Institute for Systems Engineering

Z7

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What is Systems Thinking?

How does it relate to Systems Engineering?

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.

It is founded on three key ideas:
Layers
Loops
'New process*

* See panel 4

Open University Definition

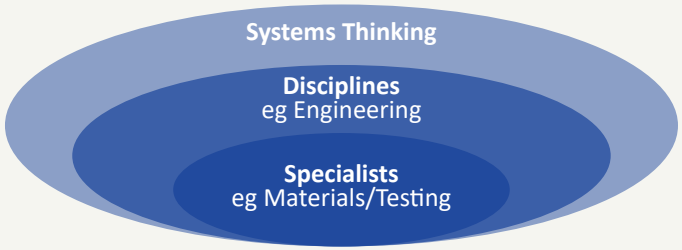
Systems Thinking enables you to grasp and manage situations of complexity and uncertainty in which there are no simple answers. It's a way of learning your way to effective action by looking at connected wholes rather than separate parts. It is sometimes called practical holism.
-Open University

Business Management Definition

Systems Thinking is a framework for seeing interrelationships rather than things, for seeing patterns rather then static snapshots. It is a set of general principles spanning fields as diverse as physical and social sciences, engineering and management.
-Peter Senge , The Fifth Discipline

How Systems Thinking contributes to Systems Engineering

Systems Thinking is an essential skill for systems engineers which is shared with many disciplines and provides a key intellectual underpinning for Systems Engineering.



Benefits of Systems Thinking

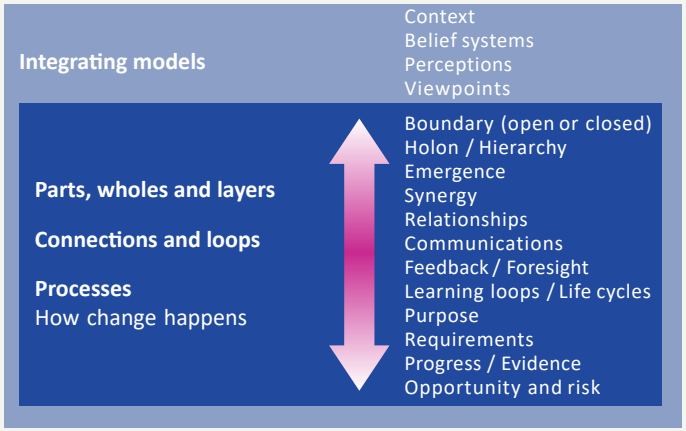
Systems Thinking provides a rigorous way of integrating: people, purpose, process and performance and

- relating systems to their environment.
- understanding complex problem situations
- maximising the outcomes achieved.
- avoiding or minimising the impact of unintended consequences.
- aligning teams, disciplines, specialisms and interest groups.
- managing uncertainty, risk and opportunity.

Background – Systems Thinking:

- is complementary to other ways of thinking e.g. scientific reductionism which focuses on a component itself, rather than its relationship with others.
- applies to any discipline or practice e.g.
  > Social Science, Management, Engineering, Biology and Pure Science.
- origins are distant > 2500yrs.
- recent cross disciplinary groupings include:
  > Learning Systems, General Systems Theory, Cybernetics, System Dynamics, Soft Systems Methodology, Critical Systems Thinking, Complexity Theory and Systems Engineering.

A Framework for Systems Thinking



Parts and Wholes in Layers

- A holon, is anything considered, at the same time to be both a part and a whole.
- Components are seen as being organised in hierarchies of holons, which have emergent properties that derive from the co-operation of the parts. An example of a soft system is you. You are a part of: your family, your neighbourhood, your country etc and yet you are also a whole made up of parts or sub-systems i.e. skeleton, nervous system etc...
- Inside and outside are defined by boundaries.

Connections and loops

- The behaviour of a system cannot be determined by consideration of the parts in isolation.
- The relationships between the holons and their ability to communicate determines the emergent behaviours and the possibility of unintended consequences.
- It is generally useful to think in terms of feedback and feed-forward loops to create learning and foresight and so to manage the processes involved.
- Systems Dynamics is one way of simulating processes.

Context

- The context for a system is its environment sometimes referred to as its meta-system or meta-holon.
- An open system is one which continually interacts with its environment, whereas a closed system is assumed to be self contained.

‘New process’

The phrase ‘*new process*’ is used to identify a holistic view of process, which describes natural, people and physical processes in a consistent way. This helps to integrate all types of system. It also helps to align stakeholders to purpose and reduce a substantial source of complexity.

Processes define ‘How change happens’.
This definition includes naturally occurring change as well as man made.

Answers to the questions ‘who’, ‘what’, ‘why’, ‘where’, ‘when’ and ‘how’ enable us to describe a process in terms that are applicable to both people and physical processes. ‘Why’ identifies the **purpose** and hence drives the change in ‘who’, ‘what’, ‘where’ and ‘when’ through the transformations identified by ‘how’.

The output of a process may be a product but that in itself has a **life cycle** and is also a process.

Integrating models

Systems Thinkers use models to make sense of complex problems.

A Systems Thinker’s Goal is to fulfil Purpose

- **Purpose** is the result, outcome or effect that is intended from the system. Purpose is the answer to the question: Why are we doing this process?It is the driver of intended change and defines unintended consequences.
- A **requirement** is an unambiguous statement of the capability that the system must deliver. A requirement is expressed in operational terms (what the system will do) rather than solutions (how the system will do it).
- **Effective requirements can only be produced once purpose is clear.**

Systems Thinkers recognise that:

People:

- through their perceptions, determine purpose, use process to deliver performance and use change in patterns to measure progress;
- understand the need to be good team players; are our customers, stakeholders, designers, developers and users; have varying levels of rationality, intentionality and even perversity;
- have **belief systems, perceptions and viewpoints** developed through culture, training and views of best practice within disciplines;
- are not separate from the problem, project or programme with which they are engaged. They are an integral part of System Thinking models.

Performance measurement:

- evidence should be used and suitably monitored to ensure that the purpose of the system is being fulfilled;
- will need to be a combination of quantitative and qualitative measures that communicate a historical and forward view of performance
- is often done inappropriately because people choose to measure what is easy to measure, rather than what needs to be measured to ensure that purpose is delivered

Uncertainty:

- is an inevitable attribute of a complex system.
- is managed by first recognising what we do not know and expecting unintended consequences particularly when new systems are being introduced or systems are used in a different context.
- requires the inclusion of feedback and feed-forward learning loops in the process to minimise its impact.

About This Z Guide

This leaflet is intended to provide an introduction to Systems Thinking and how it relates to Systems Engineering. It is grounded in a review of definitions from divers sources and related to engineering through the strong systems heritage at the University of Bristol and validated at INCOSE AA 09.

Further information about Systems Thinking can be obtained from the following:
https://www.bristol.ac.uk/engineering/research/systems-centre/
http://openlearn.open.ac.uk/mod/resource/view.php?id=183660
http://en.wikipedia.org/wiki/The_Fifth_Discipline

This Z Guide originated from the Systems 2030 Seminar held in Bristol in April 2008. It has been prepared by Members of the Systems Centre at University of Bristol:
https://www.bristol.ac.uk/engineering/research/systems-centre/
and drafted by Patrick Godfrey.

The content of this Z Guide was tested at the 2009 Autumn Assembly of the INCOSE UK in an interactive session led by John Davis and Theo Tryfonas. It has been peer reviewed by INCOSE UK/IfSE.

In addition invaluable input has been provided by David Blockley, John Davis, Theo Tryfonas, Mike Yearworth, Hillary Sillitto, and Dave Hawken.

For further information, advice and links to helpful websites go to:
www.ifse.org.uk

Download copies of this leaflet and other Systems Engineering resources online at: www.ifse.org.uk

For more information about the worldwide Systems Engineering professional community, go to: www.incose.org

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