Draft:

Concepts in Innovation and Change

by

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Chapter 2: Innovation and Systems

Introduction

In Chapter 1. we defined 'innovation' as

The process of transforming an idea into something that works .

In this chapter we will focus on the word 'something'. 'Something' and 'thing' are hard words to get away from in English – we seem to use them all the time. 'Something' and 'thing' are basically what we can point at or refer to. But, as words, they are too vague – too imprecise – to be particularly useful for *our* purposes of examining innovation and change. Although using the precision of *mathematics* to describe innovation processes is too ambitious, we can sharpen our thinking by using well-chosen *images*. This chapter introduces the core images that will be used throughout this book.

It is the 'way' of our culture – the 'Western Philosophical Tradition'[1], or more narrowly, the 'Scientific Method'[2]– to want to *analyse* what we observe or sense: we want 'things' to be 'deconstructed'– to be described in terms of:

- their constituent parts;
- the relationship between those parts; and
- how the thing came to be what and where it is.

(This can be contrasted with the Eastern Philosophical Traditions, which generally emphasise holism and harmony and usually consider analysis to be folly).

Philosophers call this kind of study *ontology*[3] and *epistemology*[4]. *Ontology*, in essence, is about *systematising* things, and *epistemology*, in essence, is about the *origins and nature of what we know*. *This* chapter is essentially about the ontology of things and the *next* chapter is about epistemology. Although these notions seem to be arcane to most innovators – the province of academic philosophers – they turn out to be important to us if we are to 'get under the hood' of innovation. As this book is about innovation – not philosophy – and hopefully its readers are innovators – not philosophers – we will try to use everyday words and examples as often as possible to describe these ideas.

But, like the philosophers, we want our description of the world to be *systematic – ie system–atic*. We think – with some justification – that if we can name and analyse 'things', then we can deliberately change them more efficiently and effectively than if we just treat them holistically – as an undifferentiated mass. The following quote summarises the views of many:

> *A standard argument of economic thinkers of the not too distant past was that new information technology would soon make the real economy around us fully transparent and accessible for analytical understanding, optimization of individual and aggregate behavior and the circumstances perfectly arranged for informed central planning. Such were the predictions of neo-Walrasian analysts and their derived believers in the*

business world…So far no such full-information equilibrium-real-economy has materialized.[5]

Despite the obvious fact that the 'information age' has not reduced life to the electronic processing and analysis of everything, it can't be said that *analysis* has failed as a way of dealing with many issues and problems. This book tries to advance the use of analytical techniques in the area of innovation – an area where previous techniques have had less success than had been hoped for. In this chapter we focus these analytical techniques on the word 'thing'.

Systems – a Basic Definition

From now on, we will replace the words 'something' and 'thing' with the word 'system'. In broad terms, the word 'system' suggests that what we are pointing at is *bounded* and has some kind of *detailed structure*. By 'bounded' we mean that it is 'point at-able' – it is *not* everywhere and invisible to the senses. By 'detailed structure' we mean that it usually has parts that are connected in some way. So every 'thing' that we can perceive or imagine could be described as a 'system' – rocks, rockets, chairs, cherubs, computers and tigers.

The subject of *systems theory* is vast, and in this book we will focus on a small part of it, called *General Systems*[6]. As this book is primarily about innovation and change, within the area of General Systems we will focus on systems that have been *deliberately constructed* – systems that have a *purpose*. So our working definition is:

- ***Definition: A system is a collection of related elements with a purpose.***

A stylised basic system is depicted in Fig 2.1. The circles (elements) are 'things', which can be tangible ('real') or abstract (exist only in our imagination), and are parts of the whole – which is also a 'thing'.

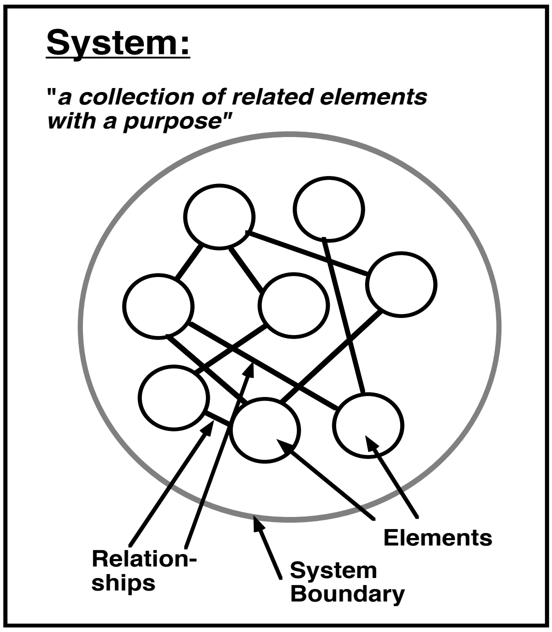


Fig.2.1: The basic definition of a System.

- **Example 1**: In a *technological product*, such as a computer, the elements are the *components*, such as the hard drive, screen, CPU, memory and the programs encoded in the memory etc. The usual 'purpose' of the computer is to enable the storage, processing and transmission of information that is ultimately used to perform some task, ranging from financial analysis to games.

- **Example 2**: *A business* could also be depicted as a system, comprising elements in the form of people, buildings, equipment such as phones, photocopiers and computers, software and documentation that are related for the purpose of producing particular goods or services.

We will now take some space to analyse our definition of systems word-by-word, in the same way that we analysed our definition of innovation in the previous chapter.

Analysing the Definition of Systems

1. *Elements*: When we look at a system, we usually see that is not a uniform or homogenous lump – it comprises smaller bits that go together to make up the system. Bits, components, parts, lumps, things – a lot of different words that we will replace, for the most part, with the rather clinical, chemical or mathematical word 'elements'. Elements are meant to be the basic parts of the whole. We think of the elements as having similar status as parts of the whole. For example, when we describe the elements of a chair, we talk of the legs, the back, the seat and the struts; we usually don't talk about fibres or the molecules of metal from which these parts are made – we have a fairly fixed notion as to what comprises the elements at a particular level. This is somewhat arbitrary, as we will see that many of the distinctions that we make in definitions have some degree of arbitrariness about them. We will return to this issue many times in this book.

2. *Collection*: When we *collect* things, we put them in some sort of container:

- a collection of stamps is a *stamp album*;
- a collection of electronic components is a *computer*;
- a collection of people, equipment and information in a building is a *company*;
- a collection of words is a *book*;

…and so on.

By making or defining that container, we are dividing the world into two parts – those things, or elements that are *inside* the container and those things that are *not*. For example, we have made the decision that only certain stamps go in our album, because it is intended to be a collection of 19th century stamps; or, there are no manufacturing tools in the company, because it is limited to retailing; and so on. So we set limits on our collection by defining a *system boundary*. Sometimes that boundary is fairly obvious and sometimes it is quite arbitrary. Defining what *is* in and *is not* in our system-of-interest can become the source of much discussion and we may find that we have included or excluded elements in error. So the 'collection' is the set elements *within* the system boundary. Again, that boundary is often arbitrary and much effort may go into defining or setting that boundary to include or exclude certain elements. In general, this is a useful exercise, but it can also be time-wasting and counter-productive.

3. *Related*: By itself, the word *collection* seems to denote a certain lack of order or organization among the elements in the collection – like the toys in a child's toy-box. The *relationships* between the elements are the means by which the elements are *connected* to make up a particular system, and the way that they *interact* with or *respond* to each other is *through the information transmitted through these connections*.

- **Example 1:** In a *computer*, the CPU is connected (electronically or optically) to the memory chip (RAM) and hard drive so that it can retrieve information to process and return it to be stored. Computer languages are used to encode the instructions and the various components are built to respond to those instructions in a particular way. The transmission of an instruction by one element to another and the response by the receiving element constitute the basis of the relationship between elements. (need picture here).

- **Example 2:** In an *organisation*, or company, there are relationships between people in written, oral or non-verbal forms that determine how tasks are delegated by the supervisors or managers to the staff members, and how the results of that work are received by the managers or delegating officers. People also relate to the equipment (the photocopier, fax and computer for example) in different ways for different purposes. A *relationship* defines what, how and when elements communicate with each other.

The issue of *power* in relationships – ie the *imperative to respond to commands* – or protocol – is central to the way systems behave and change. The computer in our example is designed to respond to the commands of the person using it (within the limits of its design) and in turn, the computer is designed so that the RAM will provide information to the CPU when the CPU requests it. The concept of power means that the *relationship is not symmetrical* – eg, the computer does not give commands to the user, the RAM does not give commands to the CPU, the staff member does not give commands to the manager, etc. Each of these interactions can be thought of as a relationship which has a power structure – the purpose of the system prevails over the relationship between its elements, and so on.

4. *Purpose*: Purpose is the *goal*, the *reason*, or the *meaning-for-being* or *attainment of an intended outcome* of the system. The distinction is often made between *purposeful (or purposive)* and *non-purposeful* systems:

Purposeful systems: These systems behave, or change over time in a way that could be inferred as being driven by some *deliberate aim* and respond to interactions with their environment in a way consistent with maintaining that aim.

Non-purposeful systems: Not all systems are 'purposeful', at least in any obvious way. A rock could be thought of as a system, comprising grains of silica and other minerals that are bound together (relate) through chemical bonds. But, without straying into theology, we cannot ascribe a purpose to it – no-one deliberately made it, and it appears to have no means of modifying itself, so we considered it non-purposive. Things or systems that we describe as *inanimate* are easier to consider as non-purposive than living things.

The philosophical study of purposeful and non-purposeful systems is called *teleology*[7].

We often use the criterion that the system, or its maker, must be able to describe its purpose if it is to be considered as purposive.

- **Example 1:** *Living things*, including people, are often thought of as systems, comprised of elements, in the form of organs, which work together for the purpose of sustaining life.

- **Example 2:** *A business*, with its people, equipment and information, is a system, whose purpose is usually defined by its *mission statement (see chapter xxx)*.

- **Example 3:** *The competencies within one person*, which together makes up that person's 'skillset', or knowledge – the 'system' by which they perform a particular deliberate, or purposeful action.

As shown in Fig xxx, we can depict the purpose of a system as a relationship between the system and some system in its wider environment. There maybe more than one such relationship, as the system may have more than one purpose. The possible conflict between these purposes will be discussed in Chapter xxx.

Systems hierarchy

We have defined a system as comprising *elements*, which, in turn, could be thought of as being systems in their own right. For example, a computer's disc-hard-drive, which is a single element of a computer is comprised of a number of parts – disk, head, axle, wires, electronics etc. The keyboard comprises a base, keys, springs, contacts and electronic parts, etc. So if we define, say, 'the computer' as our system, then its elements are then called *sub-systems*, each with a *use*, or purpose, which is *more narrowly defined* than the system as a whole. The purpose of the computer's hard drive is to store and retrieve information that can be processed by that computer. In turn, these sub-system's elements might be further divisible into *sub-sub-systems*, and so on. Alternatively, the computer may be considered as a sub-system of the organization that uses it, which, as we have nominated the computer as 'the system', we would call a *super-system*. In turn, the organization may be one of many in a business park or shopping mall, which would be a super-system of an even higher order.

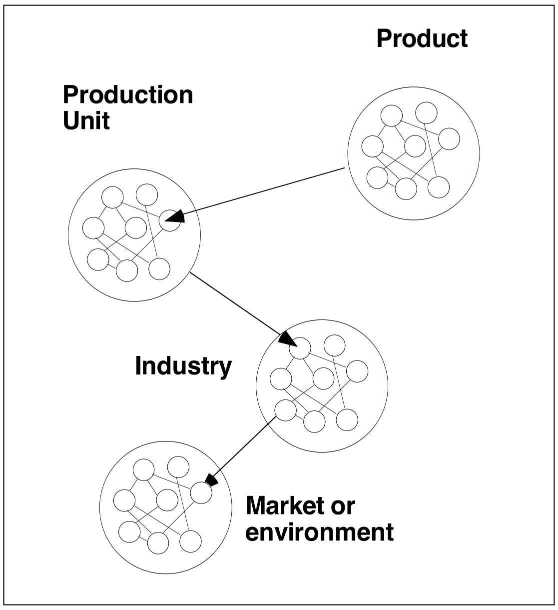


Figure 2.2: Systems can be "nested".

System boundaries

While the *physical* distinction between a computer and its immediate surrounds is usually fairly obvious, the *system* boundaries may be less so. The computer is a sub-system in a computing system, which most obviously comprises the desk, chair, electrical and data (intranet and internet) connections and the person who operates the computer. Less obvious are the links (relationships) to the office, the building and the city, other staff in the office who supply information, management and support, and the people who generate the online information and their computers, desks, chairs etc. So system boundaries are often quite arbitrary, and really depend *on the purpose for which we choose to declare certain elements as a system.*

Indeed, the same element may be part of more than one system. Our desktop computer is, at the same time, part of the 'company system', whose purpose is to make a profit by serving its customers, as well as part of the internet service provider's system of many interconnected computers, whose purpose is to make a profit for *its* customers.

So what comprises a system depends on the *point of view* of the system's observer, or analyst. It's rather like viewing colour-blindness test patterns, where different images are seen in the same picture, depending on the viewer's visual state and the different coloured filters that are held over the picture. In systems language, this is known by the German word *weltanschauung,* or 'world view'. Wikipedia defines weltanschauung as *the framework through which an individual interprets the world and interacts in it*. It is therefore with some care and caution that we should select what we include in our system-of-interest and what we exclude. Our main criterion for selection is that certain elements *appear* to be *strongly connected* and are therefore included, and others that *appear* to be *weakly connected* are excluded. The connections are the 'relationships' between the various systems. As to what constitutes a strong or weak relationship is a subjective and arbitrary matter.

Systems failure is often caused by underestimating the strength of the relationships between particular elements. In reality, many systems are complex systems[8], with many relationships with many feedback loops. It is therefore with some caution that we simplify systems-of-interest to general (linear) systems – we can consider the systems approach taken in this book as a useful "first approximation" to actual situations. If it is found to be inadequate, we must look to more sophisticated ways of solving our problems.

The definition of "innovation" from a systems perspective

We now have enough systems language and basic images to re-visit our definition of 'innovation'. We shall return again to this challenge after we have introduced *life-cycle theory* in Chapter XXX.

Fig 3.3. illustrates innovation from a systems perspective. On the left-side of Fig 3.3, some of the elements, some of the relationships and the boundary of our 'model system' are comprised of dotted lines to indicate that, although the system is *envisaged* or *imagined (*ie it is an *idea, or invention)*, it does not yet exist in a form that we can see, feel or use. *This is the system at the beginning of the innovation process.* Essentially, the system has been 'invented', but has not been 'innovated'.

The process of innovation will entail changing the dotted lines into solid lines on the right-side of Fig 3.3 – that is, giving meaning and form to the elements and relationships that do not yet exist. The system boundary is also dashed, as the process of innovation will entail not only making some of the components, but also deciding what to put in the system and what to leave out.

- **Example:** If we were developing (ie innovating) a new computer, we would envisage and design it, then, perhaps, use some already-existing components (say the keyboard and screen), but develop a new CPU and RAM. Whether to include a disk drive as well as USB-ports may not be decided until later, depending on the uncertainties of, say, internal space or selling price. When we have a CPU that works – and works as planned in the computer – we can replace the dotted lines with solid lines.

But the *internal* transformation of the system is only part of the story – that is, the 'something that works' part of the above definition. We might have something that looks like a new computer, but it isn't a computer unless it computes – ie it 'is brought into use'. And by 'use' we mean the use for which it was intended – its *purpose*. While it sits there on the table, not switched on and being used as a computer, it is merely a visible object that takes up space. It must *relate* to the world outside itself to be a computer. Not only do we have to construct or establish the elements and relationships *within* the system, but we also have to establish relationships *between* the system and the world in which it is going to serve its purpose (its super-system). These relationships are depicted by the line outside the system in Fig 3.3.

The full range of relationships that have to be considered comprises the substance of this book.

A systems-based definition of innovation

We can now refine our definition of (the process of) innovation to be

- ***the development of a system to be used for its intended purpose.***

This is depicted in Fig.3

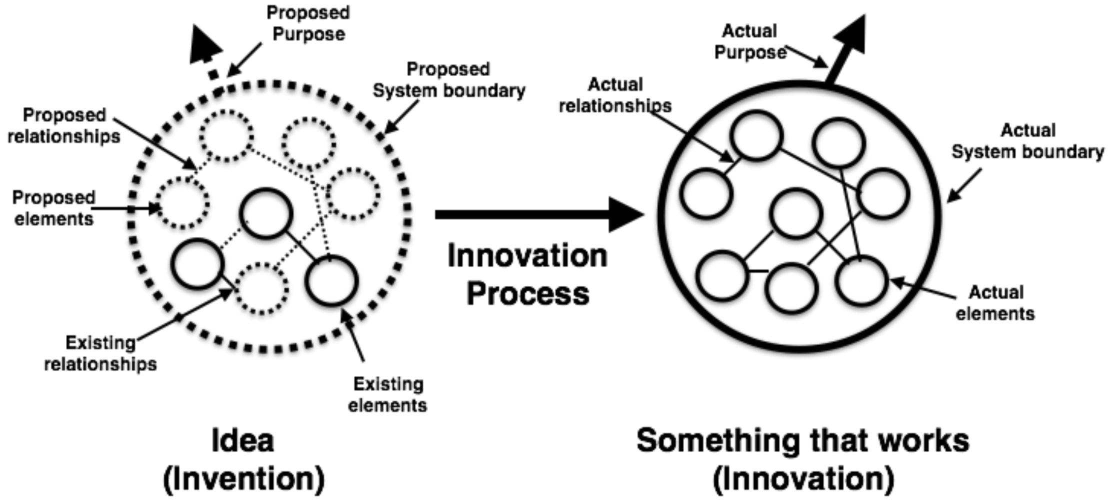


Fig. 3.3: A systems definition of "innovation"

By *development*, we mean 'the building of'. I use the word *development*, because the wo rds 'research and development' (R&D) are often used to describe the innovation process, particularly when it is applied to what we call 'technology'. By *research*, we mean

- ***Research: the use of systematic reason and experimentation to solve problems.***

This is what we often call 'being scientific'. Notice that the word 'system' has crept into this definition. The *scientific process* of research can be thought of as

- ***Scientific process: developing descriptions of the causal relationships between systems.***

To do this we guess at (hypothesise) and trial ideas (experiment) to find out whether the concepts fit together according to our notions of causality.

Hence we can see that

- ***Research and development (R&D) is the process of constructing a new system.***

The research process is intimately linked to innovation, because 'problem solving' is the process of making the unknown known. When we started innovating our idea, some elements and relationships were in existence, but some of the elements (such as the CPU in our computer example) were not in existence and although we *believed* that they could be made – and made to work – it was just a *belief* – an *idea*, or a *vision*. The challenge was to find a way of transforming that belief into a reality. Perhaps the idea had to be modified to work with the resources at hand; perhaps the functioning of the system had to be modified to match the realities of the new components or subsystems – *that is the essence of innovation*.

In summary: Our *vision or idea or invention* of a system might be modified by the process of innovation. What do we mean by this? We started out with an intention to build a system – a collection of related elements with a purpose. By the time that we have 'innovated' our idea, it might well be different from what we originally intended. The elements might be a bit different, the relationships might be a bit different, and the purpose might be a bit different. It is a matter of basic philosophy as to how different it can be, and still be 'the same system'. But so long as it is *new*, and has a *purpose*, then we have *innovated* something!

System Configuration – a Pattern Emerges

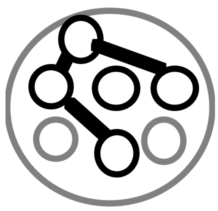
The capacity of a system to fulfil its purpose is very much determined by the systems configuration.

- **Definition: By *configuration* we mean the particular pattern of relationships between the elements and the nature of those relationships.**

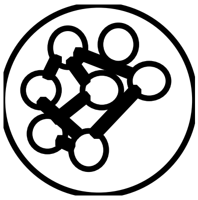
The pattern that we are interested in is the existence or absence of *strong* relationships between particular elements. In most practical systems, not all elements have direct relationships to all other elements. In other words, when a particular element performs an operation, it does not *directly* affect every other element, although it may eventually affect other elements through the consequences of its effect on elements with a direct relationship. For example, not everyone uses the photocopier in the office; the CEO only communicates with junior staff through executives and managers.

Of course, the more elements in a system, the greater the number of possible configurations. However, we find that in most viable or practical systems there are a limited number of *basic* patterns or configurations. For our purposes, we find that eight different configurations will suffice. These are displayed in Fig 3.

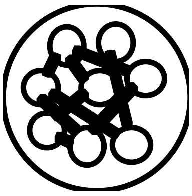
The following is a brief description of the basic features of these eight configurations. It will only describe the image or geometry of the relationships between the elements. The strength, length, type and direction of flow of communication between the elements will be described in section XXXX. In the following chapters we shall return many times to the issue of configuration and how it affects the way that the system operates and changes.



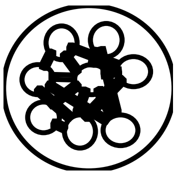
1. ***Information*** (or *Pre-organisational*): In this stage, the system does not actually exist, so the description is usually retrospective. It is the *pre-cursor* to a system. Some of the elements of the system-to-be exist, tangibly or as descriptions of ideas – these are depicted as solid small circles. The small dotted (shaded) circles indicate possible elements. Some relationships between the elements exist, as shown as solid lines, and some others that will be developed are shown as dotted lines. As the system does not actually exist, it has no defined boundary, or purpose, and the dotted (shaded) line suggests the boundary to come. We show this stage to remind ourselves that much of what might comprise a system exists before it is formed, *and a 'new' system may be an old system with a few changes and maybe a new purpose*.



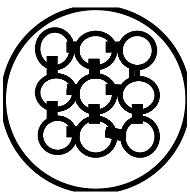
2. ***Invention:*** Although it has no material form, by definition, the basic system has been conceived, or invented, and therefore can be depicted as a collection of related (solid lines) elements (solid circles) with a purpose (solid boundary). The dotted lines and circles indicate that the invention's basic functioning might be elaborated as more thought is applied to its possibilities. The elements might be connected to each other in a fairly haphazard way, some with many connections (relationships) to others, some with only a few, indicating that more thought and design might be required to make the invention workable (*i.e.* capable of fulfilling its purpose) even in theory.



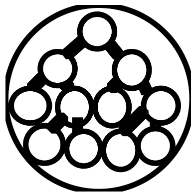
3. ***Innovation:*** In this stage, the idea is made manifest, so the system is depicted as having solid elements, relationships and purpose. It is experimental, so many changes to the elements and relationships might occur, and even modifications to its purpose. Many of the elements are not new, as they have been previously produced for other systems with other purposes. Some of the elements may be new, as it is found that the system may not meet its conceived purpose as just a new configuration of existing elements. In some systems at this stage, all the elements may have been adopted from other systems. A similar situation obtains with the relationships – some elements are connected in ways that have been known before, others have to be developed anew. But overall, to qualify as a novel system, there must be at least some relationships between the elements that are new, even if the nature of that relationship is not new. The overall configuration of the elements shows multiple connections between the elements, indicating that many of the elements are involved in the same relationships – ie there is a certain amount of *redundancy* in the system.



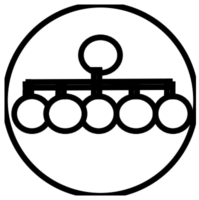
4. ***Diffusion*** (or *Take-off*): This is the first stage of the system being 'tested in the marketplace' ie it is endeavouring to fulfil its purpose. It is similar to the innovation stage, with multiple connections (relationships) between elements, and noticeably, the emergence of an element that has more and/or stronger relationships than the others. In organizations, this is the *entrepreneur*, who wants to be involved with everything, but not necessarily to control everything.



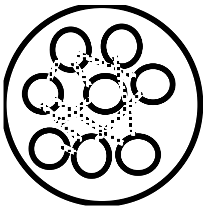
5. ***Matrix*** (or *Shake-Out*): As the system grows the number of redundant elements and relationships, and the degree of leadership involvement may become dysfunctional, leading to a system-wide rationalisation, or 'shake-out'. In this configuration there is still a high degree of multiple-connectivity, where one element may perform a particular function with a number of other elements. In organizations, this matrix-management occurs where the skills of a number of workers are shared across a number of projects.



6. ***Hierarchical***: As functions become more specialised the number of relationships of each element reduces to the point where it may have only one relationship (if it is 'purely operative') or two kinds if it is 'middle management' – one to a 'superior' element and a number (up to about ten) to 'subordinate' elements. This leads to a pyramidal configuration, which also has the characteristic that many elements only communicate with each other via a long chain of relationships with others.



7. ***Revitalised*** (or *Corporate/Rationalised*) In these organizations many levels of 'middle management' have been removed as they appear to be unnecessary as the operatives are now sufficiently skilled to function without them. The operatives are connected directly to the 'executive' elements and to a group around them who form a team to perform a particular function. This is the so-called 'flat management' system, which is similar to the 'entrepreneurial' configuration in that there are strong relationships to a dominant element. It differs in that the corporate system has few cross-relationships as function-redundancy has been minimised. The nature of the relationships has also changed in that the communication 'up' is mainly performance -monitoring data and the communication 'down' is commands to ensure or alter the required performance of the operatives.



8. ***Decadent*** (or *Decline*): This configuration may be broadly similar to *Hierarchical* or *Revitalised*, with the difference that many of the elements relationships have disappeared, reduced or become dysfunctional, thus denoted in grey. This is a system that is disintegrating.

Most people will quickly identify with these configurations and recognise that their organisation compares closely with one of them.

Importantly, these configurations are relevant to all kinds of systems, not just work-related organisations. They relate equally well to the 'design' of artefacts or equipment or technology and also to other social structures. In fact *all* purposive systems seem to fit into one of the patterns and curiously, many non-purposive systems seem to fit too. (see Hurst and Zimmerman[9])

The important implication of configuration is that some configurations are better suited for achieving certain purposes than others. For example, in organisations, the 'experimental' and 'entrepreneurial' configurations are better suited to innovation than the hierarchical and corporate. Alternatively, the latter two are better suited to mass production than the former two[10]. Future chapters deal with this in detail.

Conclusion

We now have a model for visualising an innovation as a system, rather than just referring abstractly to it as 'something'. Further, we have analysed the system as comprising elements, connections between the elements (relationships). As a system's elements often have distinct parts, they can be considered as sub-systems and in turn, our system-of-interest may be considered as an element in a super-system. The purpose of a system can be visualised as its relationship to its super-system. Finally, we have seen that although there are a myriad of ways that a system can be configured, in practice there are a limited number of generic configurations – we have settled on eight.

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