Systems Thinking
Making sense of complexity and managing its unintended consequences

Professor Patrick Godfrey
FREng, FICE, FCGI, FEI, FIA (Hon)
Director Systems Centre
University of Bristol

Learning together
Complex problems
(wicked or messy)

4 integrated concepts
• People
• Purpose
• (new) Process
• Performance

Learning together
Some complex systems?
Some complex systems?

- Globalisation,
- Privatisation,
- Sustainability
- Democratisation,
- Creating shareholder value
- Internet communications
- Supply chain
- Safety constrained innovation
- Interdependence of infrastructure
Addressing whole problems and needs

• We are living off our legacy infrastructure and it is failing us economically. We have to do far better for much less.

• Successful business will be businesses that can LEARN better and faster TOGETHER than our competitors.

• Otherwise the future is decline into a third world economic performance
What do we mean by complexity?

Is this Complex?

Learning together
A Tree - Complex or Complicated?

- It depends on your point of view
- To the Ecologist it is complex
- To the Structural Engineer it is complicated but not complex to analyse
Relationships between people – complex or complicated?

It depends upon your point of view

A Wedding

Stakeholder’s points of view?

Learning together
Need to manage uncertainty

“Engineers are increasingly concerned with complex systems, in which the parts interact with each other and with the outside world in many ways – the relationships between the parts determine how the system behaves. Intuition rarely predicts the behavior of novel complex systems.”

Source: ‘Creating systems that work’ Royal Academy of Engineering 2007
Introducing systems thinking

**Systems Thinking** is a way of thinking used to address complex and uncertain real world problems. It recognises that the world is a set of highly interconnected technical and social entities which are hierarchically organised producing emergent behaviour.

INCOSE UK Z7 Guide

http://www.incoseonline.org.uk/Documents/zGuides/Z7_Systems_Thinking_WEB.pdf
Systems thinking is an engineering habit of mind.

Thinking like an engineer (2014) Royal Academy of Engineering
A clarifying principle

Soft (people)

Purpose

Hard (physical)
Safety Assurance of Robotic Co-Workers

• Human-centric perspective
  – Managing expectations
  – Cognitive models for Human Robot Interaction (HRI)

• Robot-centric view
  – Integration of safety considerations from the outset, i.e. “by design”
  • Formalize safety requirements as high-level policies to guide learning!
The need is real: kidney operation

- Da Vinci Xi is a new surgical robot
- replace open surgery with a minimally invasive approach
- It is learning to do it under supervision not control of surgeon

Sunday Times 08/03/15
New Process

• A holistic view of process
  – people and physical processes
  – consistency helps integrate hard and soft
  – helps to align stakeholders to purpose

• Process define ‘How change happens’.
  – includes natural, hard (physical) and soft (people).

Why (purpose) is the driver
How is the means, operates on (who, what, where and when)

Blockley D, The importance of being process. 2010, Taylor and Francis on line, DOI: 10.1080/10286608.2010.482658.
What has to be architected

Problem situation

Wicked problem

This decision is key!

Part that can be “solved”

Part that must be “managed”

Integration project

Sustainment strategy

Transition strategy

Transition

Operation

Specs and contracts

Delivery projects

Sub-Systems

Expected “value”

Perceived “value”

Gap to be managed by optimisation and adaptation in service

And the world moved on - - - ???

INCOSE UK Sillitto (2010)

Learning together
The learning loop

- Intervene to manage the changing uncertainties

Learning together
Complex Wicked problem

The Learning Journey

Design and build

Operate

Outcome fit for purpose

Projects

Learning together
ICIF Learning Journey Process

Supporting the way stakeholders **learn together** to deal with uncertainty

- Identifying Purpose
- Generating Learning Power
- Structuring Knowledge, Experience and Data
- Performing and Evaluating

*Learning together*
Problem structuring

Shared model Building

• A means of
  – Aligning stakeholder objectives to purpose
  – Establishing a problem structuring framework
  – Engaging the organisation in performance improvement
  – Identifying and dealing with unintended consequences

Learning together
Shared Model Building - Big Picture

Learning together
Example of shared model at Roll Royce
Accelerate improvement in Systems Engineering


Learning together
Infrastructure interdependence, resilience and cross-sectoral working

15.28 ....... “The Interdependency Planning and Management Framework (IPMF), published in November, enables the identification and appraisal of cross-sectoral delivery benefits and facilitates engagement between stakeholders. It was developed in a joint research programme between the University of Bristol and University College London.”
Wicked Problem

Stakeholder Needs & Capability Requirements

Matrix Approach

Identification of Interdependency

Stakeholder Viewpoints

Appraisal based on an interpretation of STEEPLES, 5 Capitals, HalSTAR or similar

Learning together
Generating transformative change

Engaging the public and policy makers

Taking professional responsibility ie CEng

Leading and influencing other engineers

Satisfying Industry needs

Applying research & design

R1 projects

Disseminating evidence of IMPACT

Communicating the benefits, feeding back generic learning

R4 Industry case studies

Feeding back practice to science

Valuing and Using systems design and leadership in Industry/Government by policy makers

R3 Policy influence

Structuring Generic Learning

Extending systems science knowledge and models

R6 Academic & professional learning

Organisational learning

R5 Community loop

Researching

Engineering System & Design Projects

Producing high quality publications inc Thesis

Integrating People, Purpose, Process and Performance

Bad

Good

Agreeing what is success

Looking for opportunities

Not agreeing success criteria

Missing opportunities

PEOPLE Arguing

PROCESS Inadequate Structures

Not sharing benefits

Not collaborating

Not suggesting improvements

Sticking to rules, & target incentives

Failing to agree values

UNCLEAR PURPOSE Weak Foundations

Reducing trust

After David Blockley

Integrating & improving PERFORMANCE

Suggesting improvements

Not sharing assessments

Not agreeing measures/assessments

PEOPLE Learning together

Collaborating

Agreeing measures/assessments

PROCESS Strengthening Structures

Sharing benefit

Agreeing values

Enabling judgement & discretion

Building trust

Purpose Firming the Foundations

Systems Thinking
Questions?