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The Importance of Being Process

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Summary

The purpose of the paper is to outline the particular interpretation of systems thinking developed at the University of Bristol over the last 30 years. The importance of process and uncertainty are central themes. Put at its simplest, systems thinking is joined-up thinking. It is 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). The three ideas at the heart of delivering systems thinking are thinking in layers, thinking in connected loops and thinking about *new* processes. Everything has life cycle and hence is a process – but one that is set in the context of a system containing other connected processes – some at higher and some at lower levels of definition. All processes have attributes that are characterised using *why, how, who, what, where, when*. There is a need to integrate hard and soft systems. This requires us to be very clear about the meaning and usage of the terms subjective and objective when we argue that engineering judgement is both valid and important. It is argued that truth is to knowledge as the inverse of risk is to action. The three attributes of uncertainty are stated as FIR – fuzziness, incompleteness and randomness. Robustness and its inverse, vulnerability have been neglected. Systems thinking is not simply an engineering approach rather it is a philosophy for solving many practical problems such as joined-up government, social work, dealing with climate change and terrorism. Finally it is argued that our journey to 2030 requires us to adopt an evolutionary observational approach using systems thinking.

Introduction

In the play 'The Importance of Being Ernest' by Oscar Wilde premiered in 1895, Lady Bracknell has an exchange with the leading character, Jack Worthing, who wants to marry her daughter Gwendolen. After Jack tells her he was found abandoned as a baby in a handbag on Worthing station, she exclaims, 'A handbag!' The line has been delivered with such a mixture of horror, incredulity and condescension by so many famous actresses, that it has become a classic line in English speaking drama. Lady Bracknell continued 'To lose one parent, Mr Worthing, may be regarded as a misfortune; to lose both looks like carelessness'.

To most people a handbag is an object. To a systems thinker a handbag is a process that plays a role in other processes. In simple terms the handbag has a life cycle in which it was conceived, designed, made and used and eventually disposed of. However it is unlikely that it was designed to carry an abandoned baby. Nevertheless in that role or function the handbag played a crucial part in keeping the infant Jack safe and, as revealed as the play unfolds, allowing him to be found and rescued into a good family upbringing. So another idea at the heart of systems thinking is dealing

with uncertainty – managing the unexpected. In particular recognising that there are limits to what we know and hence what we can predict. Richard Whatley, a 19th century Irish cleric, said 'He who is not aware of his ignorance will only be misled by his knowledge'. In a similar vein from an unknown source, 'Once you have accumulated sufficient knowledge to get by, you are too old to remember it!'

The importance of process and uncertainty are central themes of this paper. The objectives are a) to review in outline the particular interpretation of systems thinking developed at the University of Bristol over the last 30 years, b) to sketch out some examples and c) to share some thoughts about future directions.

What is Systems Thinking?

So how do we characterise systems thinking as developed at Bristol? For simplicity I will drop the phrase 'as developed at Bristol' in the rest of the paper and assume it is implied. Put at its simplest, systems thinking is joined-up thinking. By that I mean '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)'. When systems lack joining-up then a message doesn't get sent or received or is poorly formulated, incomplete, misleading or is without adequate justification.

There are three ideas at the heart of delivering systems thinking. They are thinking in layers, thinking in loops, thinking about *new* processes. Let us consider these in turn.

First, a systems thinker sees the world in levels of definition – all of which are important and useful depending on the type of problem being addressed. None are deeper or more fundamental than any other. You choose a level based on your need to solve a problem. High level statements tend to be less precise but of wide scope – a national authority might assert that 'All bridges in the UK are safe'. At a lower level a bridge designer might say that 'The stresses in all arch bridges are low'. At a detailed level an engineer could calculate that 'The deflection at the centre of the span of this girder bridge was a maximum of 50 mm under live load'. Lower level definitions tend to be of narrower scope, be more precisely stated and in reductionist science be considered as more fundamental.

The word 'holon' was first suggested by Arthur Koestler (1967) to capture the idea that at a given level of definition something is both a whole and a part. That something is a 'whole' in the sense of it being a totality, an individual thing made of parts at a lower level of definition, but also a 'part' in the sense of playing a role (just like the 'handbag' referred to by Lady Bracknell) in a higher level set of processes.

Second, a systems thinker is a 'loopy thinker'. Systems thinkers look for connections and feedback and feed forward. Many people tend to think in straight lines – moving from cause to effect. Peter Senge in his excellent book (Senge 1990) on systems thinking gives many examples of thinking in loops. Connectivity or connecting (i.e. joining, linking communicating) is at the heart of modern complexity theory, leading as it does to the important concept of 'emergence'. An emergent property at a level of definition is one that results from interactions between the parts that make the whole. It is in this sense that the whole is more than the sum of its parts. So any holon has emergent properties. For example the air in a balloon has pressure. If we examine

this 'whole' balloon in terms of its parts at a lower level of definition then one contributory part is the air pressure. At this lower level the air can be modelled as molecules of oxygen, nitrogen etc 'buzzing around' and colliding with each other and with the inside surface of the balloon. Such a model, based on statistical mechanics, depends on capturing the interactions between the constituent parts which make up the pressure as defined at the higher level. Another example of emergence in construction management is in the use of critical path analysis. Here a network represents the time interdependencies between activities that are needed to bring a project to a successful conclusion. Those time attributes such as earliest and latest start times emerge from the interactions between activities.

Thirdly, a systems thinker sees everything as a 'new' process. The adjective new is included here to emphasise the need to reject all existing preconceptions of what constitutes a process and to create a new and all encompassing definition. So a new process is not just an input being transformed to an output, or a Gantt bar chart, a recipe, a flowchart, a network of an IDEF0 diagram – it is all of these and more. A new process characterises everything that we know. As already stated, everything is viewed and modelled as a process because everything exists through time. The handbag to which Lady Bracknell was referring, a kettle, a building, an aeroplane, a power station, an airport terminal and all living things, including human beings, are all represented as processes. So a systems thinker starts by knowing that everything has life cycle – but one that is set in the context of a system containing other processes – some at higher and some at lower levels of definition. All processes have attributes that are characterised using *why, how, who, what, where, when* (Figure 1).
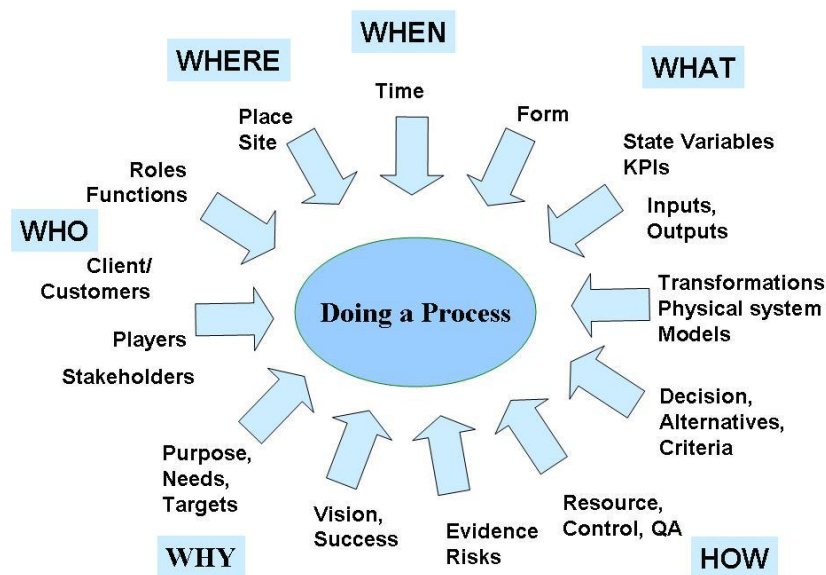

Figure 1 Thinking about NEW PROCESS

The purpose, functionality, success and failure criteria, concerning a given process at a given level of definition, derive from all the relevant questions *why* that can be identified. Answers to all *how* questions define the transformations or methods that will change the starting or input state to a finishing or end state in a defined time period. Answers to all *who* questions define players or actors, clients and stakeholders. Answers to *what* questions define all state variables and performance indicators. Answers to all *where* questions define place and context. Answers to all

questions *when* define parameters of time. These may be fast (as in sub-atomic physics or the flutter of a bridge deck) or slow (as in climate change or geological aeons). We can capture the relationships between these questions as *why=how(who, what, where, when)*. However this expression is not to be interpreted as an algebraic formula – rather it is an attempt to represent the idea that *why* is the voltage or difference of potential that drives the transformation *how* in the flow or current of change in the attributes *who, what, where* and *when*.

There is one crucial state variable or *what* attribute that needs to be highlighted. This is a measure of the dependability of the evidence that the process will be successful. As stated earlier, the meaning of success is formulated from the questions *why*. This success is normally expressed in terms of target states, aims, objectives and, at higher levels, by mission and vision statements. In work at Bristol we have used Italian Flags based on interval probability as this measure of the dependability of the evidence that the process will be successful or will fail (Blockley, Godfrey 2000). The measure is used both in hard and soft systems thinking.

Hard systems are physical, material set of things – but modelled as processes. A soft system involves human beings. In hard systems there is an action that creates a reaction which we normally understand through reductionist engineering science. That understanding is sufficient to create hard systems, such as bridges, that work or are fit for purpose – i.e. they are successful. However all hard systems are embedded in soft systems (Checkland, 1981, Godfrey & Blockley, 2000) since it is through soft systems that we understand the world around us. But soft systems are hard systems with an extra complication - multiple layers of human intentionality. At its simplest, intentionality is having a purpose, aim or goal. It is this multiple layered interacting intentionality that makes soft systems so difficult. Figure 2 shows the potential and flow and impedance in some typical hard and soft systems.

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

Figure 2 Thinking about NEW PROCESS

A systems thinker must be a philosopher by night and a man of action by day – a reflective practitioner (Schon 1983, Blockley 1992, 1999, Dias, Blockley 1995). By that I mean that systems thinkers think that thinking about thinking is important and

that it is important to develop as clear a set of ideas as is possible to underpin what is accomplished by practical action. In this regard the works of Popper (Magee 1973), Kuhn (1962) and Dewey (1930) are influential. The first realisation that this reflective thinking reveals is that we must recognise that science cannot deliver absolute Truth. Truth with a capital T is an attribute of statements that correspond to facts in all possible contexts. Indeed, as Popper pointed out, what we mean by describing something as a fact is itself problematic and has to be defined in a meta-language. This leads to a (philosophically) uncomfortable infinite regress. Systems thinkers resolve this by seeing all statements as only being true in a specific (but often not clearly identified) context. They therefore use a notion of *dependability* to mean common sense contingent truth. A dependable statement is one that is highly tested – where the tests are sufficient but not necessary since non-tested statements may sometimes be dependable. Tests will vary from almost nothing (and relying instead on an assessment of the trustworthiness of the messenger) to very strong where we depend on well established engineering science. Nevertheless all practitioners know that, again following Popper, the potential for unintended and unwanted consequences are ever present. So systems thinkers do not focus purely on the predictive tools of reductionist engineering science, rather they use the tools of science in the context of evidence towards the management of a process to success. Evidence comes from past experience (such as historical data and case studies), present observations (such as the growth of a crack or deflection of a retaining wall) and future possibilities (such as predicted by finite element analyses). Any piece of evidence from whatever source is used as appropriate. The sources are therefore many and various from 'subjective' judgement to 'objective' measurement. Each piece of evidence has to be understood in context and its dependability assessed. Inevitably this requires a comparison of what seems to be 'chalk and cheese' that requires a very clear idea of what constitutes subjective and objective evidence. Blockley and Godfrey have discussed the use of hard and soft measures in some detail (Blockley, Godfrey 2005) following an earlier analysis by the author (Blockley 1980).

Subjectivity is a difficult concept and widely disparaged. The consequence is that the skill of judgement tends to be undervalued by academics and researchers. Systems thinkers place great emphasis on being clear about the meaning and usage of the terms subjective and objective - the thinking is as follows. We reach out to the world through our senses. We hear noises, we see things and we touch them. But what is the world really like? If our eyes were sensitive to X rays we would see the world quite differently. Subjective means 'existing in the mind or belonging to the thinking subject rather than to the object of thought'. So our mental models would be quite different if our senses were different. Subjective perceptions are of two kinds. First we have perceptions and private thoughts that cannot be shared – they are truly subjective e.g. a pain in my stomach. Secondly we have many perceptions that we can share. Indeed, by discussion, we agree about them. We call these shared perceptions inter-subjective. An example might be the colour of a fabric. We have no way of knowing the actual perceptions of others but we can agree that each time we perceive that colour we all use the same name. In that way we learn to describe the inter-subjective perceptions that we all have. With these shared perceptions we construct ideas and relationships. We make measurements in ways that are repeatable and dependable. As we agree we begin to describe the knowledge as objective and when it is also testable we call it science. Objective information exists outside any one person's mind (Magee 1973).

Unfortunately objectivity is often wrongly thought to consist of only measurable information. Of course measurable information is objective but not vice versa. Objective is commonly defined to mean belonging to the object of thought rather than to the thinking subject. However we can only construct such objects through shared inter-subjective perceptions that clearly exist outside of the mind of anyone individual – it is information that has been agreed and is available to everyone. We can think of it as all of the books in the library and all of the information available on the internet. Objective knowledge has an objective existence (i.e. outside any one mind) even though it derives from our collective subjective minds. However this test of shared existence of knowledge must not be confused with the test of whether it is true or false. Objective knowledge can be fictional e.g. Sherlock Holmes and mermaids exist objectively but are fictional. So objective information can be true or false, accurate or inaccurate, dependable or undependable.

Systems thinkers value engineering judgement because it relies on experience and personal characteristics and whilst it is not easily measured and demonstrably dependable, except in hindsight, it is essential for good decision making. It is not arbitrary and subjective, as so often is asserted though when it is measured (for example by voting) the results may be of variable dependability. But how do we recognise good judgement? Dependable judgement has to be tested if at all possible and there are various ways that can be done. The least satisfactory way is to rely on the previous sound performance of the decision maker. The best way is to test the judgement against specific criteria or physical circumstance – but this is often not possible.

Clearly systems thinkers, indeed all decision makers, prefer dependable objective knowledge but they do not reject engineering judgement based on experience and expertise. However they do tread carefully as they attempt to manage the process, about which decisions are being made, towards success and avoiding failure.

Truth is to knowledge as risk is to action

Knowledge	Action
Intention of *knowledge* is to achieve *understanding*	Intention of *action* is to achieve an *outcome*
Truth/dependability is an attribute of the correspondence of understanding with **'facts'**	Risk is an attribute of lack of the correspondence of outcome with *consequences*
Has a degree of truth/dependability between *True & False*	Has a degree of risk between *Failure & Success*

Figure 3 Truth is to knowledge as the inverse of risk is to action

Systems thinkers see developing knowledge and action as leapfrogging over each other. In other words to act you need to know and to know you need to act. Reductionist philosophy sees knowledge as more fundamental than action but systems thinkers value both equally. Indeed truth is to knowledge as the inverse of risk is to action as illustrated in Figure 3.

Quality

Systems thinkers see quality as the ultimate expression of what they want to achieve. Quality expresses the totality of what we want from a process. It has two common interpretations, degree of excellence and fitness for purpose which are commonly confused. Systems thinkers see these two expressions as the same as long as you are clear about context and purpose. Systems thinkers define excellence as a state of pre-eminence or of having the highest value. Value and values are the worth we give to something. This worth is expressed through our purpose – through the answers to *why* and *what* questions. A common example of confusion is demonstrated by the question – 'Which car has the higher quality – a Mini or a Rolls Royce?' A Mini which meets the specification of a Mini perfectly is of high quality in the sense it is fit for the purpose of being a Mini. Likewise a Rolls Royce which meets the specification of a Rolls Royce is a high quality Rolls Royce. Thus in the sense of being fit for purpose then they are equivalent. However if we include in our value systems a preference about the degree of excellence of the specification then most of us would agree that the specification of a Rolls Royce is higher than for a Mini. The confusion between quality as excellence and quality as fitness for purpose is often caused by not being specific enough about the values being used. There has to be a clear statement that a Rolls Royce is valued higher than a Mini *if that is what is intended*.

Systems thinking is about integrating all aspects, all points of view and all interests in a given system of multiple interdependent processes to deliver quality – it is therefore important that all important values for all players in a set of processes are clearly identified as early in the overall process as is possible.

Risk and reliability

Structural reliability theory is a good example of a theory that has been well developed by a number of excellent researchers. However it is partial and misses much of what is required to improve the management of structural risk. It is based on three misconceptions - firstly that the only kind of uncertainty is randomness. Secondly that human error is somehow beyond what needs to be addressed. Thirdly, until relatively recently, robustness, and its converse vulnerability, have been neglected. Vulnerability is where small damage can lead to disproportionate consequences.

Systems thinkers see uncertainty as having three attributes from which all other attributes of uncertainty emerge. They are FIR – fuzziness, incompleteness and randomness. Some writers refer to randomness as aleatory uncertainty i.e. dependent on chance, accidental events or other contingencies. At the same time they refer to

epistemic uncertainty as the lack of dependability or truth likeness of conditions under which we can claim to know anything. So aleatory uncertainty is either another word for randomness or we have to unpick exactly what defines an accidental or contingent event since an understanding of those terms is crucial for managing uncertain processes to success. Categorising uncertainty as epistemic is not very informative. Indeed it is about as useful as stating that all error is human error. Both of these categories are too wide to be helpful. Indeed all that we understand is epistemology. The author even asserts that ontology (the study of the nature of existence or being) is epistemology since we can only have an understanding of what it means to exist through how we make sense of the world in which we live. That is why the title of the paper is the importance of *being* process i.e. *being* is also itself a process.

Systems thinkers think that attributes of uncertainty such as ambiguity, ambivalence, indeterminacy, unpredictability, conflict and contradiction are emergent properties of FIR. So when we make a statement such as the stresses in arch bridges are low – we say something useful and dependable but not very precise since what we mean by low stress is not precise. We model fuzziness within the levels of definition. At high levels we tend to use fuzzy expressions – such as all UK bridges are safe. At lower levels we are more precise but necessarily we must reduce the scope of the context in which that precision is applicable.

Incompleteness is perhaps the aspect of uncertainty most neglected – some even deny its very existence. Incompleteness is that which we do not know. Of course we must distinguish between that we individually do not know and that we collectively do not know. All of us, as individuals, do not know things that others do know, that is why we must work in teams. However as Plato wrote, 'How can we know what we do not know?' That is a fundamental challenge to the management of uncertainty and it is one that should make us always work with a degree of humility. There are historical examples of failure due to things which no-one knew at the time (Blockley 2010). To spot them is a real challenge. There seems to be only one maxim – be prepared. In other words as we manage processes we develop a habit of looking out for unintended and unwanted consequences and we deal with them before there is serious damage (Turner, Pidgeon 1998). Unintended but not necessarily unwanted consequence can present new opportunities. Many new discoveries and many new products have been found this way.

Randomness is defined, following Popper, as the lack of a specific pattern in some data. Probability theory handles patterns which occur over populations of data – it is not specific. The interpretation of chance and risk is tricky – we all know of the 90 year old man who has smoked 40 cigarettes a day since the age of 12. Smoking and ill health are not causally related in the sense that death *always* follows smoking – rather smoking dramatically increases the risk of ill health over populations.

Ambiguity is doubtfulness or uncertainty of meaning or intention – it derives from an unclear, indefinite or equivocal word or expression. It emerges as a potential for more than one interpretation of the meaning of a statement through interacting fuzziness and incompleteness. Likewise ambivalence is the inability to make a choice or by a simultaneous desire to say or do two opposite or conflicting things again through interacting fuzziness and incompleteness. Contradiction and conflict emerge from

incompleteness because they derive from inconsistencies which would not be present in complete information.

Reliability theory addresses only one aspect of uncertainty – randomness. The parameters to a deterministic scientific model of a phenomenon are modelled as random variables. The consequence is that probabilities of failure resulting from these calculations are just more rigorous, but more complicated, versions of traditional safety factors.

It is difficult to include fuzziness and incompleteness in models of the physical phenomena. Capturing these types of uncertainty in the physical models requires us to develop underpinning models at lower levels – rather as statistical mechanics supports thermodynamics. But such models are rarely available – and often, if they are, they are too complex to be practical. Systems thinkers therefore see the best way of dealing with all aspects of uncertainty as follows. Use the best science (explanatory and predictive) available, assess all sources of evidence and use that information to manage the processes in which the phenomena occur in reality to eventual success.

A similar conclusion can be drawn, but even more forcefully concerning human error. Indeed, as hinted at earlier, systems thinkers now reject the term 'human error'. The whole topic is much more subtle involving, as it does all aspects of social science. The capacity for people to do unexpected things seems to be without limit. So again the only pragmatic solution is to gather evidence, systematically and rigorously, about all aspects of a process. Then use that evidence to make good decisions that steer a process through a mine field of hazards to avoid failure limits and to reach success. For example incubating conditions are hazards (as set out by Turner 1978 and discussed by Blockley (1992) that have to be identified and managed.

A much neglected property of systems is that of robustness and its inverse which is vulnerability. A system is vulnerable, and hence not robust, when small damage can cause disproportionate consequences. For example the Ronan Point high rise block of flats or apartments in London in 1968, was a vulnerable structure because a small domestic gas explosion in one apartment, caused the whole side of the building to collapse. Vulnerability is about low chance - high consequence risks such as the unexpected collapse of the WTC on 9/11. Good theoretical treatments of vulnerability have been lacking and the topic needs much more attention. This is particularly so for all highly interconnected and interdependent systems from computer networks to engineering structures. A theory of vulnerability, which is also a theory of form, has been developed (Lu et al 1999, England et al 2008) at Bristol. The major purpose is to find weak spots. A system is clustered into a hierarchy of levels of definition. A search algorithm finds various scenarios of possible damage and its consequences. Each is tested against a measure of vulnerability to isolate those which require detailed attention. The importance of this theory is not that such a scenario is highly likely (as is the aim of traditional reliability theory) but that the consequences of small damage are so serious that even a remote possibility must be dealt with.

Systems thinking is not simply an engineering approach it is a philosophy for solving many practical problems. Tony Blair's first 'New Labour' UK government wanted to

get departments and agencies to work more closely together. They saw a need for better collaboration across organisational boundaries to deal with shared issues. They wanted to improve the flow of information to deliver better services with a focus on the needs and convenience of the customer rather than the provider. So the government introduced major programmes to attempt to modernise many parts of government bureaucracy including the NHS and the criminal justice system. The commitment was set out in the "Modernising Government" White Paper (1999). One of the three stated aims of the new policy was to ensure 'that policy making is more joined up and strategic.' It was an ambitious project that set out to reform the very processes by which Government itself works. So what happened? The 'joined-up' phrase was used for some time but then got quietly dropped. Perhaps that is understandable since the issues are tough - but they haven't gone away.

Examples from social work and the criminal justice system abound. There is insufficient space here to give details. However the terrible treatment and murder of Victoria Climbié was one example that shocked the nation (Victoria Climbié Inquiry 2003). Harold Shipman was a family doctor who murdered many of his patients (Shipman Inquiry 2005). Ian Huntley was guilty of the Soham murders (Bichard Inquiry Report 2004). All of these case histories show a lack in the joining-up of agencies that eventually led to disastrous consequences. Pieces of evidence, considered in isolation, were pieces of a jig-saw. Had the pieces been put together, then a very different picture would have emerged. If someone had been able to do that then it is quite likely that the tragedies would have been prevented.

Constants that will find new expression	Developing trends	Issues
• War • Crime • Gossip • Sex • Misunderstandings • Accidents	• Extreme weather • Energy • Waste • Technology • Poverty • Faith & Reason	• Ethics • Reconciliation • Prediction/control • Vulnerability & • Robustness • Work-life balance

Figure 4

Systems thinking is needed for many pressing modern problems such as managing the consequences of climate change, dealing with terrorism and managing social disorder. Figure 4 illustrates some other issues including the constants of human history that are always finding new forms of expression such as war, crime and gossip. Developing trends are extreme weather due to climate change; management of energy resources, both fossil and renewable; the management of waste; reducing poverty and most deeply of all, the apparent conflict between faith and reason. The latter depends on a new radical approach to ethics. Therefore ethics leads the list of issues (and is a topic of another paper in this edition of the journal) together with reconciliation after deep

conflict, the use of prediction in control, vulnerability and robustness and work life balance. Systems thinkers feel that none of these issues will be dealt with satisfactorily without systems thinking.
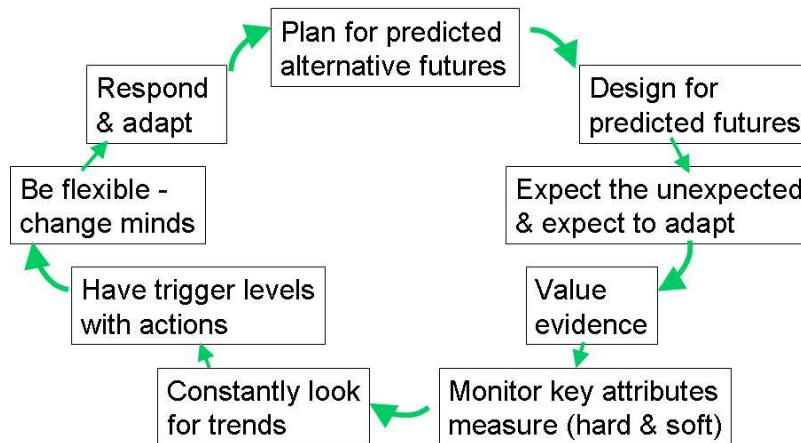

Figure 5 Evolutionary Observational Method
Be prepared by
managing an **integrated** hard and soft systems process

Finally Figure 5 illustrates a systems thinkers imaginary journey to 2030. It is based on the premise, already stated, that we must steer a path through a minefield of future hazards by being as prepared as we possibly can be. The journey will require us to integrate and manage a set of hard and soft processes as described earlier. The decision making loop is shown in the diagram - but it is a loop though time to 2030. So actually it is a spiral in time as we constantly go through the loop to end up where we started but further on in time and a new need to plan. It is an evolutionary observational approach (Le Masurier et al 2006, Blockley 2010).

Conclusions

1. Put at its simplest, systems thinking is joined-up thinking. It is 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). When systems lack joining-up then a message doesn't get sent or received or is poorly formulated, incomplete, misleading or is without adequate justification.

2. There are three ideas at the heart of delivering systems thinking. They are thinking in layers, thinking about connections and loops, thinking about *new* processes.

3. A 'holon,' as suggested by Arthur Koestler captures the idea that at a given level of definition something is both a whole and a part. That something is a 'whole' in the sense of it being a totality, an individual thing made of parts at a

lower level of definition, but also a 'part' in the sense of playing a role in a higher level set of processes.

4. Everything has life cycle and hence is a process – but one that is set in the context of a system containing other processes – some at higher and some at lower levels of definition. All processes have attributes that are characterised using *why, how, who, what, where, when*.

5. Hard systems are physical, material set of things – but modelled as processes. A soft system involves human beings and therefore has the added complication of multiple layers of human intentionality.

6. Systems thinkers think that thinking about thinking is important – they are reflective practitioners.

7. Systems thinkers place great emphasis on being clear about the meaning and usage of the terms subjective and objective. Shared perceptions are inter-subjective. We have no way of knowing the actual perceptions of others but we can agree about them. We use them to construct ideas and relationships. We make measurements in ways that are repeatable and dependable. As we agree we begin to describe the knowledge as objective and when it is also testable we call it science. Objective information exists outside any one person's mind e.g. all the books in the library

8. Systems thinkers value engineering judgement.

9. Truth is to knowledge as the inverse of risk is to action.

10. Uncertainty has three attributes from which all other attributes of uncertainty emerge. They are FIR – fuzziness, incompleteness and randomness.

11. Quality expresses the totality of what we want from a process and it defines purpose. It has two common interpretations, degree of excellence and fitness for purpose, which are commonly confused but which are entirely compatible.

12. A much neglected property of systems is that of robustness and its inverse which is vulnerability. A system is vulnerable and hence not robust when small damage can cause disproportionate consequences.

13. Systems thinking is not simply an engineering approach it is a philosophy for solving many practical problems. Tony Blair's first 'New Labour' UK government wanted joined-up government but they failed to deliver. Other examples derive from social work, the criminal justice system, managing the consequences of climate change; dealing with terrorism and managing social disorder.

14. Our journey to 2030 requires us to steer a path through a minefield of future hazards. It requires an evolutionary observational approach using systems thinking.

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