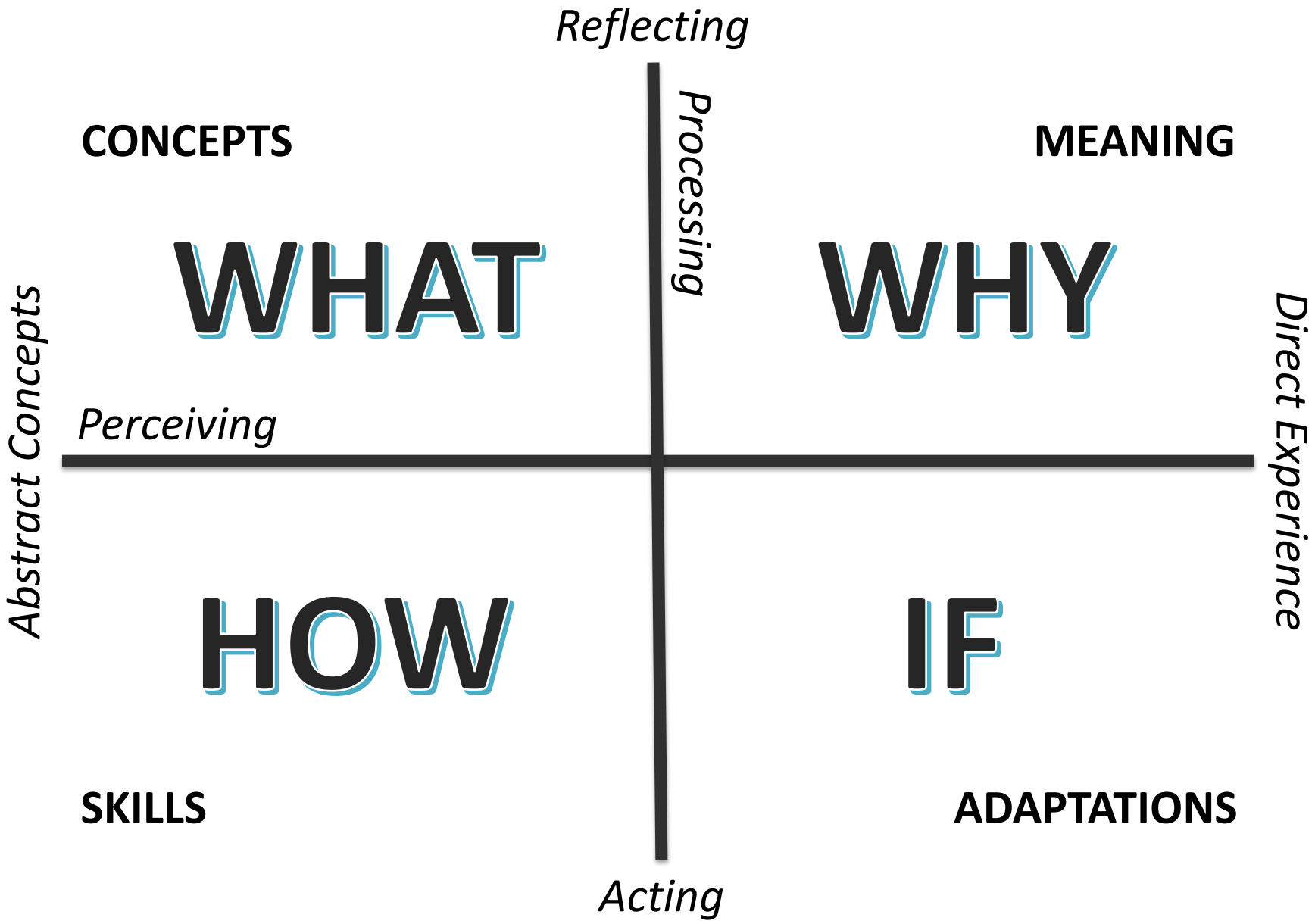
- You can integrate some of the data some of the time… but you can't integrate all of the data all of the time.
- Ask, if the data were all integrated the way you imagine, what would you do with it?
  - The answer is what you should start with
- What we need is **easier ways** to create applications using data from multiple sources and formats.
  - Everyone codes (learn Python)
  - More multi-level access libraries (easy for easy uses)

Systems Engineering:

…Time to create better narratives

Remember the SE ‘egg’

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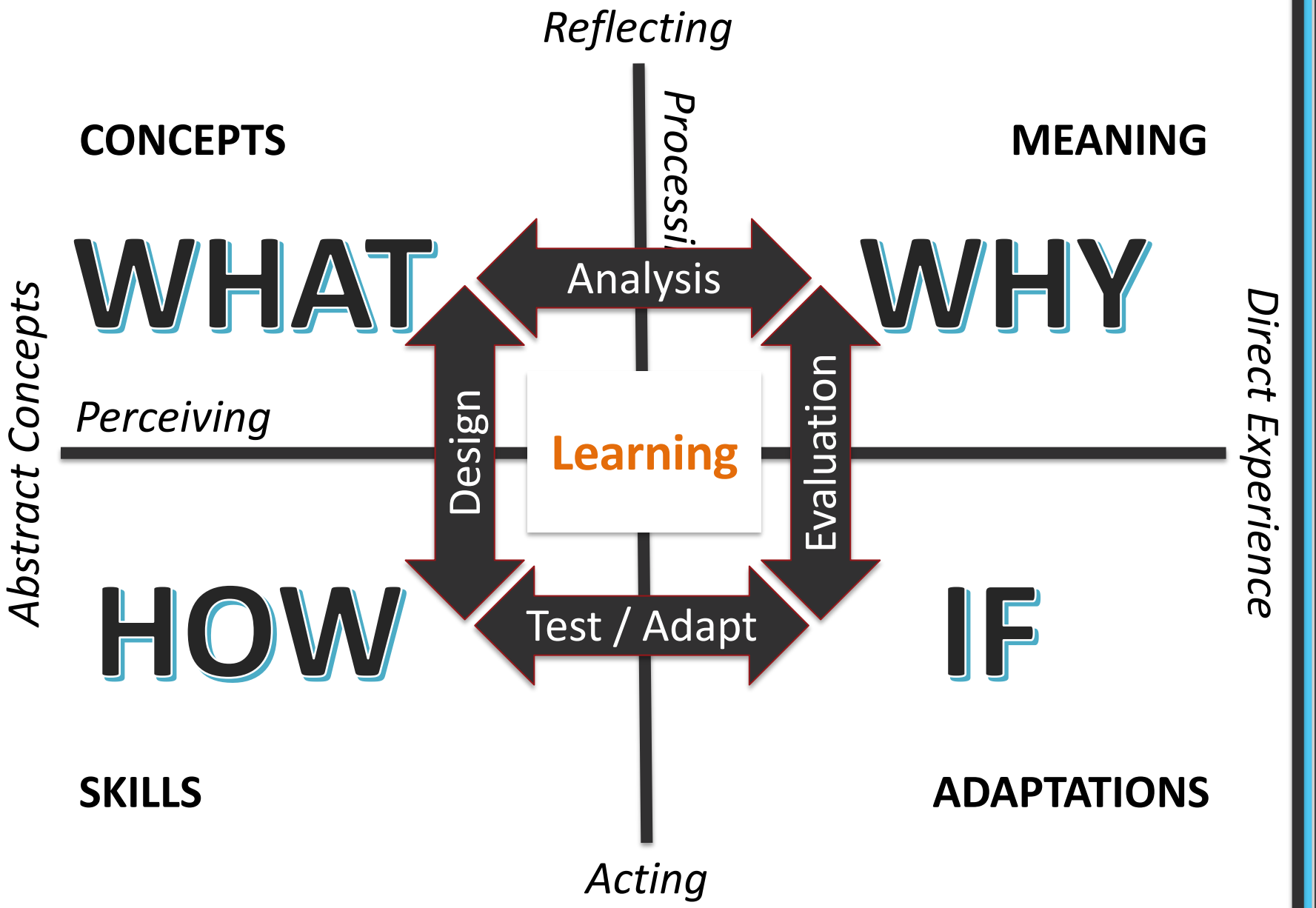
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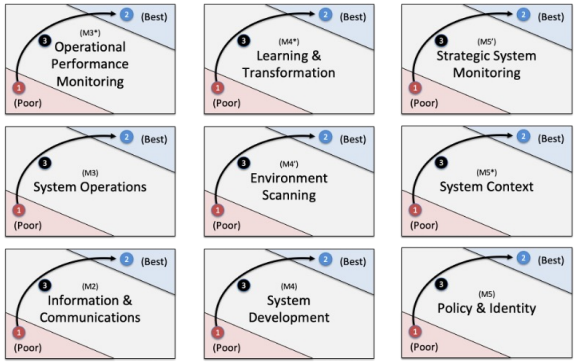

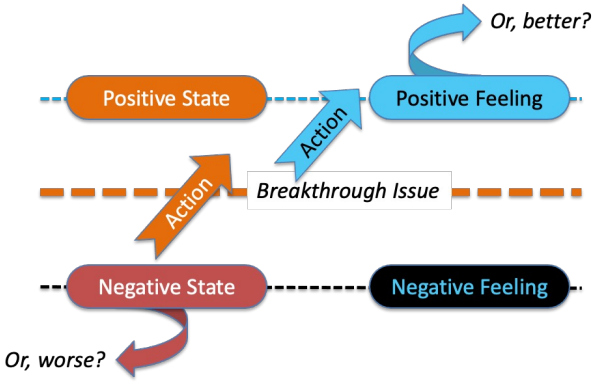

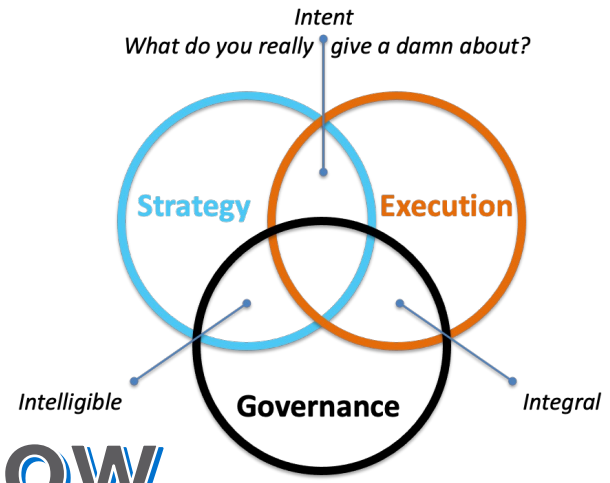

M5	(Poor)	Transformation Issues & Integral Approach	(Best)
M5*	(Poor)	Transformation Issues & Integral Approach	(Best)
M5'	(Poor)	Transformation Issues & Integral Approach	(Best)
M4	(Poor)	Transformation Issues & Integral Approach	(Best)
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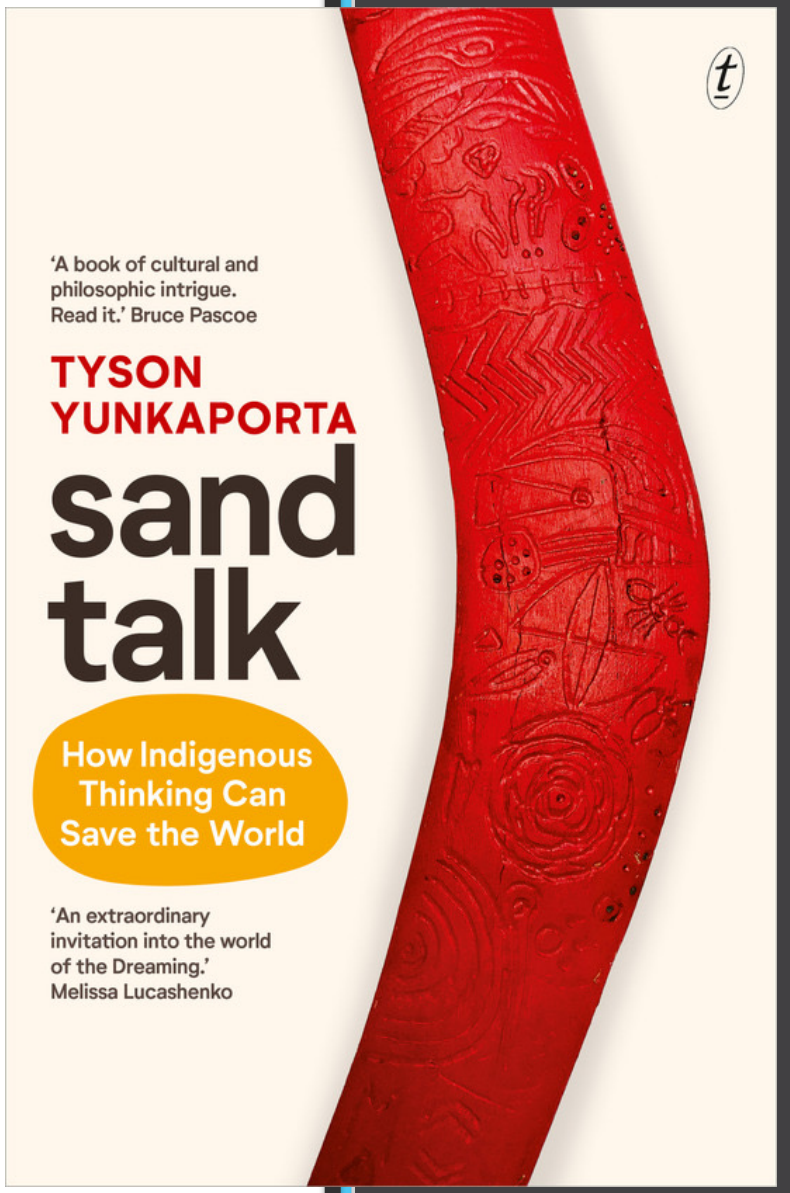
Designed Integral Approach


Dr Tyson Yunkaporta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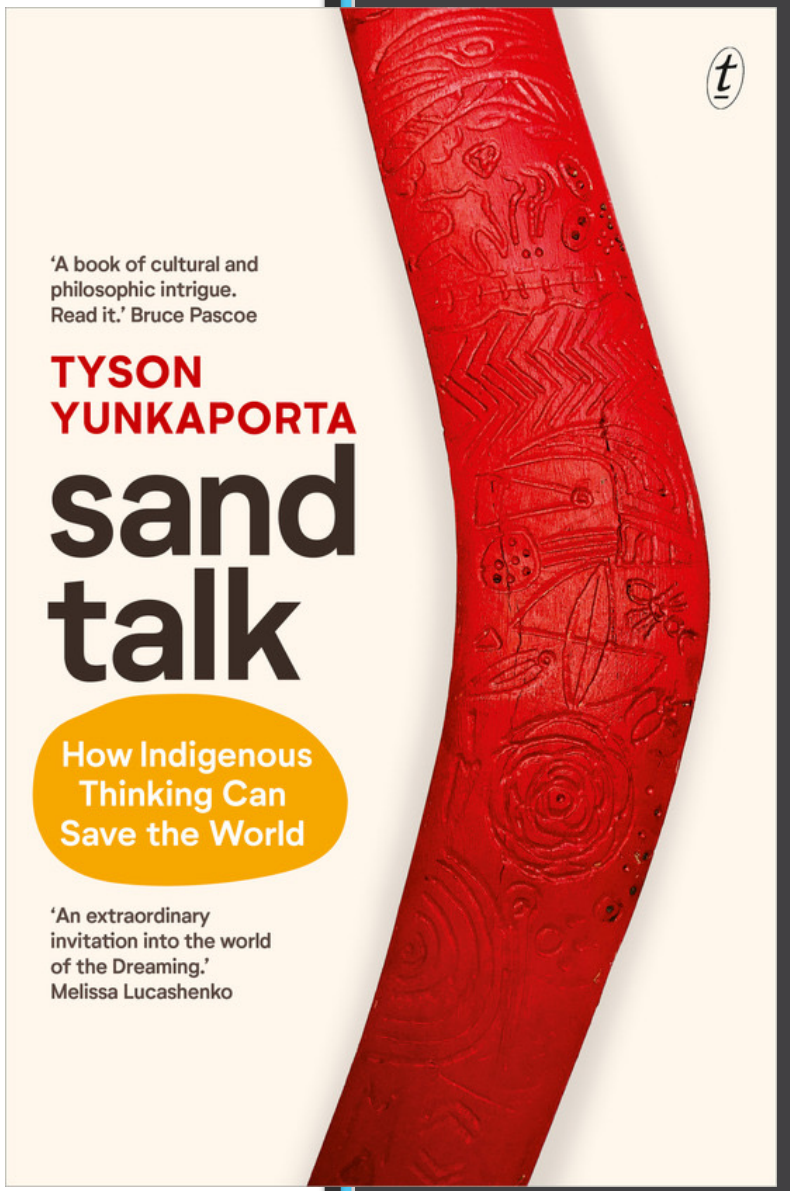
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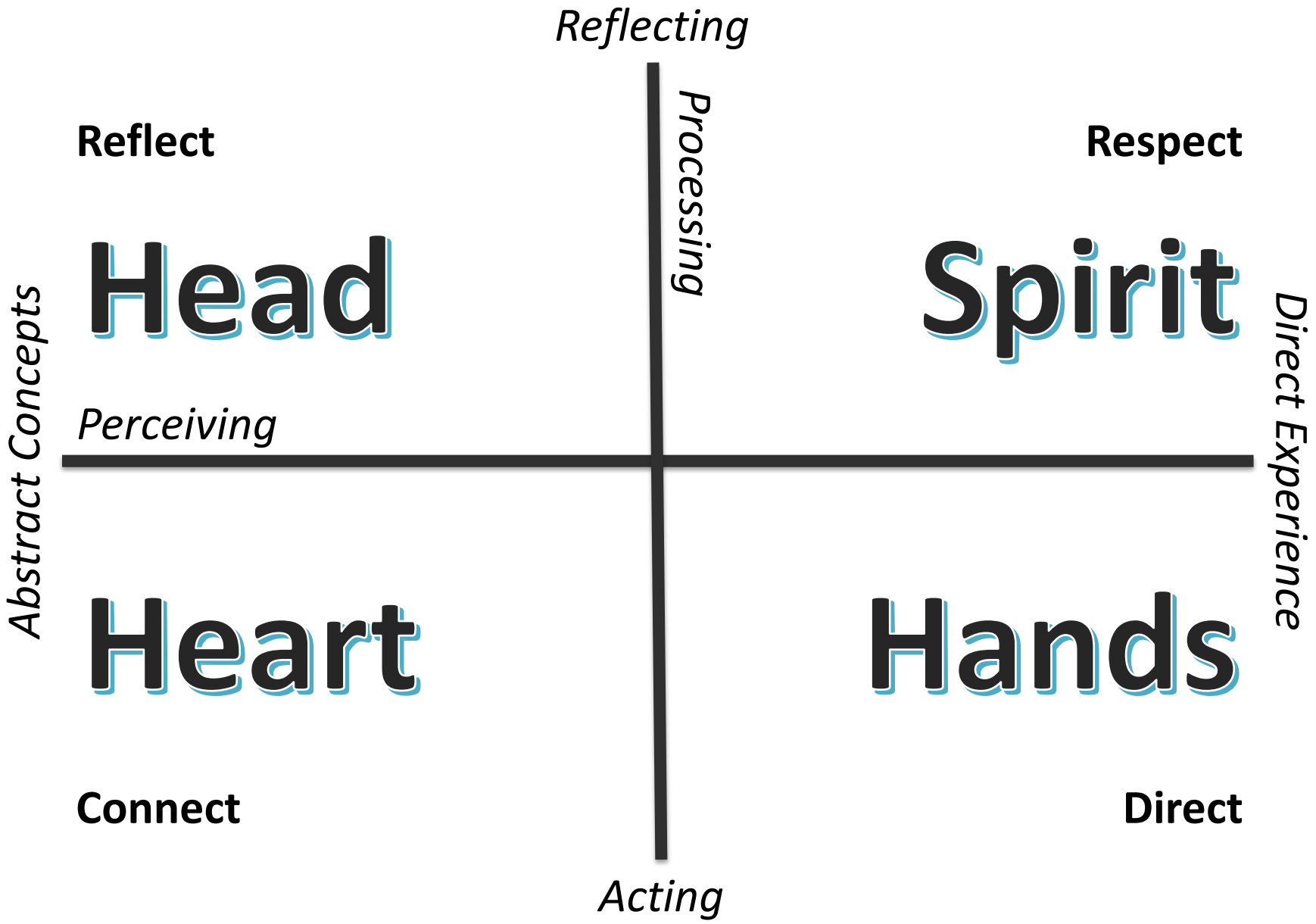
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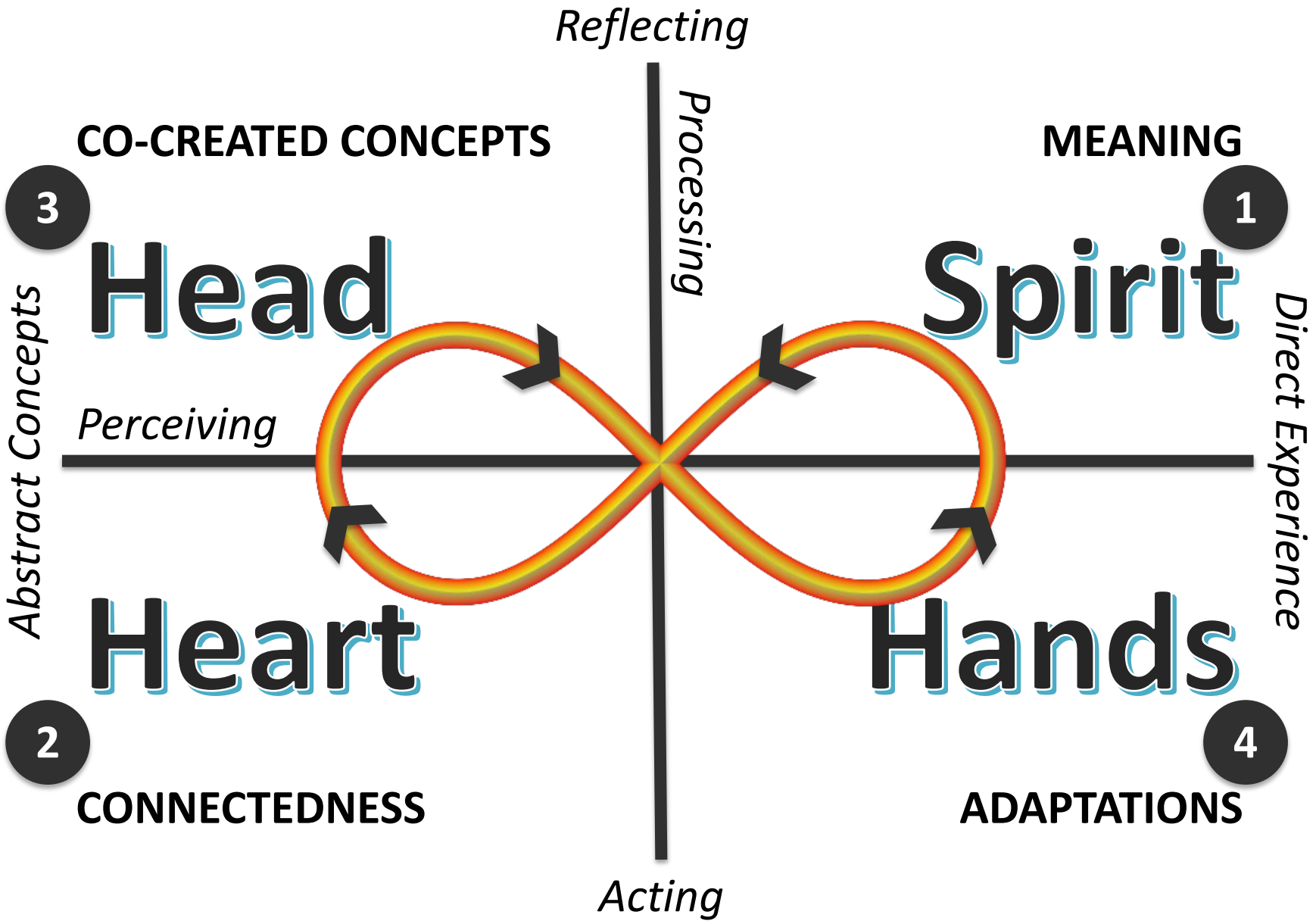
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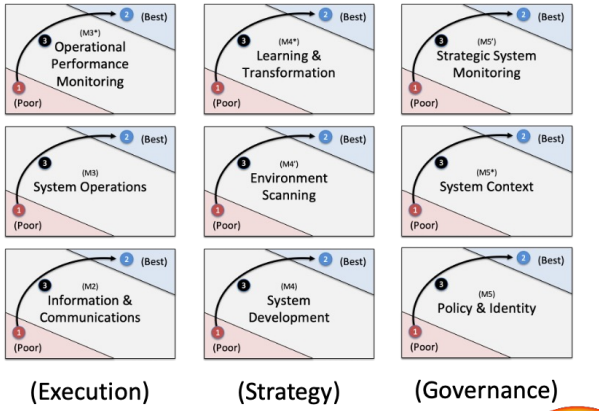

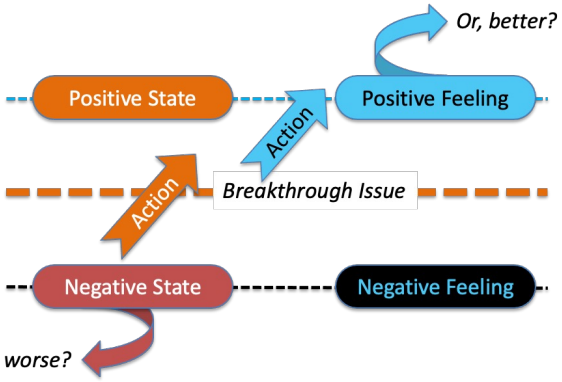

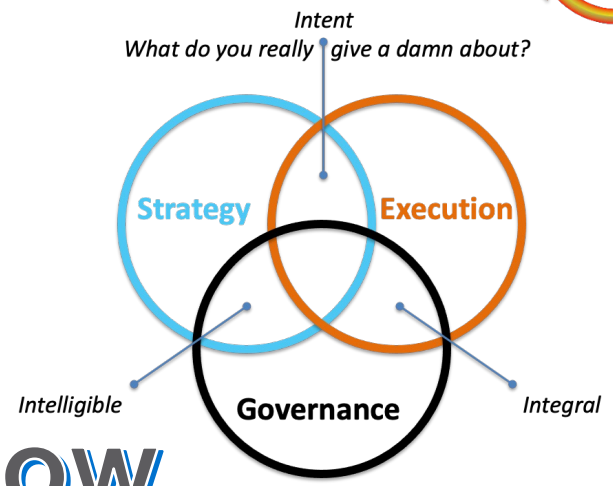

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Designed Integral Approach


Sustainable Progress Depends On Leaders Connecting with Care & Courage