Systematic Innovation: A comprehensive model for business and management with treatment on a South African case.

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Abstract

This thesis addresses innovation of business and management with the purpose of advancing innovation in South Africa.

A Design Science Research methodology is utilised to evaluate the current knowledge base of business and management innovation and construct a high level model for Management Innovation that pertains to all management areas of business including technology and innovation management.

This thesis evaluates Learn-by-Experimentation (Trial and Error), Van Gundy's Structured Creative Processes and Mann's model constructed in practice. The Learn-by-Experimentation is a methodology only suited for physical innovation. The Structured Creative Processes are found to be of a generic nature which is not suitable for Innovation of Business and Management. Mann's model is a projection of TRIZ onto business and management that addresses a subset of the business areas. The literature study in this thesis showed the identification of innovation opportunities was explicitly addressed by Van Gundy and implicitly treated by Mann.

The "General Internet Access" for South Africans, as envisioned in the National Development Plan to stimulate economic growth, has been analysed for systematic innovation potential and did not render the desired outcome. The NDP will require further development to enable systematic innovation.

In the course of this research a spiral innovation model for systematic business and management is developed through intensive literature analysis to cover the identified gaps. The model consists of the following steps:

1. Identification
2. Analysis and Definition
3. Select Approach
4. Create Potential Solutions
5. Verify and Validate Solutions
6. Implement the best Verified and Validated Solution

with the idea to converge towards an Ideal Final Result.

The results of this study is a contribution to the knowledge base of business and management innovation.

Acknowledgements

Soli Deo Gloria.

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Creative Problem Solving (CPS) ix, 11, 17, 18, 19, 20, 21, 37

Design Science Research (DSR) xi, 5, 6, 7

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Engineering Management (EM) 107, 108, 110, 139

Gini index is an indication of income inequality ranging from 0 to 1. If one household has all the income and the rest none it would be 1, else if all households have the same income it would be 0 (**USCB** 2018). 1

Gross Domestic Product (GDP) Income generated by the citizens of a country internally. xi, 2

Human Development Index (HDI) 1, 2

Ideal Final Result (IFR) 64, 65, 85, 89, 90, 91, 92

Intellectual Property (IP) Intellectual Property includes patents, trademarks & copyright 61

Quality Function Deployment (QFD) A structured method to define customer needs or requirements and deriving plans to produce products to meet those needs. (**DRMA** 2016) 80

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Theory of Inventive Problem Solving (TRIZ) English translation of: "Teoriya Resheniya Izobreatatelskikh Zadatch") xi, 37, 38, 39, 40, 51, 92, 105, 115, 116, 117, 118, 119, 125, 126, 127, 128, 129, 131, 139, 142, 146, 149, 150, 151

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Chapter 1

Introduction

§1.1. Introduction

In South Africa the distribution of income is skewed and many households earn much less than the upper income groups. The Gini index (GI) for the country is high. The measured values since 1993 until 2014 range from 57,3 to 64,8 as is shown in Figure 1.1 (**WB** 2018).

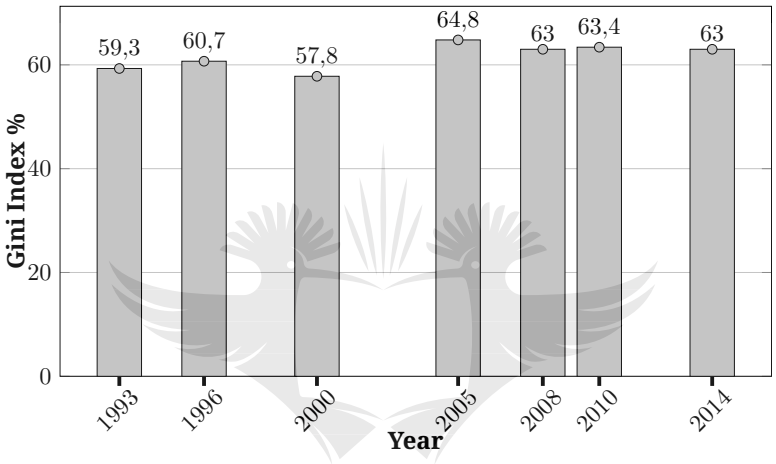

Figure 1.1.: Gini Index for South Africa since 1993 until 2014 [based on **UNDP** (2017)].

The United Nations Development program has a measure to indicate the progress in human development, called the Human Development Index (HDI) (**HDRO** 2016). South Africa showed a change from 0,621 in 1990 to 0,666 in 2015 (**UNDP** 2017). This equates to an average improvement of 0,28 %/annum over 25 years.

The unemployment rate for SA is as shown in Table 1.1.

Table 1.1.: Unemployment rate for SA (**StatsSA** 2018a).

Year (Q2)	Unemployment rate [%]
2008	22,6
2009	23,2
2010	25,1
2011	25,6
2012	24,8
2013	25,3
2014	25,5
2015	25
2016	26,6
2017	27,7
2018	27,2

The annual growth rate of GDP for South Africa is shown in Table 1.2.

Table 1.2.: Annual growth rate of GDP for South Africa (**StatsSA** 2018b).

Year	Growth in GDP [%]
2012	2,2
2013	2,5
2014	1,8
2015	1,3
2016	0,6
2017	1,3

The GDP show a minimal positive growth. The HDI a lesser improvement, but the unemployment rate has only improved in 2012 and 2015. This means that major action would be required to correct the economic situation in the country.

§1.2. Need for and benefits of innovation

The key drivers of the creating of sustainable jobs are Creativity and Innovation. The nurturing of these amongst students is the best way to create sustainable jobs and reduce unemployment. Innovative products and services should result from the stimulation of creativity. That would lead to the generation of employment for others that participate in the establishment and implementation of the products or services (**Brownson** 2014:939-940; **Esfahani**, **Karimi**, **Salahshouri** and **Tavakol** 2014:977-978).

Research conducted in 2013 by Ernst and Young showed that 70% of entrepreneurs believed that innovation is the prime cause for their enterprises' growth and it is a real job creator. It is also the real advantage they have over competitors according 88% of the entrepreneurs interviewed. Innovative skills is currently an essential skill employers look for when employing new people. Many firms believe that their market position depends on making innovation a part of their organisation culture (**Brownson** 2014:940; **Esfahani** et al. 2014:977-978).

There are many step-by-step innovation methods in the literature, for instance **Mycoted** (2009) lists in excess of 190 methods and variations of them. **VanGundy** (2005) & **VanGundy** (1988) describe more than 100 creative techniques. **Michalko** (2006) also provides a multitude of techniques to follow. Each of these methods or techniques have recommended steps to follow and could therefore be classified as a systematic method. Analysis of the techniques will show that the majority of them are methods to find either new ideas or solutions for problems. Some of these techniques will assist the user to use divergent thinking. Most of them, however, use current knowledge and observations. This and the common approach to see what the boundaries of potential implementations are, leads to accepting compromises. Accepting compromises in solutions means that they could probably be innovative, but by accepting the compromises as rules to innovation would be limiting on the solutions.

Many organisations implement Learning by Experimentation or as is otherwise known as Trial-and-Error. **Thomke** (2008) discussed problem areas associated with this approach. The biggest problem is however the cost to iteratively search for solutions or implementation of ideas. The cost and availability of resources could either make the process not being fully implemented or slow or place it out of the reach of smaller organisations.

Altšhuller (1998) developed an algorithm for inventive problem solving in which the aim is not to settle for the compromises, but to go beyond. It was developed by analysing numerous patents

to derive the generic steps followed. Derivatives of this algorithm like SIT (**Horowitz** 1999) and USIT (**Sickafus** 2006) aim to do the same but with less complexity. These methods start with a known problem and work to an ideal generic solution.

§1.3. Definitions

Innovation is defined in two ways according to Miriam-Webster: "the introduction of something new" and "a new idea, method, or device — novelty" (**M-W** 2014a).

Two related concepts are renovate and invent. The definitions of renovate are: "to restore to a former better state (as by cleaning, repairing, or rebuilding)" and "to restore to life, vigour, or activity" (**M-W** 2014c). The problem comes in when one for instance should add new paint to a vehicle (renovation) so that it has a totally new appearance, which would mean something new was introduced and therefore it could be reasoned that it is innovation that occurred. Adding to this, the paint could be a totally new and improved type of paint which will outlast the vehicle by many years. The effect is to optimise some of an object's characteristics.

Invent is defined as: "to find or discover", "to devise by thinking as in fabricate" and "to produce (as something useful) for the first time through the use of the imagination or of ingenious thinking and experiment" (**M-W** 2014b). Real innovation introduces new instances of objects or systems with new and better characteristics. From this it is reasoned that to invent could be seen as the higher level innovation.

Miriam-Webster provides several definitions of systematic, for the purpose of this research two are selected. The first: "presented or formulated as a coherent body of ideas or principles" and the second in two parts: "methodical in procedure or plan" and "marked by thoroughness and regularity" (**M-W** 2014d).

The conclusion is that systematic innovation would consist of a thorough methodology formulated as a coherent body of ideas or principles, that could regularly be applied to reliably obtain a very similar result. It would have a coherent body of principles as basis, irrespective of the area of application.

§1.4. Importance of innovation

The growth and survival of organisations depend on innovation. **Dervitsiotis** (2011:554) indicated that this was identified by several people since 1985 as a method to overcome discontinuities in the world economy. Several companies in the United States, 87 %, did not achieve growth similar to the national growth rate due to the absence of innovation.

According to **Fey** and **Rivin** (2005:4) the key question in defining a technology strategy for an organisation is: "What is the next winning technology to satisfy the potential or perceived market need?". The next identified hurdle is psychological inertia which is determined by cultural and educational backgrounds, previous experience and "common sense", this causes people and organisations to always, without other training, use trial-and-error as the preferred method to find solutions (**Fey** et al. 2005:5).

Innovation is regarded as the key to unlocking the future and Technological Innovation is sometimes labelled the master key (**Eckermann**, **Lin** and **Nagalingam** 2003).

In history many innovators paid dearly with their lives, because it was considered wizardry (**Pavlac** 2013). Da Vinci disguised some of his innovations to shield him from persecution and many of his findings were only made known centuries after his death (**Jones** 2012).

The witch hunt has ceased in modern times, but now it is considered as something only gifted persons can achieve. So although progress has been made, it is now regarded as reserved for the geniuses of today.

On the other hand a lot of methods have been put forward as the solution to achieving innovation, the most famous one of these being Brainstorming. A quick internet search provides a list of in excess of 150 innovation methods (**Mycoted** 2011). Many of these are different variants of the same methods and an investigation would most probably reduce this to a much smaller amount. **Changqing**, **Kezheng** and **Fei** (2005:2) states that from the 1930s to 1980s more than 300 innovation methods appeared.

§1.5. Systematic systemic innovation

If a non-commercial and scientific based method of innovation could be determined the results would have the following advantages:

1. It would not be constrained as in the case of Brainstorming
2. It could shorten the time from the determination of the opportunity to innovate to the realisation of the innovation
3. It could be introduced at all levels of education which would bring about a common understanding that innovation is not reserved for geniuses
4. By shortening the development time it would be much more economical and would not require huge sums of money.

§1.6. Context of this research

In the context of this research it is important to distinguish between "management innovation" and "innovation management". The latter in general refers to the management of innovation of products, services, their rendering processes" in business. This research is concerned with business and management innovation where the innovation occurs in terms of the business model or the management of the business areas. (**Samson**, **Gloet** and **Singh** (2017) conducted research on the rendering of services, not on management innovation.)

Van Aken (2004:220) believes that in management, apart from doing descriptive research, predictive research should be conducted that would provide design solutions for problems in management.

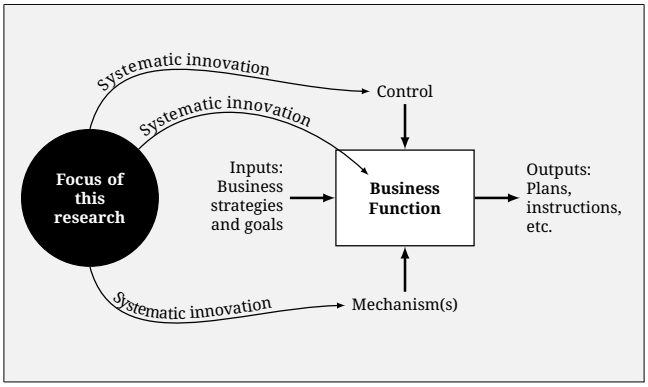

Figure 1.2.: IDEF0 representation of the focus of this research adapted from **DSMC** (2001)

According to **Gassmann**, **Frankenberger** and **Csik** (2014) will the competitive advantage of the

future not be based on innovative methods and outputs, but based on innovative business models. Empirical evidence to the effect has shown in research over a five year period that innovation of business models resulted in six percent more profitability to contemporaries focussing on products and processes. Out of the 25 top innovative companies, 14 focussed on innovating their business models. This correlated with research conducted by IBM in 2012 that showed the businesses who outperformed their peers innovated their business models at least two times more frequently than their peers. Although the characteristics of the outputs and the methods to render them has not lost their importance, they are not the determinants of future success. It is now the era where business model innovation will determine the future sustainability of a business.

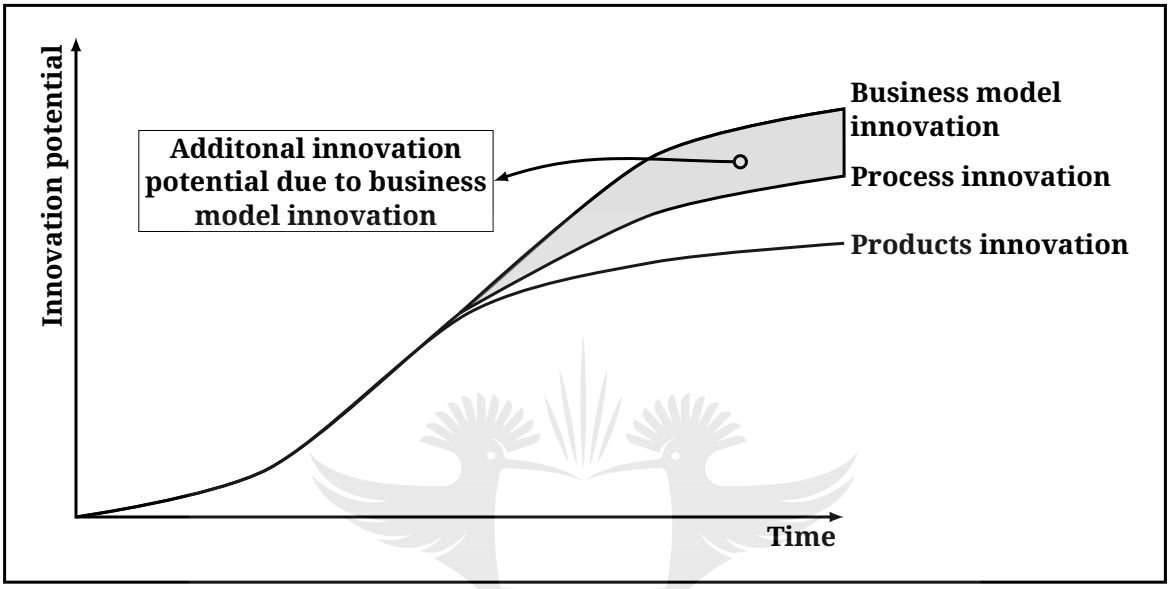

Figure 1.3.: Business model innovation advantage over product and process innovation redrawn from **Gassmann**, **Frankenberger** and **Csik** (2014).

§1.7. Purpose of the research

In this research the question will be to develop a systematic innovation approach for business and management. The aspects that will be included are:

1. The possibility to have a single systematic innovation approach for business and management;
2. If a single approach is not possible, how would the appropriate one be selected;
3. The stage at which the innovation process has reached its full effectiveness; and
4. The management of a comprehensive innovation process.

§1.8. Overview of the research

This research will be conducted by means of a typical Design Science Research(DSR) Method. The steps of the process are as in Table 1.3.

Van Aken (2005:22) stated that a more realistic approach is followed by research in design sciences as compared to the exploratory sciences where the goal is to at least reach an understanding of causal patterns. The final aim is rendering knowledge that can be utilised to design solutions that solve practical problems.

According to **Barab** and **Squire** (2004:5) design based research aims to create and promote a

specific set of theoretical concepts that surpasses the environment where they were created, chosen or improved. This is in contrast to empirical or evaluation research.

Table 1.3.: Outline of a typical DSR Study adapted from **Gregor** et al. (2013:350).

Section	DSR Contents
Introduction	Problem definition, problem significance/motivation, introduction to key concepts, research questions/objectives, scope of study, overview of methods and findings, theoretical and practical significance, structure of remainder of document. The required goals of the artefact to be developed.
Literature Review	Prior work that is relevant to the study, including theories, empirical research studies and findings/reports from practice. In the case of DSR, the prior literature surveyed should include any prior design theory/knowledge relating to the class of problems to be addressed, including artefacts that have already been developed to solve similar problems.
Method	The specific DSR approach adopted should be explained with reference to existing authorities.
Artifact Description	A concise description of the artefact at the appropriate level of abstraction to make a new contribution to the knowledge base and should include at least the description of the designed artefact.
Evaluation	Evidence that the artefact is useful. The artefact is evaluated to demonstrate its worth with evidence addressing criteria such as validity, utility, quality, and efficacy.
Discussion	Interpretation of the results: what the results mean and how they relate back to the objectives stated in the Introduction section. Can include: summary of what was learned, comparison with prior work, limitations, theoretical significance, practical significance, and areas requiring further work. Research contributions are highlighted and the broad implications of the paper's results to research and practice are discussed.
Conclusions	Concluding paragraphs that restate the important findings of the work. Restates the main ideas in the contribution and why they are important.

The process selected is as depicted in Figure 1.4.

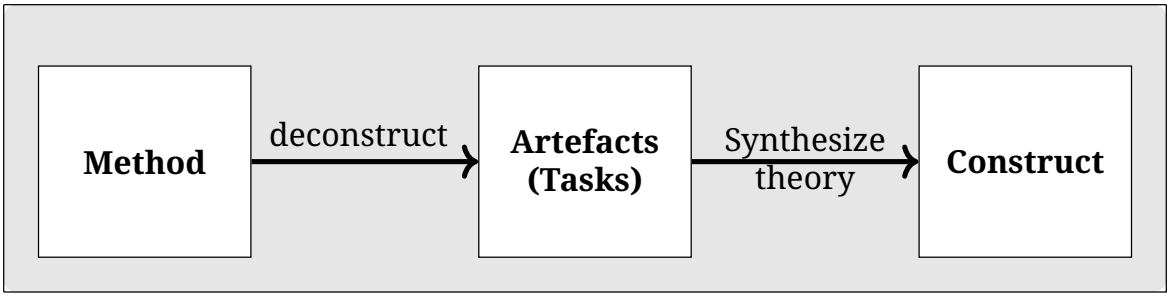

Figure 1.4.: Process overview

Knowledge is also a possible output of Design Science (DSc), but it also includes knowledge in theoretical form (**Venable** 2006:9-11). This could be at the level of being emergent to generalised and accepted. It could also be in the form of constructs, models, methods, and instantiations. Theories are required to build a body of knowledge.

Barab et al. (2004:2) stated that design based research is a collection of approaches with the aim to render new theories, artefacts and practices describing and possibly impacting the real world.

The outline of this document in relation to a typical DSR:

Table 1.4.: Outline of a typical DSR Study adapted from **Gregor** et al. (2013:350).

Section	DSR Contents
Introduction	Chapter 1
Literature Review	Chapter 2
Method	Some Chapter 1 and the detail in Chapter 3.
Evaluation	Chapter 1. Continuous evaluation and some evaluation in Chapters 3 and 4.
Discussion	Chapters 3 and 4.
Conclusions	Chapter 5.

§1.9. Summary

The focus of this research will be on systematic innovation for business and management, which amongst other utilises physical items. Some methods discussed in Chapter 2 are deemed to be useful in any area. Others are seen as more suitable for business and management.

Literature will be examined in the next chapter to determine what has been written about systematic innovation. The methods provided in the literature will be analysed and their shortcomings identified. Based on the results of the analysis a construct will be proposed and potential further research identified.

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Chapter 2

Systematic Innovation

§2.1. Introduction

In this chapter innovation methods from literature will be examined to determine their applicability for business and management.

The first area of concern is how the literature defines innovation to determine a acceptable definition to use. Innovation needs the allocation of resources which has to be justified and this will be examined.

Different innovation methods and sets of them will be explored. The first one being "Learn by Example". Secondly to be investigated are the group called Structured Creative Processes. The most well known is Brainstorming. These processes are deemed to be applicable to any area according to **VanGundy** (1988).

Altšhuller (1998) provided a set of methods for innovation in the physical world. This method was adapted in derivatives of it. This will be discussed as it relates to the next set of processes investigated.

The set of systematic innovation approaches for business and management compiled by **Mann** (2007a) will be analysed.

The most comprehensive source on Structured Creative Processes is **VanGundy** (1988). It provides detail of the methods as well as their advantages and disadvantages. Many other sources can be found that detail some processes as far as their steps as concerned. Some processes have been commercialised and the information on them would typically require attending a course or hiring an accredited consultant, but it would not provide a critical view of the process.

§2.2. Definition of Innovation

Abe, **Suzuki**, **Etoh**, **Sibagaki** and **Koike** (2008:2141) defines product and service innovation as the successful commercialisation of a new product or service that is new or substantially improved.

Changqing et al. (2005:1) states that innovation thinking results in a breakthrough, which will restructure the current knowledge and experience to create a new and valuable achievement. In a process model the inputs are 'knowledge and experience', which are transformed through the 'innovation method' into the output, that would be the 'innovation action'.

Drucker (2014:19) stated that "whatever changes the wealth-producing potential of already existing resources constitutes innovation".

Dervitsiotis (2010:905) defined innovation as the capability of an organisation to create new value propositions for its stakeholders, especially in periods of significant change, when the current value of the existing offerings becomes less attractive. It is an issue of 'fitness for adaptation and survival, which is a basic property of all living systems, including socio-cultural systems.

Dervitsiotis (2010:911-912) states the major key results and benefits of the innovation process

as:

1. Impact on customer satisfaction through offering greater value with increased loyalty;
2. Impact on employees resulting from greater satisfaction with increased loyalty and cooperation within the organisation;
3. Impact on the organisation as manifested by increase in levels of trust, improving attitude towards risk and improving cooperation, that result in increases in functional and effective informal networks to realise the exchange of information and knowledge.
4. Improved overall organisational performance as shown by
   - Economic and financial factors, time to realise return on investment
   - Market share and time to market and
   - Environmental footprint: changes in requirements for energy and other critical resources as well changes in the levels of pollution.

The views of **Drucker** (2014:19) and **Dervitsiotis** (2010:905) only relates to business and market attractiveness of the products and services of organisations and as a mechanism to survive in harsh economic conditions. Some key results and benefits that **Dervitsiotis** (2010:911-912) provided could be generalised, but not all of them are applicable to innovation in general.

The idea of new value to the stakeholders can be expanded to business and management. This would mean that all the core business process should be subject to innovation not only the products and services in terms of their market attractiveness. The definition of innovation in the context of business and management that would be more encompassing would state the introduction of new objects, processes or system that improve business and management in any of the core business areas.

§2.3. Problems and opportunities

Innovation is aimed at introducing something new as the definition in §2.2 implies. **VanGundy** (1988:2-4) indicated that the purpose is to close an identified gap, which then makes provision for the gap being towards something that does not exist or to solve a problem in the present environment.

§2.3.1. Problem Types

A problem exists when there is shortfall between the current situation and the desired situation. The solving of the problem can occur in a single step or multiple steps, which could result in the desired situation or at least towards it (**Savransky** 2002:3).

Problems are classified as routine if all the critical steps to solve them are known. **Savransky** (2002:4) classified a step as critical if the problem cannot be solved without it. There are numerous methods in specific fields for solving routine problems. The knowledge of the steps are generally available, although it may be unavailable where the problem exists.

When at least one or more of the steps critical to the solution of the problem are unknown, **Savransky** (2002:4) classifies the problem as non-routine or inventive. Part of these are cases where the initial situation is complex, the desired situation is not well-defined or the search directions for the solution is hidden. It must be distinguished from engineering, technical and design problems, where the knowledge and process to solve the problem are known, although the solution has not yet been done before. An inventive problem is one where the input and output of the solving steps are not all defined or where there is "irrelevant or conflicting" information available. Inventive problems in general have novel, elusive solutions because it is often ambiguous or not well understood.

Savransky (2002:4) placed three boundary requirements on technical problems:

1. Physically possible as in complying with laws of physics;
2. Technical feasible, that would mean by means of the resources and the technical and scientific abilities of current society; and
3. Economical profitable.

§2.3.2. Problems as gaps

All spheres of human life involves problem solving that would through their solution change the nature of society. Changes in human behaviour create new problems. There is little activity of humans that would not require the need for a form of problem solving. People spend a considerable part of their time to solve problems, the amount will depend on the perceived importance and complexity of the situation. All problems require some attention, even if it would be a decision to take no further action and hoping that it would disappear by itself or to focus on it in an attempt to solve it (**VanGundy** 1988:1).

The success of the problem solving depends on the characteristics of the problem and the approach taken. Existing knowledge and experience would be sufficient to overcome problems of a routine nature. It also entails that the characteristics of the problem is well-defined, the method to solve it is well-known and the likelihood of success is high. If the problem is slightly more difficult less information about it would be available and less certainty regarding the method and chances of success would be the case. To solve these some known information and methods could be adapted to handle them, but the expected possibility of success would be less certain. A third class of problems would entail the ones that are very difficult to solve. The approach would require unorthodox approaches and a considerable amount of effort. The lack of information and clarity about the characteristics with a lot of uncertainty precludes known and regular methods as means to solve them. They would require specially developed solutions that would be attained through adapted approaches by means of structured problem solving and this also does not provide certainty that a solution would be found (**VanGundy** 1988:1-2).

Through a strategy of trial and error many special methods are obtained. Patterns that can be derived from small pieces of collected information to define the problem. Attempts to derive a solution is then made based on the incomplete definition. It would typically involve a hit-or-miss process and are usually less systematic. Efforts to add some structure might be made, but there would in general be no fundamental theoretical basis or consistent logic (**VanGundy** 1988:2).

More formal and structured approaches have been developed with the aim to solve the complex problems, which are called CPS techniques and they are the main concern of the techniques described by **VanGundy** (1988:2). These appear to be lacking the fundamental theoretic basis or logical pattern, but they are founded on specific assumptions and principles of problem solving and creative thinking.

The existence of a problem is a prerequisite for using CPS, else it would be a fruitless effort. The basic characteristics of the problem must be known for effective problem solving. A perceived gap could be perceived as problem, the perception being the main qualifier. The difference between the status quo and the desired is used to define the type of situation as follows (**VanGundy** 1988:2-3):

1. Anticipated opportunities exist when a change in goals would be required because a static situation exist, but the desired status is changing;
2. A threat to the goal would exist if the status changes, while the desired state remains constant; and
3. Opportunistic development such as totally new ideas might be possible if both states are

changing.

The degree of change in the status will depend on the perspective of the observer and his perceptions. This makes the extent of the change a subjective issue.

Apart from the existence of a gap, **VanGundy** (1988:2) provides four prerequisites for the existence of a problem:

1. Realisation of the existences of a gap, without this a problem is not detected;
2. A perceived requirement to solve the problem;
3. The extent of the gap must be quantifiable; and
4. To solve the problem would require skills and resources that must be at least available, without these a solution would not be obtained.

§2.3.3. Categories

Problems can be categorised in accordance with their degree of organisation. Derived from the level of available information three categories of problems exist (**VanGundy** 1988:4):

1. Well-formed;
2. Semi-formed; and
3. Ill-formed.

If a problem is well-formed, then all the information required to close the gap is readily available. Only one of the following are less than fully known: 1) The exact current state; 2) The required or desired state; and 3) The exact method to move from the current state to the desired state. The situation would be characterised by aspects that are routine and repetitive. The solution would normally involve the use of a Standard Operating Practice (SOP) (**VanGundy** 1988:4).

In the case of an ill-formed problem little, if any, information on the best method to obtain a solution would be available. The process to close the gap is ill-defined and it would require improvisation and use of specially derived solutions. The information regarding the best answer to the problem would be obtained and generated during the creating of the solution (**VanGundy** 1988:4).

The semi-formed category of problems is situated between the other two, as the name implies. Characteristics of the gap are only known in part, but the nature of the current or desired states are unclear and contains uncertainty. The answer would in general be combination of SOPs and creative results, because it would preclude the utilisation of only standard known processes (**VanGundy** 1988:4).

VanGundy (1988:4) indicated that the categorisation as described above is not independent of the person who applies it and that two persons with the same degree and depth of information would most likely have a different perception of the same situation.

The general response to the formation of a problem is either algorithmic, heuristic or creative. Algorithms are applied to the category of well-formed problems, it is seen as a guaranteed solution that is obtained from the application of a recipe. Heuristics are used for semi-formed situations, which would entail rules of thumb or guidelines to improve the probability of success; this is therefore not guaranteed as in the previous case although quite possible. Creative techniques are the most effective approach for ill-formed problems. There may be cases where heuristics could solve an ill-formed problem or where a creative approach would be the best approach to a semi-formed problem (**VanGundy** 1988:4-5).

§2.4. Trial-and-Error Method

An iterative process is followed of specifying one or more solution concepts, after which prototyping, testing and experimentation is conducted in an attempt to find a workable solution (**Thomke** 2008:405). The process is regarded to consist of four phases:

1. Design
2. Build
3. Run
4. Analyse

The build phase consists of defining the expected outcomes of the experiment or the specific issues to clarify with the testing. Existing information, observations, and previous experiments are revisited, brainstorming is used to generate new ideas, and constructs are formulated derived from existing knowledge. Sets of experiments are chosen to be conducted in parallel and analysed (**Thomke** 2008:406-407).

The build phase involves the building of physical or virtual prototypes and constructing of testing equipment or models that are required to conduct an experiment (**Thomke** 2008:407).

During the Run phase tests are done in either a real environment or under laboratory conditions. The latter are not real and the measurements are typically designed for specific outcomes. Real faults may not be detected and unreal ones could be observed due the unique circumstances that the experiments are conducted in (**Thomke** 2008:407).

The "Analyse" phase would involve the analysis of the test measurements and comparing it against the expected outcomes. The result of the analysis would be more understanding of the system or item being investigated. From this the definition for the next cycle would then be refined. The minimum advantage would be to remove failed expectations from the expected solution. It also leads to revised prototypes or virtual models to better reflect what has been observed. In the process an improved understanding will be gained and uncertainty about causes and effects will be reduced (**Thomke** 2008:407).

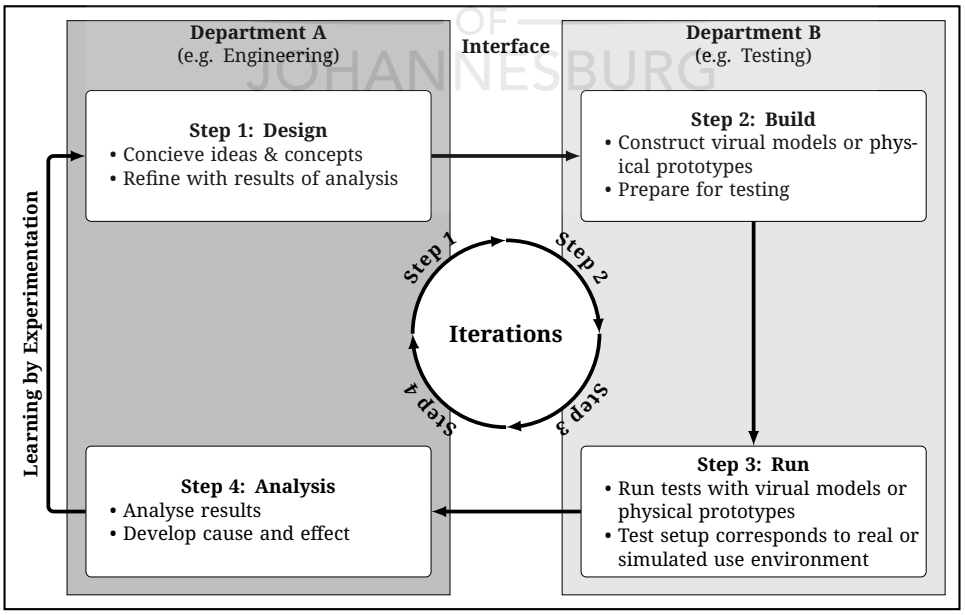

Figure 2.1.: Experimentation as iterative process (based on **Thomke** (2008:406).

Thomke (2008:407) identified several problem areas in this method:

1. Managing of the interfaces
2. Selection of models and technologies
3. Speed of learning
4. Required testing capacity
5. Serial or parallel processes
6. Frequency of testing

§2.4.1. Managing of the interfaces

The standard practice is as shown in Figure 2.1 to use at least two different entities of the organisation to execute steps 1 and 4, and step 2 and 3. Each of these entities have different and likely not totally aligned goals, incentives and resources. A major factor in the difference across the interfaces is the priorities, the Engineering department wants to have the test results as soon as possible. The department(s) responsible for Build and Test (B&T) are likely to also have other building and testing work that relates to the production of the organisation, this is the income generating activities of the organisation and they are generally of higher priority than building and testing with regard to a Research and Development (R&D) activity. The B&T required by the Engineering department is also not the standard processes used by the other departments, for which everything is in place and runs without intervention. The capacity of the departments responsible for B&T is also planned to be economical with regard to production. The result of this is that the R&D would have slow progress whilst the outputs could be important to the organisation (**Thomke** 2008:407-408).

§2.4.2. Selection of models and technologies

During experimentation models of the real world are used that are simplified version of reality. This is because during testing it is less expensive to focus on the major aspects of the intended environment than the whole and it enables the reduction of part of the real environment to simplify the analysis of the results. The models used can be of a physical nature or they could be simulations of the reality (**Thomke** 2008:408-409).

Models and prototypes are not reality, but are required to conduct experiments. The problem that arises is the parts of reality that are removed could eventually create problems in the final results. **Thomke** (2008:409) refers to this as the fidelity of the model, defining it as the extent of representation of the reality. Higher fidelity models are more expensive than the lower counterparts. The suggestion is to use lower fidelity models in the early stages and as the product or system progresses towards completion to increase the fidelity until it ultimately reaches 100 %. This would improve the understanding of how close the effort is to providing a solution and because modelling errors can get propagated through the process.

Table 2.1.: Classes of Errors due to incomplete models (from **Thomke** (2008:409)).

Class of Error	Description	Example	Result
Type I: False negative	Detection of false problems	Test conditions are more severe than in reality	Over design
Type II: False positive	Failure to detect an actual problem	The test does not provide for hazards	Design Failure

Incomplete models could lead to two classes of unexpected errors as shown in Table 2.1. As indicated in the table Type I errors would lead to over design, which is wasting of resources in

development and production. Type II errors on the other hand could have catastrophic effects as in the failure of the Challenger Space Shuttle (**Thomke** 2008:410).

§2.4.3. Speed of learning

Delay between feedback and the original lead to less efficient learning. The problem that is experienced in the learning by experimentation process is that there are long delays between the submission from R&D and results from B&T. The time-to-market pressures would cause the developers to continue without the results due to the delay, this causes the feedback to be irrelevant or only be used for verification rather than learning. The data from testing could reach the developers too late to influence the planning of the next round of B&T. In many cases the results are only used when they show major defects like not meeting the regulatory standards. A secondary problem that relates to delays is the availability of resources for developing and building the prototypes. If the resources are not available it also causes delays which result in slow 'learning' (**Thomke** 2008:411).

Another problem that occurs is when certain aspects cannot be controlled or when there are too many aspects of the situation that are being manipulated. It is tied to the situation where too much noise is contained in the results of the testing. This could cause important effects of the experiment to be overlooked or could require excessive processing to eliminate the effect of the noise or determine relationships between aspects (**Thomke** 2008:411-412).

§2.4.4. Required testing capacity

An organisation's capacity for testing determines the ability to rapidly provide test results to the developers. If the numbers of tests required exceed the organisation's testing capacity a backlog will develop and the feedback to action link will be broken This occurs when the testing capability is utilised beyond 70% of its capacity (**Thomke** 2008:412).

There is tendency to overload the capacity if long delays are expected, which slows down the process even more. Developers submit more experiments hoping some will make it through the process quickly, not taking into account how that will affect the overall process (**Thomke** 2008:412).

§2.4.5. Serial or parallel processes

The indicated process in Figure 2.1 shows that iterations are a standard element of the process. During the development of a product several iterations could occur. It is possible to do it either sequential or parallel. This will be determined by how much the one cycle would depend on the results of a prior iteration and whether iterations could be mutually exclusive. Subsystems are likely to be parallel processes until they are integrated. The advantage of parallel processes are that they could make it possible to achieve the desired results sooner given that the capacity exists to execute many iterations concurrently (**Thomke** 2008:414).

§2.4.6. Frequency of testing

In many organisations efficiency and costs are the major factors to decide how many complete iterations are possible. The optimal frequency of testing is seen to be when the benefits gained from testing is equal to the cost of it. The fidelity of the tests used also comes into effect, low fidelity tests cost much less than ones with high fidelity and could therefore be conducted more than ones with high fidelity (**Thomke** 2008:415-416).

The rough estimate of amount of tests is given by the following equation:

$$\text{Number of test rounds} = \sqrt{\frac{a}{t}}$$

Where:

$$\begin{aligned} a &= \text{ avoidable cost} \\ t &= \text{ cost of one round of tests} \end{aligned}$$

Avoidable cost is the expenditure that would not be incurred if continuous testing detected problems without any delay (**Thomke** 2008:416).

§2.5. Structured Creative Processes

In this section structured creative process as a group of innovation methods will be examined.

VanGundy (1988:5) indicated that the solving of problems is a multi-stage process consisting of the following three primary stages:

1. Intelligence;
2. Design; and
3. Choice.

During the intelligence phase the problem is realised and information is collected to define it. Problem solutions are developed during the design stage and the most appropriate one is selected and executed during the last phase (**VanGundy** 1988:5).

The stages utilise convergent and divergent thinking processes. The narrowing down of information to a more manageable set is called convergent thinking. Adding and widening the scope of the view and information is called divergent thinking as demonstrated in Figure 2.2.

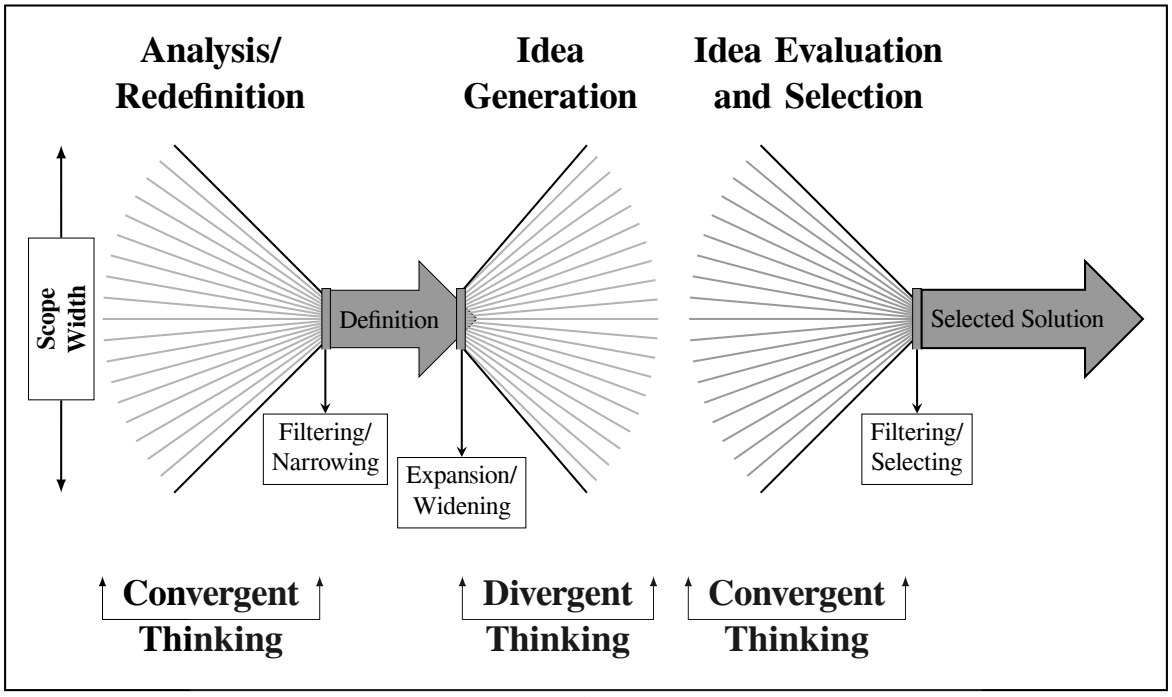

Figure 2.2.: Convergent and Divergent Thinking (redrawn and adapted from **VanGundy** (1988:6))

VanGundy (1988:6) believes that this model is too limited to clearly indicate the elements of each stage of the process. An improved approach would be to see each stage as a separate problem solving activity that consists of: (1) intelligence; (2) design; and (3) choice. In this framework the required activities can be more distinctly recognised.

The model was expanded by Brightman as provided by **VanGundy** (1988) and it incorporates CPS techniques, expanding each phase to make provision for the activities as stated above. Added to the previous model is also: a) Stimuli; and b) Implementation. During each of the major phases is a collection, a generation and selection sub-phase. The expanded model is illustrated in Figure 2.3.

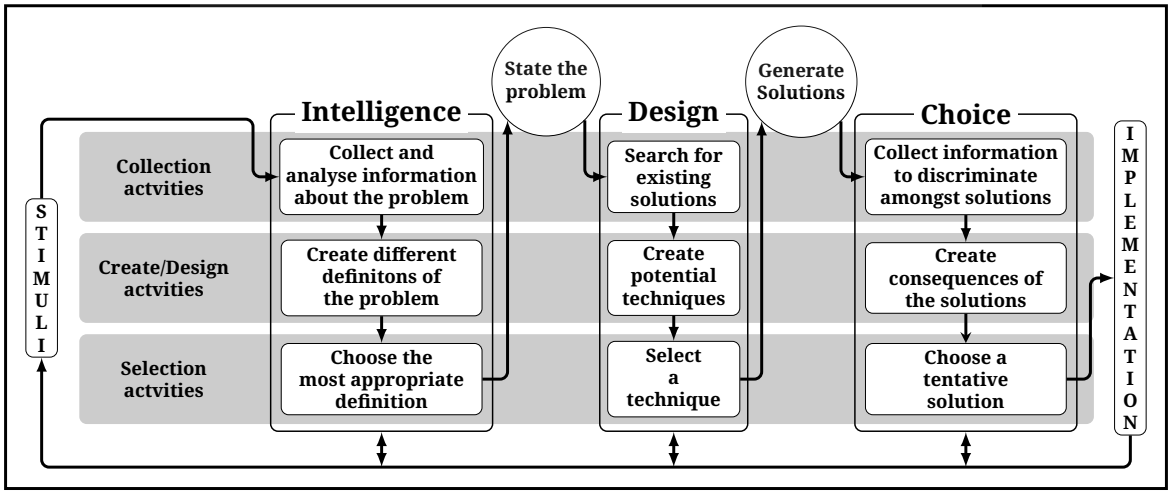

Figure 2.3.: Expanded CPS Model (adapted from **VanGundy** (1988:7)).

The expanded model provided in Figure 2.3 describes the stages of CPS and its sub-stages, but

it does not provide information about the creative process itself. For that purpose **VanGundy** (1988:8) selected the creative steps of Wallis (in **Proctor** 2006:51):

Preparation:
The collection of information about the situation and it corresponds to the Intelligence sub-phase;

Incubation:
Suspension of conscious effort, but it still receives subconscious attention;

Illumination:
The experience when a feasible solution is found, which is considered to be present in all the process sub-stages; and

Verification:
Testing the validity of a solution and making the required refinements to it that is part of the choice sub-stage.

Weisberg (see **Proctor** 2006:51) stated that first of all is Incubation ambiguous and second of all that none of these have any supporting evidence. He believes that conscious mind is creative.

VanGundy (1988:8) stated that all the stages of the creative process are important to the CPS process, but not all of them are fully utilised by the techniques he described. Nearly all of these are weak in terms of incubation, which is substituted by creating many concepts in a short time span. The techniques aimed at individual provide greater opportunity for incubation of ideas.

According to **Proctor** (2006:68) the CPS would consist of nine stages:

1. Scanning an analysing the environment for possible problems;
2. Finding the Objective – determine the problem area;
3. Finding facts - collect information;
4. Finding the problem – specify the problem correctly;
5. Determine and list the applicable assumptions;
6. Finding ideas – create solutions to solve the problem;
7. Idea/solution Evaluation – evaluate and select amongst possible solutions; and
8. Implementation – implement chosen ideas correctly; and
9. Management to make sure the objectives are met after the implementation.

The first five stages correlate to Intelligence stage and its result as in expanded model of **VanGundy** (1988:7). The fifth stage is similar to Design stage of **VanGundy** (1988). The sixth stage is the result of the Choice stage that **VanGundy** (1988) provided. Implementation is again the same as in model in Figure 2.3. **VanGundy** (1988) make no direct mention of management of the solution after its implementation. The sixth stage is the result of the Choice stage that **VanGundy** (1988) No mention is made of feedback from any of the stages to previous stages to serve as stimuli.

The CPS techniques are not fail-safe and would require trade-offs. The results are limited by skills, abilities and motivation. The incorrect or inappropriate use of these techniques could also increase the severity of problems (**VanGundy** 1988:9-10).

The benefits of using the CPS techniques correctly are as follows (**VanGundy** 1988:10-11):

Decreased uncertainty:
most of the CPS techniques reduce the uncertainty by providing more information regarding the problem and it's solutions;

Increased alternatives:
the quality of the solution is improved by the creation of many alternative solutions;

Improved competitiveness:
that comes through the increased alternatives and the new perspectives on the issues, it can also identify new markets;

Reduction of revisions:
will result from the emphasis on analysing issues and creating many alternatives; and

Efficient use of persons:
comes about because most persons utilise only a part of their abilities and CPS can provide new ways of solving problems.

VanGundy (1988:11-14) classified problem solving techniques into five categories: 1) Problem refinement and analysis; 2) Generating ideas; 3) Evaluation and selecting of ideas; 4) Implementation; and 5) Eclectic and miscellaneous techniques. The first four are major steps that would typically be followed in solving a problem. Creative problem solving is applicable where inadequate information is available, the outcomes are indeterminate and routine procedures are insufficient.

Absence of an adequate definition of a problem is a major set back for efficient solution of problems, without it there exists a high probability that a solution will not be found. The initial perception of a problem in general will determine the approach taken to solve it. The first category of CPS techniques consists of methods that are redefinitional or analytical or in same cases both, there is also overlap between the subclasses (**VanGundy** 1988:12).

The CPS techniques for the creation of ideas are typically divided whether they are more suitable for individuals or groups, but this classing is not always absolute. Some of them in either subclass could be modified and adapted to be used in the other. Another distinction can be applied to the items in each subclass: a) Brainstorming and brainwriting; and b) Free association or forced relationships. Brainstorm refers in this case to the verbal creation of ideas and brainwriting refers to creating ideas by means of writing. The former is typical a group method and the latter mostly used by individuals. Both of these is based on either free association, forced relationship or a combination of them. Free association is the creating of ideas without any specific stimulus, the ideas generated could serve as stimuli. In the case of forced relationships a specific stimulus serves as the source for creating ideas, it forces together related or unrelated concepts (**VanGundy** 1988:12-13; **Clark** 2014).

Bao, **Gerber**, **Gergle** and **Hoffman** (2010:1233-1234) researched the efficiency of prompting participants before the brainstorming took place and found that the results provided better solutions. This effectively included forced association prior to the actual brainstorming.

The category of techniques for the selection and evaluation of ideas was not subdivided as more appropriate towards either evaluation or selection as they are in general indiscriminate. The only exception are ones that entail voting, where the evaluation is not formally done (**VanGundy** 1988:13).

To implement ideas **VanGundy** (1988:13) discusses four techniques. Three of them are primarily used to implement moderate to complex solutions. The fourth is aimed detecting the potential negative results of the possible solution alternatives, but it could also be used to assist in the selection of alternatives.

The techniques categorised as being Eclectic and miscellaneous are the ones that do not clearly fit in any of the other categories. Eclectic techniques are the ones that consist partially or fully of two or more other techniques. The miscellaneous techniques incorporate two or more stages of the problem solving process, but do not include components of other techniques (**VanGundy** 1988:13-14).

VanGundy (1988:14) warned about the categorisation of the techniques. The first warning is that if techniques are in the same category they would not necessarily render the same results. This is because the amount of comparative research done on the techniques is very little. The second warning is that through the categorisation a too high emphasis could be placed on the organisation of the techniques.

Proctor (2006) reached the same results on several of the same topics as **VanGundy** (1988).

To select a CPS technique **VanGundy** (1988:17-39) provided guidelines as pertaining to the following stages:

1. Before attempting to solve problem;
2. Analysis and definition;
3. Generation of ideas;
4. Evaluation and selection amongst ideas; and
5. Idea implementation.

The criteria to apply before making an attempt to solve a problem are indicated in Table 2.2.

Table 2.2.: Before attempting to solve a problem (compiled from **VanGundy** (1988:18-21, 36-37))

Step	Action	Guideline
1.	Determine the available information of the gap	The cost of this step must be less than the cost of not bridging the gap
2.	Quantify the gap in real terms	Reliable and valid measurement criteria indicates the existence of a problem
3.	Determine if the problem needs to be solved	The closing of the gap must satisfy a requirement or a value
4.	Determine what resources are available	Without resources now or later it would be fruitless to attempt to close the gap
5.	Determine if your sphere of influence covers the problem	Without any authorisation or approval no attempt can be made to solve it

For the definition and analysis of the problem the applicable criteria indicated in Table 2.3 apply.

Table 2.3.: Definition and analysis criteria (compiled from **VanGundy** (1988:21-26, 37)).

Step	Action	Guideline
1.	Collect and analyse the information about the problem	-
2.	Determine if it is an ill-formed situation	The amount of applicable information available indicates how well the problem is structured or formed.
3.	For problems that are not ill-formed search for and evaluate existing solutions.	-
4.	In the case of an ill-formed problem, determine whether a group or individual approach should be followed to define and analyse it	Select an individual if time is scarce and the acceptance by other stakeholders is not required, otherwise select a group technique. Group techniques could also be selected to develop persons if time is available and acceptance by other stakeholders is not critical.
5.	Pick one or more of the analytical and re-definitional methods.	Justified by the available time and resources, as many as possible methods should be used.
6.	Create alternative definitions of the problem.	-

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Step	Action	Guideline
7.	Choose a tentative definition of the problem.	To avoid conflict over a preferred definition or if there are many definitions that are equally attractive use group methods.
8.	State the selected definition.	-

Table 2.4 indicates the criteria for creating ideas.

Table 2.4.: Idea creation criteria(compiled from **VanGundy** (1988:26-32, 37-38))

Step	Action	Guideline
1.	Search for available current solutions	-
2.	If there is an available current solution to the problem apply it and measure it's success in solving the problem.	If there is time available and the current available solution is not the most effective solution use CPS methods, else use the available one.
3.	Determine if an individual or group approaches would be the most suitable	The criteria are available time and criticality of acceptance by others, sufficient time and low criticality indicates an individual approach.
4.	Choose a group or an individual idea creation method	
	4.1 Determine if the choice is justified by the scope of the problem.	The selected method should be appropriate to the complexity of the problem's scope.
	4.2 Determine if the choice is justified by the difficulty of the implementation.	The selected method should be appropriate to the difficulty of the need to find a solution.
	4.3 Determine if training is required, the choice is justified by difficulty of the problem.	The selected method should be appropriate to the training importance to the need to find a solution.

The criteria for the selection and evaluation of solutions is shown in Table 2.5.

Table 2.5.: Selection and Evaluation criteria (compiled from **VanGundy** (1988:32-36, 38))

Step	Action	Guideline
1.	Determine if a group or individual method should be used to do the evaluation and selection of ideas	-
2.	Search evaluation information pertaining to the solutions.	
	2.1 Determine the availability of resources.	The resources for a particular solution must be available else it cannot be implemented.

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Table 2.5 – continued from previous page		
Step	Action	Guideline
	2.2 Validate the solution against the solution criteria.	-
3.	Choose a group or individual method to evaluate and select solutions 3.1 Establish if time is vital. 3.2 Establish if the difficulty of the implementation would justify the selection.	-
4.	In the case of individual techniques, create and analyse the consequences of the potential solutions; select a provisional solution.	
5.	If group methods are utilised, establish if voting techniques are needed.	It will depend on whether if there is a possibility of unresolvable differences pertaining to the preferred alternative, if it is the case use voting methods, else it is recommended to choose a solution by consensus.
6.	If voting is used, the available resources are used to select the appropriate method.	-
7.	Create and analyse the consequences of the potential solutions; select a provisional solution to implement.	

For the Implementation Phase the steps and criteria are as shown in Table 2.6.

Table 2.6.: Implementation criteria and guidelines (compiled from **VanGundy** (1988:35-36, 39))

Step	Action	Guideline
1.	Using implementation techniques implement the solution when appropriate.	1. Use PERT[1]for complex solutions that require close coordination of activities and events. 2. Use RPDs[2]for less complex solutions. 3. The 5W1H (§2.5.1) method could be used for solutions that do not require the use of structured methods of implementation.
2.	Establish if the problem gap has been bridged.	
3.	If the problem gap has been reduced satisfactorily or removed, the process is complete.	
4.	If there still is a gap, follow the process from the step where the existence of the gap is evaluated.	

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Table 2.6 – continued from the previous page		
Step	Action	Guideline

[1] Program Evaluation and Review Technique
[2] Research Planning Diagrams

§2.5.1. Redefinitional and Analysis Methods

VanGundy (1988:44-67) provides the redefinitional and analysis methods as shown below.

1 Redefinitional Techniques

A summarised description of these techniques are:

a Boundary Examinations

The steps for using this method are (**VanGundy** 1988:43):

1. Compile an initial problem statement;
2. Mark words and phrases and search for potential hidden assumptions;
3. Identify the important impacts that are suggested by them, without validating them; and
4. Compile new problem definitions based on the important aspects.

It provides clarity of problem definition, but does not specify how to assume the boundaries.

b Goal Orientation

It consists of the following steps (**VanGundy** 1988:45; **Mycoted** 2011):

1. Compile a general problem statement, that includes all important information.
2. Determine the following:
   (a) What needs to be achieved? – Needs;
   (b) What is preventing the achievement of the needs? – Obstacles; and
   (c) What are the restrictions that must be accepted to find a solution? – Constraints.
3. Using the determined needs, obstacles and constraints to redefine the original definition.

This is mostly a change management method to create the right attitude, but it could also run out of hand to rationalise on the problem and immediately solve the problem with preconceived methods (**VanGundy** 1988:45).

c Five W's and H

The problem is explored by answering the following questions (**VanGundy** 1988:47):

W1: Who might we …"?
W2: Why might we …"?
W3: In what ways might we …?
W4: Where might we …"?
W5: When might we …"?
H: How might we …"?

This method is very useful to obtain and analyse the problem situation. It can be time-consuming.

d Progressive Abstractions

This method creates alternative definitions of the problem by elevating it to higher levels of abstraction until the definition is satisfactory. To use this method the following steps are executed (**VanGundy** 1988:49):

1 Compile a general problem statement.
2 Create potential solutions in response to the question: "What is essentially the problem?"
3 Use the solutions to create a new problem statement.
4 Repeat steps 2 to 3 until the solution goes beyond current skills and technology resources or it is no longer in the current area of influence of the solver.
5 Choose a satisfactory definition of the problem and start to seek for solutions.

VanGundy (1988:51) states that it provides a systematic method to examine connections and problem substructures, but it could render definitions that are considered too abstract.

e Why Method

Abstraction of the problem definition at the correct level will result in a more broad and complete problem statement. This is similar to "Why Why Why" by **Mycoted** (2006d). This method is one to achieve a more broad and complete problem statement. It consists of the following steps (**VanGundy** 1988:52):

1 Use the initial problem statement;
2 Ask why the problem should be solved;
3 Obtain an answer to the question in step 2;
4 Rephrase the answer as new problem enquiry; and
5 Repeat steps 2 and 3 until a high level of abstraction is achieved.

It is useful for broadening a problem and examining the boundaries, but it could fail early in the process if the answers are inappropriate.

2 Analytical Techniques

The analytical techniques are:

a Decomposable Matrices

The principle of this method is the breaking of a system into a hierarchy of semi-independent subsystems. It is applied to ill structured problems and by applying the following steps (**VanGundy** 1988:55):

1. Determine if the problem can be investigated by examining subsystems;
2. Itemise all the leading subsystems and their parts;
3. Compile a matrix of the subsystems and their parts;
4. Rate, on a five point scale, the magnitude of relationship for the interaction among subsystems and internal to each; and
5. Select the highest rated interactions to analyse further or to create ideas.

According to **VanGundy** (1988:54) can all problems not be broken down into subsystems that can be analysed, the decomposition is also dependent on the skills of the user(s).

b Dimensional Analysis

Five dimensions are examined in the process in an attempt to answer five question about the problem.

VanGundy (1988:56) provides the following steps to use this method:

1. Compile a statement of the problem.
2. Write brief separate statements about the problem in terms of:
   (a) What?
   (b) Where?
   (c) When?
   (d) How much?

(e) How serious?

3. With the separate statements answer the questions in Table 2.7
4. Examine these answers as to the impact of each for obtaining a solution
5. Chose the areas most applicable to the situation and analyse them further.

It forces the user to take into account various dimensions of a problem, but it is based on the assumption that problems are the violation of values, which is not in general valid and the detail of how to analyse a problem is lacking, it is more of an exploratory method than an analytical one (**VanGundy** 1988:58).

c Input-Output

The simplest representation of this method is (**VanGundy** 1988:62):

$$\begin{array}{ccc} & \text{LS} & \\ & \downarrow & \\ \text{IP}_M & \rightarrow & \text{OP}_D \end{array}$$

where OP_D is the desired Output, IP_M is the major input that affects the output and LS is the Limiting Specifications that are imposed on the Output.

Through the consideration of various sequential inputs and outputs it provides valuable information for idea generation, but the amount of work and time to do it can be excessive.

d Organised Random Search

This method is based on breaking down a problem in subdivisions and components. The examining of these could then be utilised to find a direction for the creating of ideas. It consists of the following steps (**VanGundy** 1988:64):

1. Examine the problem for potential ways to subdivide it or to group parts of it; and
2. Record the subdivisions or parts and utilise them to create ideas.

It is less organised than some other analysis methods, but for less complex problems it could be useful.

e Relevance Systems

The core of this approach is to organise information regarding a problem by successive refinements of major elements of the problem. A pyramid structure is constructed by using each element and identifying elements that are connected to them. An organisational chart is a well-known form of this. Relevance Systems can be constructed top-down or bottom-up by starting either at the highest order element or the lowest order elements, it is recommended to do both to ensure the validity of the included elements. The basic steps to construct a "Relevance System" are (**VanGundy** 1988:65-66):

1. Draw the highest order element of the problem – the first level.
2. Derive and draw the next level sub-elements – second level elements.
3. Continue deriving the next level from the current level until all possible ones are obtained and the lowest level reached. The lowest level elements are typical the response to: "How?" and the highest on the other hand to "Why".
4. Assess the validity of the system by rebuilding it from the lowest one to the top.
5. The lower level elements are used as suggestion to potential solutions.
6. If the system overlaps with another area and there is a need to integrate with it, another relevance system is built where the lowest level elements of the two interface, this will be a binary relevance system.
7. Investigate the interface to find points of single or mutual influence and to examine possible limiting aspects that could impact the objectives of either system.

It requires the considering of the constraint of solutions and that could reduce the amount of solution revisions, but it could also be time-consuming.

Table 2.7.: Typical Dimensional Analysis Questions [adapted from **VanGundy** (1988:57).]

Substantive	Spatial	Temporal	Quantitative	Qualitative
1: Do × Don't? 2: Attitude × Actions? 3: Cause × Effect? 4: Passive × Active? 5: Invisible × Visible?	1: Remote × Local? 2: Specific spot(s) in an area? 3: Common × Isolated?	1: Only recent × Long-standing? 2: Current × Impending? 3: Intermittent × Constant?	1: Multiple × Singular? 2: Few persons × Many people? 3: Specific × Common? 4: Simple × Complex? 5: Scarcity × Abundance?	1: Low level × Philosophical? 2: Enrichment × Survival? 3: Primary × Secondary? 4: Which values are compromised? 5: To what extent are the values compromised? 6: Improper × proper values?
'×' means 'versus'				

§2.5.2. Idea Creation Techniques

VanGundy (1988:71-72) provides the following principles that should enhance the creation of ideas:

Postpone judgement:
Early criticism of ideas will reduce the amount of proposals given. Judgement should only be used during the evaluation and selection phases.

Quality through quantity:
This based on the assumption that if five out of hundred is good, then if a thousand is available then fifty good ideas can be expected.

Wilder ideas are better:
Wild ideas can, with modification, lead to breakthrough ideas.

Combine and Improve:
Many ideas on their own could be less worthwhile, but after they are combined with other and somewhat improved they could be very useful.

Do not ponder too long at a time:
Exhaustion reduces people's creativity, and it could useful to move to another problem after some time has been spent on the current one.

Van Wulfen (2013) indicated that a method to follow that leads to good results is to let all participants first write all their ideas on sticky notes and then when that is finished the notes are read to the group to stimulate further generation of ideas. Even if the principles are applied, but the group is large or it takes a long time to get to a participant the results are less useful.

Keeney (2012:306-312) found that focussing on each of the objectives also improved the results of brainstorming.

Half of the idea creation methods that **VanGundy** (1988:72-73) discusses were designed for individual use, but they can easily be adapted for group use. Few of the group methods can, however be modified for use by individuals.

Brainwriting as opposed to brainstorming entails the writing of ideas on paper. It is useful, especially in large groups as it allows for the complete capturing of everyone's ideas (**Proctor** 2010).

All the idea generation methods that **VanGundy** (1988:73-75) discusses are either brainstorming or brainwriting types. The latter ones are silent creation of ideas in writing, while the other ones are verbal of nature. He also states that the brainstorming definition is more generic than the technique called Classic Brainstorming. Brainwriting type of methods are in general used by individuals. Brainstorming is only useful in small groups and brainwriting is the recommended approach for large groups. Brainwriting can be conducted without a facilitator.

The idea generation methods have two dimensions:

1. The procedure dimension: Forced relationships or Free Association; and
2. The stimulus dimension: Related or Unrelated stimuli.

Forced relationship is based on the forced combination of two or more concepts to produce ideas, whereas in free associations the creation is based on the current knowledge that includes experience and observation to create ideas. The relatedness of the stimuli determines the uniqueness of the ideas created. Both types of stimuli may be present in some techniques. Related stimuli are also useful and may be the best approach to some problems and groups (**VanGundy** 1988:76).

In Table 2.8 are shown the techniques that **VanGundy** (1988:77) deemed as individual ones with their characteristics in terms of being of forced relations (FR) or free association (FA) as well as the type of stimulus used as related stimuli (R) or unrelated stimuli (UR). *As these techniques are similar apart from these differences and where the stimuli are obtained from, the detail will not be provided.*

Table 2.8.: Individual Techniques and their characteristics(**VanGundy** 1988:77)

Technique	Procedure		Stimulus	
	FR	FA	R	UR
Assumption Reversals		✓	✓	
Attribute Analogy Chains	✓		✓	✓
Attribute Association Chains	✓	✓	✓	✓
Attribute Listing		✓	✓	
Bionics	✓			✓
Catalogue	✓			✓
Checklists		✓	✓	
Circumrelation	✓		✓	
Clichés, Proverbs, and Maxims	✓			✓
Creative Visualisation	✓	✓		✓
Exaggerated Objectives	✓	✓	✓	
Focused-Object	✓		✓	✓
Free Association		✓	✓	
Fresh Eye		✓	✓	
Heuristic Ideation Technique	✓		✓	
Hypothetical Situations	✓			✓
Listing	✓		✓	
Metaphors	✓			✓
Modifier-Noun Associations	✓	✓		✓
Morphological Analysis	✓		✓	
Non-logical Stimuli	✓			✓
Product Improvement Check-list	✓			✓
Relational Algorithms	✓		✓	
Reversals	✓		✓	

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Technique	Procedure		Stimulus	
	FR	FA	R	UR
Story writing	✓	✓	✓	✓
Symbolic Representations	✓	✓	✓	✓
Two Words	✓		✓	
Wishful Thinking		✓	✓	
Word Diamond	✓		✓	

For the group techniques shown in Table 2.9 **VanGundy** (1988) also showed whether it's a Brainstorming (BS) or Brainwriting (BW) type of method.

Table 2.9.: Group Techniques and their characteristics(**VanGundy** 1988:78)

Technique	Method		Procedure		Stimulus	
	BS	BW	FR	FA	R	UR
Batelle-Bildmappen-Brainwriting	✓	✓	✓	✓	✓	✓
Brain sketching		✓	✓		✓	
Brain writing Game	✓	✓		✓	✓	
Brain writing Pool		✓		✓	✓	
Classical Brainstorming	✓			✓	✓	
Component Detailing	✓	✓	✓		✓	
Collective Notebook		✓		✓	✓	
Crawford Slip Writing		✓		✓	✓	
Force-Fit Game	✓		✓			✓
Gallery Method		✓		✓	✓	
Games	✓		✓	✓		✓
Gordon/Little	✓			✓	✓	
Greeting Cards	✓		✓			✓
Method 6-3-5	✓			✓	✓	
Phillips 66	✓			✓	✓	
Pin Cards		✓		✓	✓	
Problem Inventory Analysis	✓			✓	✓	
Role storming	✓			✓	✓	
Sculptures	✓		✓			✓
Semantic Intuition	✓		✓		✓	
Sequence-Attribute Modifications Matrix	✓		✓		✓	
Successive of problem Elements (SIL) Method	✓		✓		✓	
Stimulus Analysis	✓		✓			✓
Storyboards	✓			✓	✓	
Super Group®	✓			✓	✓	
Super Heroes	✓		✓			✓
Synectics	✓		✓	✓		✓
Systematised Directed Induction		✓		✓	✓	
Trigger Method	✓	✓		✓	✓	
Visual Synectics	✓		✓			✓
Wildest Idea	✓			✓	✓	

§2.5.3. Advantages and Disadvantages of the idea-generation methods

The combined advantages (A.nn) and disadvantages (D.mm) of the techniques as given by **Van-Gundy** (1988:82-202) are as follows:

Advantages:

A.01 Can create innovative ideas.
A.02 Can generate unique ideas.
A.03 Can overcome personal inhibitions.
A.04 Can prompt useful solutions.
A.05 Creates stimuli.
A.06 Detailed approach.
A.07 Documented in research.
A.08 Easily computerised.
A.09 Easy to use.
A.10 Force consideration of new constraints.
A.11 Force thinking of overlooked associations.
A.12 Forces separation of solving stages.
A.13 Good problem focus.
A.14 Has been widely used.
A.15 Low cost.
A.16 May produce practical solutions
A.17 No prior training method needed.
A.18 Overcomes perceptual constraints.
A.19 Period of idea incubation.
A.20 Produce large number of ideas.
A.21 Promotes member participation
A.22 Provides new problem perspectives.
A.23 Provides visual stimulation.
A.24 Quick structured process.
A.25 Reduced interference from other.
A.26 Reduces domination.
A.27 Sense of anonymity.
A.28 Structured approach.
A.29 Used with success in formal analogies.
A.30 Useful in any stage of problem solving.
A.31 Wide scope.
A.32 Writing rather than talking.
A.33 Enjoyable.
A.34 Avoids locking on obvious solution.
A.35 A practical method.
A.36 More opportunity for participation.
A.37 Suitable for large groups.
A.38 Fast.
A.39 Less inhibiting.
A.40 Looks at problem processes.
A.41 Combines rational and intuitive.

Disadvantages:

D.01 Can expand out of hand.
D.02 Can get distracted by unrelated detail.
D.03 Competitiveness may create hostility.
D.04 Could be difficult to use.
D.05 Depends on individual perceptions.
D.06 Does not always work.
D.07 Easily misused.
D.08 Factors may be overlooked.
D.09 Insufficient on its own.
D.10 Insufficient time to digest ideas.
D.11 Less unique solution.
D.12 Limited characteristics.
D.13 Limited for large amount of factors.
D.14 Loss of spontaneity.
D.15 Low number of solutions created.
D.16 May be limited by similarities.
D.17 May be dominated.
D.18 May have less stimulative value.
D.19 Maybe unclear distinction from original.
D.20 Minimal story writing ability needed.
D.21 Needs skilled leader.
D.22 Relatively simple solutions.
D.23 Requires a lot of attention.
D.24 Requires a lot of time.
D.25 Requires a positive creative climate.
D.26 Requires adherence to guidelines.
D.27 Requires further analysis.
D.28 Requires a highly trained facilitator.
D.29 Requires participant training.
D.30 Requires practise.
D.31 Requires specific knowledge.
D.32 Requires various stimuli to be useful.
D.33 Scope: only biological analogies.
D.34 Silence might be inhibiting.
D.35 Solutions less practical or unrealistic.
D.36 Some might feel inhibited.
D.37 Unnatural to defer judgement.
D.38 Unstructured.
D.39 May be perceived as hurried.
D.40 Distracted by presence of other.
D.41 Some cannot use it productively.
D.42 May be perceived as useless.
D.43 Ideas get duplicated.
D.44 Time limitation can be restrictive.
D.45 Not designed to create ideas.
D.46 Costly.
D.47 Feedback to soon could limit it.
D.48 Relies on individual ideation.
D.49 Logistics.
D.50 Can be difficult integrate ideas.

VanGundy (1988:82-202) rated the idea creation methods in terms of the above advantages and disadvantages as indicated in Table 2.10.

Table 2.10.: Evaluation of Idea Creation Methods (**VanGundy** 1988:82-202)

Name	G/B	Advantages	Disadvantages
Analogies	B	**A.07**, **A.29**, **A.02**, **A.18**, **A.22**	**D.04**, **D.30**, **D.26**
Assumption Reversals	B	**A.22**,**A.09**	**D.04**
Attribute Analogy Chains	B	**A.05**	**D.16**, **D.18**
Attribute Association Chains	B	**A.02**, **A.05**	**D.25**
Attribute Listing(AL)	B	None mentioned.	**D.02**, **D.12** **D.01** **D.19**
Batelle-Bildmappen-Brainwriting	G	**A.03**, **A.05**, **A.02**	**D.36**
Bionics	B	**A.22**, **A.14**	**D.04**, **D.31**, **D.04**
Brain sketching	G	**A.23**, **A.26**	**D.34**
Brain writing Game	G	**A.26**, **A.17**	**D.03**, **D.24**
Brain writing Pool	G	**A.25**, **A.27**	**D.14**, **D.09**
Catalogue	B	**A.02**, **A.01**	**D.04**
Checklists	B	**A.09**	**D.09**
Circumrelation	B	**A.24**, **A.09**	**D.13**,**D.11**
Classical Brainstorming	G	**A.07**, **A.20**, **A.05**, **A.20**	**D.30**, **D.22**, **D.37**, **D.31** , **D.07**, **D.10**, **D.21**
Clichés, Proverbs, and Maxims	B	**A.02**, **A.05**	**D.32**,**D.11**
Collective Notebook (CNB)	G	**A.19**, **A.05**, **A.27**	**D.26**, **D.27**, **D.09**
Component Detailing	G	**A.22**, **A.21**	**D.11**
Crawford Slip Writing	G	**A.20**, **A.38**, **A.37** (any), **A.11**	**D.49** , **D.48**, **D.47**
Creative Visualisation	B	**A.02**,**A.20**	**D.30**, **D.06**, **D.29**
Exaggerated Objectives	B	**A.22**	**D.11**
Focused-Object	B	**A.16**, **A.02**	**D.32**
Force-Fit Game	G	None mentioned.	None mentioned.
Free Association	B	**A.16**	**D.26**, **D.11**
Fresh Eye	B	**A.22**, **A.02** (Specific variation), **A.31**	**D.38**
Gallery Method	G	**A.32**, **A.20**	**D.39**, **D.40**
Games	G	**A.33**, **A.05**	**D.41**, **D.25**
Gordon/Little	G	**A.34**, **A.02**	**D.21**, **D.31**, **D.38**
Greeting Cards	G	**A.33**, **A.02**	**D.42**
Heuristic Ideation Technique	B	**A.20**, **A.31**	**D.04**, **D.08**,**D.11**
Hypothetical Situations	B	**A.10**, **A.22**, **A.09**	**D.11**
Listing	B	**A.13**	**D.01**, **D.15**, **D.09**
Metaphors	B	**A.02**	**D.04**, **D.30**, **D.29**
Method 6-3-5	G	**A.35** (v1), **A.26**	**D.43**, **D.44**, **D.14**
Modifier-Noun Associations	B	**A.02**, **A.20**	**D.04**
Morphological Analysis	B	**A.09**, **A.06**, **A.30**, **A.08**, **A.12**	**D.04**, **D.01**, **D.09**, **D.31**, **D.11**
Non-logical Stimuli	B	**A.02**	**D.30**, **D.09**
G=group B=Group and Individual			

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Table 2.10 – continued from previous page			
Name	**G/B**	**Advantages**	**Disadvantages**
Phillips 66	G	**A.36**, **A.37**	**D.38**, **D.41**, **D.04**
Pin Cards	G	**A.32**	**D.39**, **D.36**, **D.36**
Problem Inventory Analysis	G	**A.01**	**D.45**, **D.11**, **D.24**
Product Improvement Check-list	B	**A.05**, **A.02**, **A.20**	**D.04**, **D.25**, **D.46**
Relational Algorithms	B	**A.11**, **A.20**	**D.04**, **D.23**
Reversals	B	**A.15**	**D.06**
Role storming	G	**A.20**, **A.09**, **A.22**, **A.39**, **A.05**	**D.11**, **D.09**
SIL Method	G	**A.26**,**A.32**	**D.50**, **D.11**, **D.14**
Sculptures	G	**A.02**	**D.42**, **D.41**
Semantic Intuition	G	None mentioned.	**D.04**, **D.41**, **D.11**, **D.09**
Sequence-Attribute Modifications Matrix	G	Same as AL, **A.40**	**D.11**
Stimulus Analysis	G	**A.09**, **A.05**	**D.16**, **D.31**
Story writing	B	**A.05**, **A.16**, **A.22**	**D.20**
Story boards	G	**A.23**, **A.09**, **A.13**	**D.28**, **D.17**, **D.18**
Super Group®	G	**A.41**	**D.28**, **D.48**
Super Heroes	G	**A.05**	(BS) + **D.38**
Symbolic Representations	B	**A.02**, **A.31**	**D.04**, **D.38**
Synectics	G	None mentioned.	None mentioned.
Systematised Directed Induction	G	None mentioned.	
Trigger Method	G	None mentioned.	None mentioned.
Two Words	B	**A.22**, **A.02**,**A.24**	**D.32**
Visual Synectics	G	None mentioned.	None mentioned.
Wildest Idea	G	None mentioned.	None mentioned.
Wishful Thinking	B	**A.22**	**D.06**, **D.35**
Word Diamond	B	**A.09**, **A.16**, **A.15**	**D.11**
G=group B=Group and Individual			

Several of these techniques are described by other authors as processes to follow, but they do no analyse them in terms of their advantages and disadvantages.

§2.5.4. Evaluating and Selecting Ideas

The following techniques are provided by **VanGundy** (1988:211-250) for selecting an alternative amongst generated ideas:

1 Individual Techniques:

The individual techniques are:

a Advantage-Disadvantage

This basic method involves examining of the strengths and weaknesses of each alternative and selecting the one that best solves the problem. In one application of this method each alternative is examined on its own and accepted or rejected based its advantages and disadvantages.

b Creative Evaluation

This technique is simple and was developed to provide a structured method to evaluate

the results of brainstorming. It can also be used by managers to quickly do screening when confronted with a large set of ideas (**VanGundy** 1988:218).

The brainstorming group follows the following process:

1. A list is compiled of the ideas resulting from the brainstorming session;
2. The ideas are each then categorised with each idea in one of the following ways, by marking them with Roman numerals:
   2.1. Simple for ones that require minimal resources to implement;
   2.2. Hard for those that require slightly more resources; and
   2.3. Difficult when they require the greatest amount of resources.
3. Management is then presented with the idea categories for further evaluation.

c Decision Balance Sheet

This method consists of the analysing of each alternative in relation to four classes of expected consequences(**VanGundy** 1988:220):

1. Tangible Gains and Losses
   (a) For Self. This class contains all the likely results expected by an individual if the alternative is selected.
   (b) For Others. In this area are the goals towards significant other persons.
2. Approval or Disapproval.
   (a) Self. In this area all feelings a person would expect to experience if this alternative is chosen are recorded.
   (b) Social. The feelings that are expected to be experienced by significant other people are captured in this area.

d Disjointed Incrementalism

This evaluation method was developed to assist in deciding on social policy changes. It should also be useful when the decision involves complex policy decisions and vaguely defined, changing objectives. In cases where the objectives are clearly defined and somewhat constant and the amount of alternatives is limited another selection method should be utilised (**VanGundy** 1988:223-224).

Decisions are made based on trade-offs between incrementing two different aspects. The approach of analysis of gaps between the status quo and a desired state will not work since the gap is unstable and it's unlikely that other people involved in the process of policy making will agree on the values assigned to the different alternatives. This process does not evaluate whether one alternative is better than another. It is focussed on whether an increment in one area is desirable and if it can be balanced against an increment in another area. **VanGundy** (1988:225) gives the example when it is not the intent to determine whether security is more important than liberty, but how much liberty would be surrendered for improved security.

e Highlighting

This is a comparatively effective evaluation and selection method, where "hits" are combined into "hotspots" that can be modified into useful solutions. The following steps can be followed by groups or individuals (**VanGundy** 1988:232; **Mycoted** 2006b):

1. A list of merely numbered ideas is reviewed and any that seem interesting or challenging are marked – "hits". The selection is done with disregard to their usefulness.
2. Combine all the related hits, these combinations are referred to as "hotspots."
3. Investigate each hotspot and determine what it represents. These representations can address general meanings, significance, and potential impacts of each.
4. The hotspot that meets the requirement for the problem is selected. This is the

solution. Two or more hotspots can be combined to produce a final solution, if required.

f Simulation

This method involves the testing of a suggested solution on the problem by simulation of its effect on a model of the problem under consideration. It also recommended that a small scale field test should be conducted after the determination of the best solution with this method if the time and cost permits it. The process follows the following steps (**VanGundy** 1988:242):

1. Determine the objective to solve the problem objectives, investigating what the preferred solution should be if the problem is synthesised;
2. Model the problem situation, the closer it approximates the problem situation the better;
3. Determine criteria that are to be met if the problem has been solved, for instance a check list of expected results;
4. Each suggested solution is then applied to the model and its impact evaluated;
5. Choose the suggested solution that complies the best with the criteria.

g Weighting Systems

This method assign weights to the different criteria used to evaluate the final set of solutions. It ensures that more important aspects receive more emphasis during the evaluation. A typical procedure to use this method are as in the following steps (**VanGundy** 1988:248-249):

1. A table is constructed with columns for each alternative plus two more.
2. The first column is called "Criteria" and the second "What it should be". The rest of the column is for each alternative.
3. The column of each alternative is subdivided into two, one for "What it is" and one for "Subtotal"
4. The column for the criteria is filled with the evaluation criteria.
5. Numeric rates for each criterion is assigned in the second column, for instance on a scale of one to seven, one for "Not Important" up to seven for "Very Important".
6. Each alternative is then assigned a rating in terms of its compliance to each the criterion, also on the same scale as for the second column, under the heading of "What it is".
7. The "Subtotal" column of each alternative is assigned the value of its compliance multiplied by the value of the 2^{nd} column.
8. Each "Subtotal" column of each alternative is added up.
9. Using the total scores of all alternatives a decision can be made on the best option to select.

2 Group techniques with abundant time available:

In the situation where a group has abundant time the following techniques can be used:

a Castle Technique

VanGundy (1988:217) provides the following steps for the group leader to follow this process:

1. Set a specific amount of time for the process, an hour should normally be enough;
2. The group is informed that only three criteria is to be used for the evaluation of each idea:
   - Acceptability as the extent to which an idea satisfies the requirements;
   - Practicality as the extent to which an idea meets previously set financial and time constraints; and

- ▶ Originality as the extent to which an idea makes a significant advancement and provides an elegant resolution of the problem.

3. Very idea listed is to be numbered. Each group member gets the same number of votes as there are ideas. Group members then vote for each idea with either a yes or a no vote. Votes may not be accumulated to use on a favourite idea.
4. Conduct the voting by highlighting each idea in turn and the group members vote either yes or no for it. It's not permitted to discuss the ideas.
5. Indicate the two ideas that accumulated the biggest number of votes and ask the members to unify these two into one idea.

b Goalstorming

This process is the combination of goal setting and brainstorming. It is intended to be used when some parties have a vested interest in a specific issue which makes it difficult in establishing consensus. It consists of the following steps (**VanGundy** 1988:230):

1. Describe the main organisation objective.
2. List the subordinate goals related to the main objective.
3. Subdivide the secondary goals.
4. All the subdivided goals are ranked using the "more-or-less" technique.

c Idea Advocate

The steps for this process are (**VanGundy** 1988:233):

1. The group is provided with a list of ideas, which it typically has generated.
2. Advocates are appointed.One person may advocate more than one solution.
3. When the advocate's solution is discussed, he will explain why it should be chosen.
4. After the advocates have given their presentations, the ideas and presentations are discussed and the one that shows the most potential as a solution is selected.

d Panel Consensus

(Also discussed by **Mycoted** (2007a))

The ideas are screened progressively by a series of panels through five stages. This method seems to be useful when an organisation wants to solve an ill-structured problem with an efficient evaluation process, but it also requires commitment from its members to utilise it and devotion of time and resources. The process follows the following steps (**VanGundy** 1988:234-236, 240; **Mycoted** 2007a):

1. **Ideate:** People with at least some knowledge of the problem under consideration separately look at it and create suggested solutions for at least 24 hours.
2. **Screen:** The created suggestions are randomly given to a group of fifteen screening committees.
3. **Select:** Three selection committees are utilised to further reduce the number of ideas.
4. **Refine:** Suggestions are at this stage reviewed by a single committee of upper-level managers.
5. **Decide:** Suggested concepts are at this stage reviewed by a single committee of top organisational managers.

e Reverse Brainstorming

Reverse Brainstorming, also referred to as Negative creativity or the Tear-down method, was created as a group method with the intent to determine all possible weaknesses of an idea or anticipating what might fail when a suggested solution is implemented. It is the same as Classical Brainstorming, except that criticisms rather than solutions are created, it's not restricted to be utilised only with Classical Brainstorming (**VanGundy** 1988:240-241).

The steps involved in applying this method are

1. A team of six to twelve persons is compiled, which in general are the same ones who generated the suggestions;
2. First the purpose of the solution is reviewed;
3. The purpose and the list of suggestions that need to be evaluated are displayed;
4. The members criticise the first suggestion to the group leader;
5. The process is continued for each suggestion on the list; and
6. Classical Brainstorming processes, or other idea creation methods, are used to create solutions to the identified weaknesses.
7. The suggestion that has the lowest number of weaknesses and that will most probably solve the problem is selected to implement.

f SPAN Voting

This is a computer based numerical rating method that pools the individual judgements and synthesises group decisions. Participants can vote for the options under review or give other members, who they judge to be better equipped to make a decision, proxy on part of their votes. The computer programme initially only redistributed the equal amount of votes as designated by each participant, subsequent versions allowed uneven amounts to start with and later also added the possibility for a participant to add weights to each judgement made (**VanGundy** 1988:243).

g Delphi Technique

The detail of the basic steps of the process are (**VanGundy** 1988:324):

1. Create the Delphi question (problem statement).
2. Choose and contact the participants.
3. Choose the sample size.
4. Repeat the following at least three times:
   (a) Create and distribute questionnaire, incorporating the result of the analysis of the previous round.
   (b) Analyse responses to questionnaire
5. Develop the final report and distribute to all stakeholders.

The incorporation of the results after analysing the responses to a questionnaire are done without disclosing its origin.

3 Group techniques with limited time available:

In the case where a group has limited time the following techniques can be applied:

a Advantage-Disadvantage

The same steps are followed as for the individual technique that is described above.

b Electronic Voting

VanGundy (1988:229-230) indicated that this process was developed at the Batelle Institute in Frankfurt, Germany, to reduce the inefficiencies that follow after the generation of ideas, by using an electronic voting device. It follows the following process:

1. A pool of previously created ideas are discussed by the group;
2. Each member is given a nine-button terminal that with a visual display screen.
3. To vote, the members each rate every idea by pushing one of the buttons. The buttons correspond to rating scale, with 1 indicating minimal or zero value and 9 a very high value.
4. The voting results are displayed on the screen in table form for each response option. An idea may get three 9 votes, one 8 votes, two 7 votes, and so forth.

5. The distribution from the vote totals is examined to determine any potential inconsistencies. If inconsistencies are detected, the group should discuss the potential reasons. After the discussion, voting is again conducted. The resulting distribution is again investigated, if there are no inconsistencies, the process moves to the next idea; if inconsistencies are still present, the process of discussion and voting is repeated. If the initial vote shows no inconsistencies, the next idea is immediately considered.
6. Steps 3. through 5. are repeated for every idea. After voting on all ideas have been completed, the ones with the highest ratings are selected for utilisation or further investigation.

c Highlighting

The process is the same as described above in the case of use by individuals, only conducted in a group.

d Sticking Dots

This method entails voting for an idea by sticking a 'dot' on it. The dots could be any form self-adhesive and the shape is not limited to being round.

e Weighting Systems

This method is the same as in the individual case described, only the weights are now determined by a team and averaged afterwards.

f Nominal Group Technique

This method is more than a selection method.

§2.5.5. Implementing Ideas

In this area of the Creative Problem Solving approach **VanGundy** (1988) presents the following methods to implement solutions:

1. Consensus Mapping (**VanGundy** 1988:257-260)
   In this method consensus is reached through drawing of 'strawman' maps in which each subgroup depicts the sequence of activities and estimated time frames to implement an idea or a combination of ideas.
2. Potential Problem Analysis (**VanGundy** 1988:260-266; **Mycoted** 2007b)
   This method is a risk analysis method to determine the importance of risks and the abatement thereof.
3. Program Evaluation Review Technique (**VanGundy** 1988:266)
   This a standard project management technique that evaluates the critical path(s) of an implementation process.
4. Research Planning Diagram (**VanGundy** 1988:280)
   This is a process flow method with expected time values attached to each step of the process. If a process exceeds the associated time value the total process can either be re-planned or aborted if it seems that it will not be successful, depending on the progress at the specific hold point in the flow diagram.

The processes are all valid management tools for implementation, typically used in project management. They are, however, suggested as the direct follow-up of the selection of the most suited idea or set of ideas to solve a problem. In some cases, an idea might be merely implemented, but in general it would require development of the detail of the idea to be in a position to implement it and there is not a clear indication of this as a requirement in the approach depicted by ***VanGundy*** *(1988).*

Several other approaches could also be followed that would assist in the management of the

implementation of ideas. It is also not clear how these selected techniques contribute specifically to the creative solving of problems or why other methods would not also suffice.

§2.5.6. Eclectic and Miscellaneous Techniques

VanGundy (1988:287) classified fourteen methods as being either eclectic or miscellaneous. The eclectic methods combine two or more techniques and the miscellaneous ones combine stages of problem solving into one.

The techniques are shown in Table 2.11.

Table 2.11.: Distinction of eclectic and miscellaneous techniques (from **VanGundy** (1988:267))

Eclectic Techniques	Miscellaneous Techniques
1. Bobele-Buchanan, 2. Coca-Cola, 3. CPS, 4. Lateral Thinking, 5. Value Engineering (VE),	1. Decision Seminar, 2. Delphi, 3. The Idea Generator, 4. Idea Tracking, 5. Kepner-Tregoe, 6. Nominal Group Technique (NGT), 7. Packcorp Scientific Approach (PakSA), 8. Phases of Integrated Problem Solving (PIPS), 9. Problem Centered Leadership (PCL),

§2.6. Systematic Innovation Processes for physical items

§2.6.1. Introduction

In this section the innovation process developed by **Altšhuller** (1998) will be examined. In business and management physical products and systems are what is rendered to the customers. This research is not aimed at innovation of products and systems supplied to customers. The reason why this is included in this research is because this set of processes is generalised and expanded by **Mann** (2007a) as examined in §2.8. In the next chapter the generalisation will be investigated.

§2.6.2. TRIZ

TRIZ is the translated acronym of the Russian words *(Teoriya Resheniya Izobretatelskikh Zadatch)*" (**McMunigal**, **Ungvari**, **Slocum** and **McMunigal** 2006:613; **Altšhuller** 1998:39; **Fey** et al. 2005:7) that means Theory of the Solution of Inventive Problems). This is the set of innovation methods developed by Genrich Altšhuller (1926-1998) over a number of years on the basis of analysing patents to determine the method of innovation and the evolution of technical systems.

McMunigal et al. (2006:613) states that through the analysis of the patents Altšhuller found that for certain type of problems certain types of solutions worked. From this he initially developed three innovative/inventive perspectives:

1. 39 Typical engineering parameters,
2. The contradiction matrix, and

3. 40 Inventive principles [see Altšhuller's 40 Inventive principles on in Appendix A page A.1 for an abbreviated list].

The second contribution to scientific and systematic innovation made by Altšhuller is the laws of technological evolution. He initially produced eight major tendencies and through contributions from other people it has been expanded with more than 400 "sublines" (**McMunigal** et al. 2006:613).

TRIZ consists of three phases to achieve Systematic Innovation, as shown (**Yan**, **Zanni-Merk**, **Cavallucci** and **Collet** 2014:176)):

1. Problem Formulation;
2. Determination of an abstract solution; and
3. Interpretation of the abstract solution to obtain a Specific Inventive Solution.

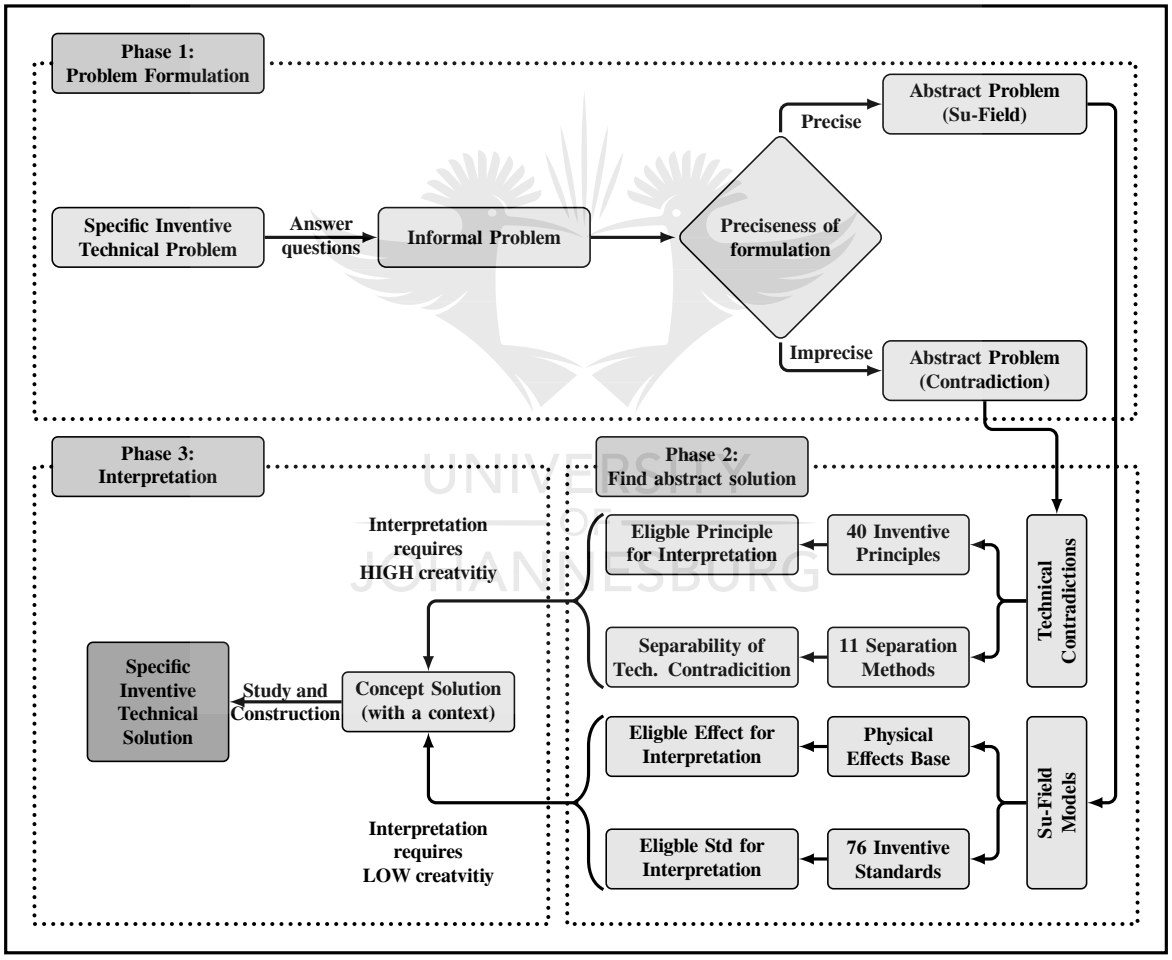

Figure 2.4.: Phases of TRIZ (based on **Yan**, **Zanni-Merk**, **Cavallucci** and **Collet** (2014:176)).

One aspect to highlight at this stage is that it starts with a "Specific Inventive Technical Problem" and terminates with "Specific Inventive Technical Solution", as depicted in Figure 2.5.

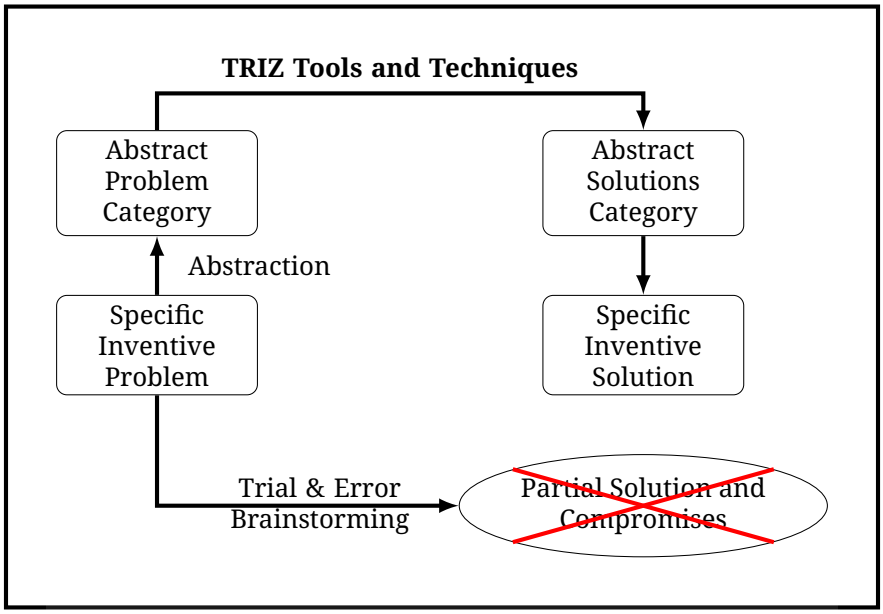

Figure 2.5.: Solution determination by the TRIZ Process (redrawn from **McMunigal**, **Ungvari**, **Slocum** and **McMunigal** (2006:619)).

The general approach of TRIZ to determine a solution is abstraction. The specific problem is described as a more generic problem. By application of the TRIZ tools and techniques a generic abstract solution is found, which is then made into a specific solution for the specific problem. This shown in Figure 2.5. **McMunigal** et al. (2006:619) contrasts it with Trial-and-Error and Brainstorming, which apparently will only render partial solutions or compromises.

The major methods of TRIZ are (**Altšhuller** 1998; **Gadd** 2011):

1. 11 Separation Methods (**Gadd** 2011:120-128)
2. 40 Inventive Principles (**Altšhuller** 1998:148-174)
3. 76 Inventive Standards (**Gadd** 2011:405-418)
4. Contradiction Matrix (**Gadd** 2011:472)
5. Evolutionary Trends (**Gadd** 2011:245-283)
6. Ideality (**Gadd** 2011:198-220)
7. Physical Effect Database (**Altšhuller** 1998:309-314)
8. Smart Little People (**Gadd** 2011:15-17)
9. Su-Field Models (**Altšhuller** 1998:48-70)

Table 2.12.: Summary of major methods of TRIZ (**Altšhuller** 1998; **Gadd** 2011).

Method	Summary
11 Separation Methods	Methods to resolve physical contradictions by for instance removing them in time and space.
40 Inventive Principles	Methods to solve technical problems
76 Inventive Standards	Combination of the 40 principles with natural phenomena.
Contradiction Matrix	A matrix of physical contradictions with suggested inventive principles to resolve them.
Evolutionary Trends	A set of observed technological trends that can be used to improve systems.
Ideality	Maximal utilisation of resources.

Continued on the next page...

Continued from the previous page	
Method	Summary
Physical Effect Database	The application of certain physical effects and phenomena to solve problems.
Smart Little People	Use of imaginary little people to solve a problem and avoid psychological inertia.
Su-Field Models	Direct problem solving with the 76 Inventive Standards.

§2.7. Management Innovation

According to **Chang** (2016:265) management innovation is seen as the creation and implementation of the following management aspects:

- Practice(s);
- Process(es);
- Structure(s); or
- Technique(s)

that is new to current best practice and with the purpose to advance the goals of the organisation. Organisations benefit from this through improving their performance and competitive position in the long-term.

§2.8. Generalisation of TRIZ for Business and Management

Mann (2007a:1-552) published a generalisation of the TRIZ approach for business and management.

§2.8.1. Overview and Frame of Reference

§2.8.1.1. Philosophy

Mann (2007a:4) bases his approach on the following philosophical principles:

1. The number of different problem types are small;
2. A similar solution to the problem at hand has already been found;
3. Inventive solutions can only be created with a few strategies;
4. The evolution trends of systems can be predicted;
5. The most powerful solutions to problems turn the undesired or adverse components of a system into useful assets;
6. The most powerful solutions actively seek out and destroy the conflicts and compromises that are considered fundamental by most design approaches.

The first two principles are demonstrated in Figure 2.6. **Mann** (2007a:6) stated that this is the first task of systematic innovation, to find a similar problem.

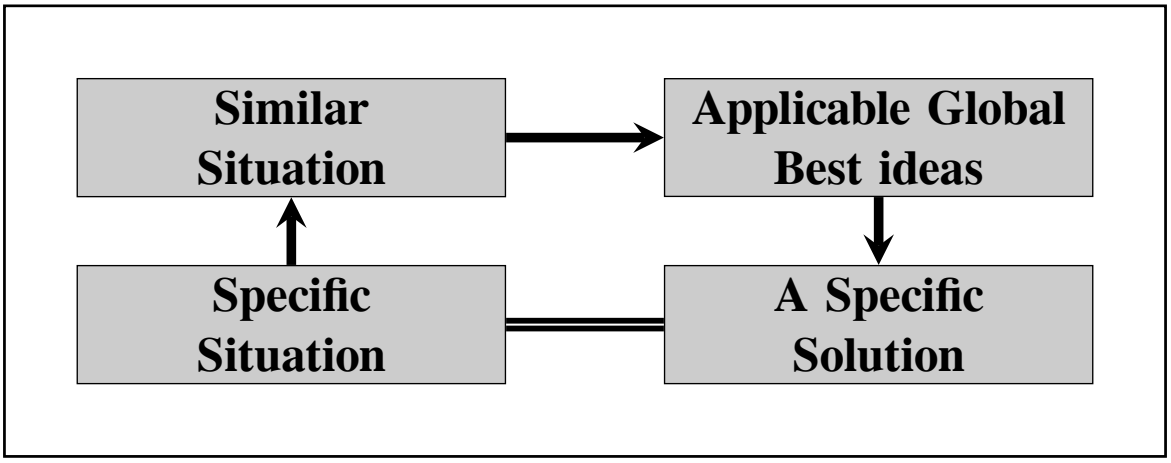

Figure 2.6.: Abstraction principle [redrawn from **Mann** (2007a:5)]

Mann (2007a:6-11) stated that a systematic innovation framework stands on seven pillars:

1. Ideality

A solution to a problem should be an improvement to the current status. It is conceptually the following:

$$\text{Ideality} = \frac{\sum \text{Actual and perceived benefits}}{\sum \text{Costs and harmful aspects}}$$

Or:

$$0 < \frac{d\sum \text{Actual and perceived benefits}}{d\sum \text{Costs and harmful aspects}}$$

The concept is as illustrated in Figure 2.31. It is also considered the moving from one s-curve to another, where the new one is on a higher level than the current one.

2. Contradiction

By solving contradictions rather than accepting compromises and trade-offs, the flattening at the top of the S-curve can be avoided or overcome.

3. Functionality

Functionality has the following perspectives:

a. A system has a Main Utility Function (MUF) and any component that does not aid to the fulfilling of the MUF is considered harmful. A system may have several other useful functions, all contributing to the benefits of the system.
b. Function mapping must also identify relationships that are conflicting, contradicting, inefficient, extravagant, adverse or absent.
c. Functionality also serves as a means to share knowledge in an organisation. Analysis and categorising of knowledge by function help to compare functions across organisations. The idea is that solutions create change, but the function should not be affected.

4. Resources

The maximised utilisation of everything that a system contains is emphasised. Every part that is not completely utilised is considered a resource. Discovery of resources show potential improvements, these include negative resources.

5. Space, Time, and Interface
The perspective to a problem should continuously be changed during the seeking of a solution. It entails changing from micro to macro level and vice versa on the aspects of space, time and interfaces. This overcomes psychological inertia which prohibits creative thinking.

6. Recursion
This principle relates to self-similarity in systems. It is apparent in the recurrence of high-level system viability characteristics in the associated subsystems. The other appearance of this perspective is in the evolving of systems from one s-curve to the next when the cycle of increasing-decreasing complexity is repeated in the evolved system.

7. Emergence
Complex objects or systems emerge very simple principles and base rules. The implication is an organisation cannot produce results that contradict its core principles and base rules.

§2.8.1.2. Distinguishing Success and Failure

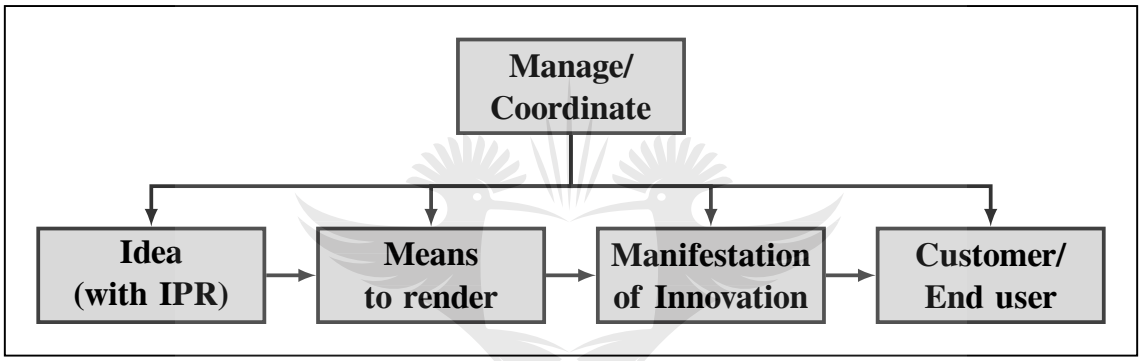

Figure 2.7.: Essential Elements of a Successful Innovation [redrawn from **Mann** (2007a:12)]

Mann (2007a:11-13) & **Mann** (2007b) indicated that it is important to distinguish between Success or Failure in systematic innovation. The measures of success for a systematic innovation is not whether it is profitable, but rather the following factors:

1. Decisive Components
   Systematic Innovation arises from the following components as depicted in Figure 2.7:
   (a) Idea/concept with clear Intellectual Property Rights,
   (b) Means to render,
   (c) Manifestation of the innovation,
   (d) Customer or end-user, and
   (e) Management or coordination between the other components.
2. Function
   End-users require functionality from a product or service.
3. Ideality
   Successful innovations have increased ideality in at least one customer segment.
4. Resources
   The innovation uses a previously unused resource or even changed a former negative effect into a useful one.
5. Elimination or reduction of contradictions
   Elimination or reduction of conflicts, trade-offs and contradictions towards higher ideality indicate success.
6. Trend Jumps

At least one discontinuous advance on one of the trends is probably a productive innovation.

§2.8.1.3. Context

Mann (2007a:14) indicated two situations were systematic innovation is not deemed appropriate:

1. Replication of a previous solution; and
2. System optimisation, as the approach contains no mathematical elements.

The two situations are rare (**Mann** 2007a:14). In the case of the first this is because people are different and time changes. Optimums indicate the existence of either a conflict, a contradiction or a trade-off and this approach aims to eliminate these rather than compromising to merely achieve a local optimum.

Mann (2007a:14-15) indicated that two of the cases where systematic innovation is beneficial should be highlighted. The first is when the target is set above the fundamental capacity of the system that is supposed to render it. The targeted parameter does not matter, at some stage it will happen. It will just occur sooner in more competitive areas, than in other. At this stage none of the standard or known changes will render the required target. The resolution could be to either change the target or the system. The former is not viable in the long term as the competitors will eventually find a method to achieve the target that is beyond the fundamental capacity of the system. Changing the system is definitely more difficult, but it is in this area where systematic innovation stands out. It provides mechanisms that would allow the achievement of the extended target and a clear indication of the part of the system that would be required to be altered. In the second case no current system exists and the characteristics of one will be conceived through systematic innovation.

§2.8.1.4. Time

It takes people a considerable amount of time to master the process of systematic innovation. There are different user profiles and each has a different time horizon associated to it (**Mann** 2007a:16-18):

1. Some people will never use it.
2. Others will use a subset of the methods and nothing else, but they could be convinced to learn more.
3. Others will use some and learn as they need other approaches to situations.
4. People who are enthusiastic about it. They will continuously collect and digest information about it to change the manner in which they innovate.

Mann (2007a:18-19) indicates that there are no correct or incorrect sequence of use or set of the tools he describes to conduct systematic innovation. One should determine the best combination that suits oneself and adapt it to the situation and personal preference.

§2.8.2. A complete method

The process starts with a perceived need for an action to be taken. It then follows a systematic process based on the underlying philosophy to obtain an unambiguous definition of the actual problem with the top solution (**Mann** 2007a:23). This is shown in Figure 2.8.

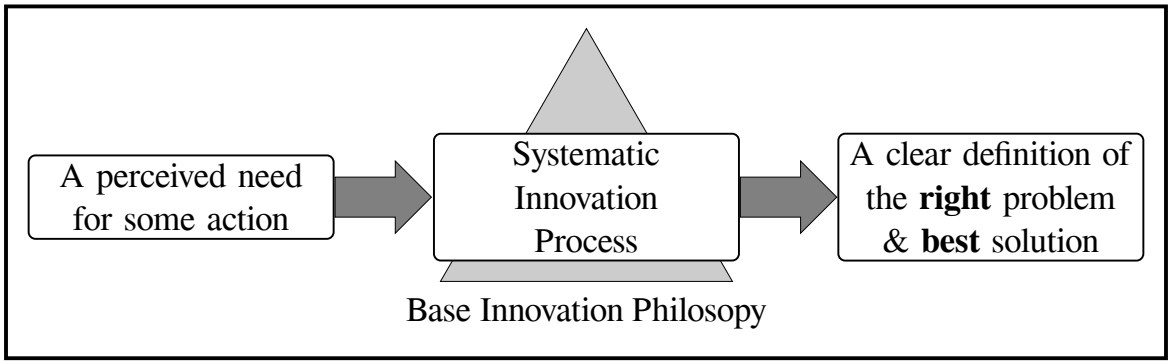

Figure 2.8.: Process Overview of Systematic Innovation (redrawn from **Mann** (2007a:23)).

The perceived need for action or change arises due to challenges and opportunities that emanate from requirements like (**Mann** 2007a:24):

1. Improve or increase outputs,
2. Identify new opportunities and directions,
3. Identify risks and their expected realisation,
4. Reduce costs and wastage, and
5. Maintaining morale and change momentum.

Mann (2007a:24-25) provides a generic process that consists of four steps to enable Systematic Innovation in the typical cases as given above:

1. Problem Definition;
2. Select Appropriate Method;
3. Create solution; and
4. Evaluate solutions.

§2.8.2.1. Problem definition

In this process category **Mann** (2007a:27-28) provides five activities, each with a specific aim:

1. Problem/opportunity exploration.
   it is considered the base activity of problem definition, during which the following aspects of the situation is captured:
   (a) Current status;
   (b) Aim of solving the problem;
   (c) Validation of the solution;
   (d) Available resources; and
   (e) The applicable constraints.
2. Function and Attribute Analysis
   (a) Assessment of the current system functionality;
   (b) Determine and capture the environment and desired outputs; and
   (c) Ascertain undesired outputs.
   This activity should render the majority of the detail to define the problem.
3. S-Curve Analysis
   During this process the maturity of the components of the current system is determined. It provides qualitative understanding of the evolutionary framework of the problem detail and guidance towards the direction to follow after the definition of the problem.
4. Ideal Final Result
   The aim of this process is to determine the ultimate end result. It frequently leads to

an improved definition of the problem and is a good process to identify the conflicts and contradictions of the situation.

5. Perception Mapping
   The purpose of this is to comprehend and map the issues around the problem from different perspectives.

§2.8.2.2. Selection of the appropriate method

Mann (2007a:28) describes this as a series of steps to be followed to determine the most appropriate tools for the problem at hand and to solve it. The tools are not totally isolated and overlap occurs among them. The process will typically also provide several possibilities that are ranked accordong to their appropriateness. The selection process also attempts to reduce the complexity in the change from definition of the problem to use of the most appropriate solution finding tool.

§2.8.2.3. Creation of solutions

Mann (2007a:29) provides the following tools to find solutions:

1. Trade-off and Conflict Removal or Inventive Principles
2. Contradiction Removal
3. Measurement Standards
4. Trends of Evolution: Linear and Non-Linear
5. Resources
6. Knowledge
7. Re-Frame/Re-Focus
8. Trimming
9. Ideal Final Result
10. Psychological Inertia Tools
11. Subversion Analysis

§2.8.2.4. Solution Evaluation

The purpose of this process is to determine the most appropriate solution amongst the results of the previous process' tools (**Mann** 2007a:30).

§2.8.2.5. Overall Process Summary

The overall summary of the process is as depicted in Figure 2.9.

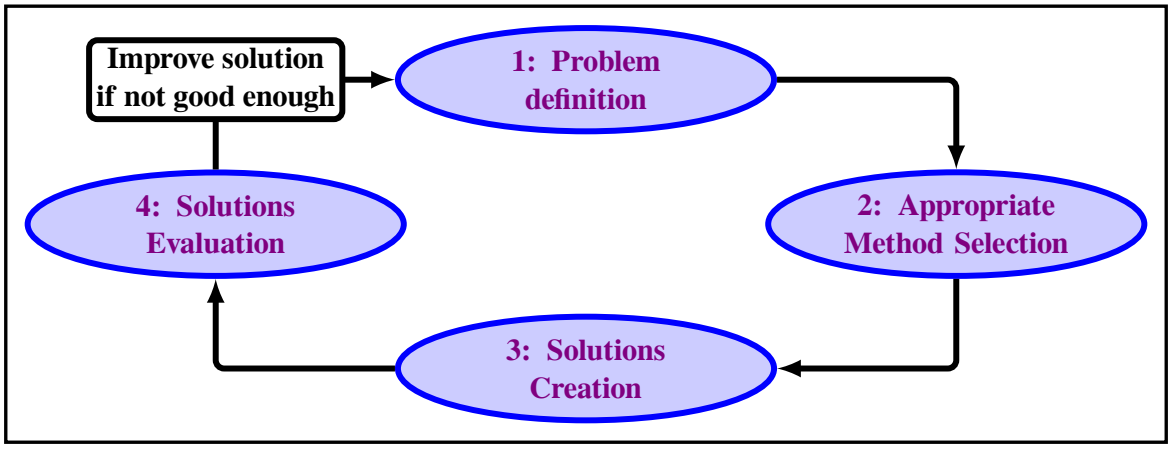

Figure 2.9.: Overall Process Summary (redrawn from **Mann** (2007a:31))

Mann (2007a:30-31) sees the process as consisting of two cycles of divergent thinking followed by convergent thinking. The first cycle occurs during the problem definition process where all the perspectives are first explored and recorded and the divergent thinking then occurs when the boundaries of the problem are taken into account and ends with the selection of the most appropriate tool to solve it. The second cycle consists of divergent thinking during the generation of potential solutions and convergent thinking in the evaluation of them. This is depicted in Figure 2.10.

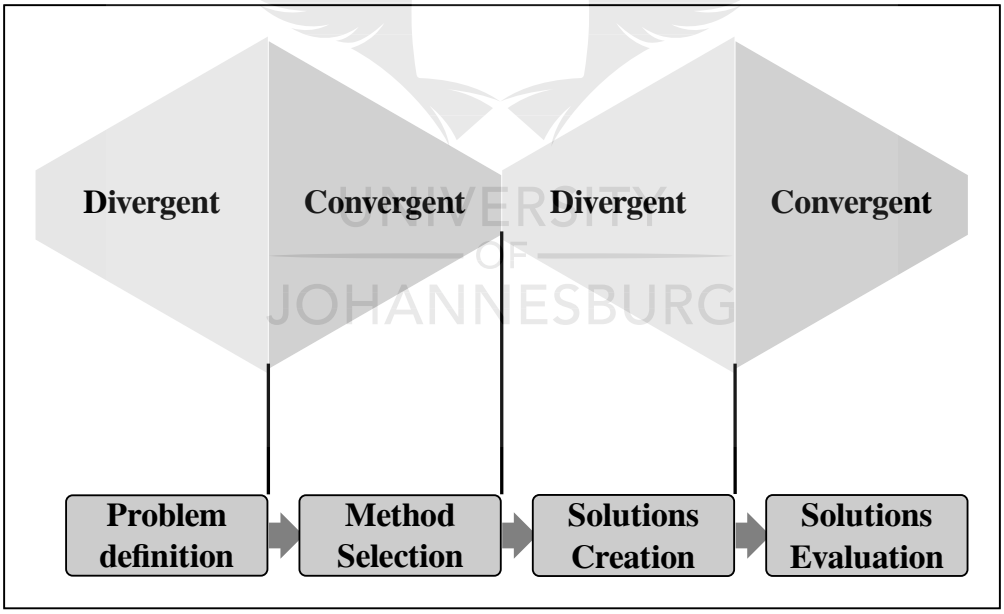

Figure 2.10.: Divergent-Convergent Cycles of the Systematic Innovation Process (redrawn from **Mann** (2007a:32))

§2.8.2.6. Problems and Opportunities

Mann (2007a:32-34) indicated that the Systematic Innovation Process could be applied with equal success immaterial whether it is a problem or an opportunity at the origin of the process. The view of how problem and opportunities relate or differ is presented in Figure 2.11. Most organisations are only active in the fire-fighting area.

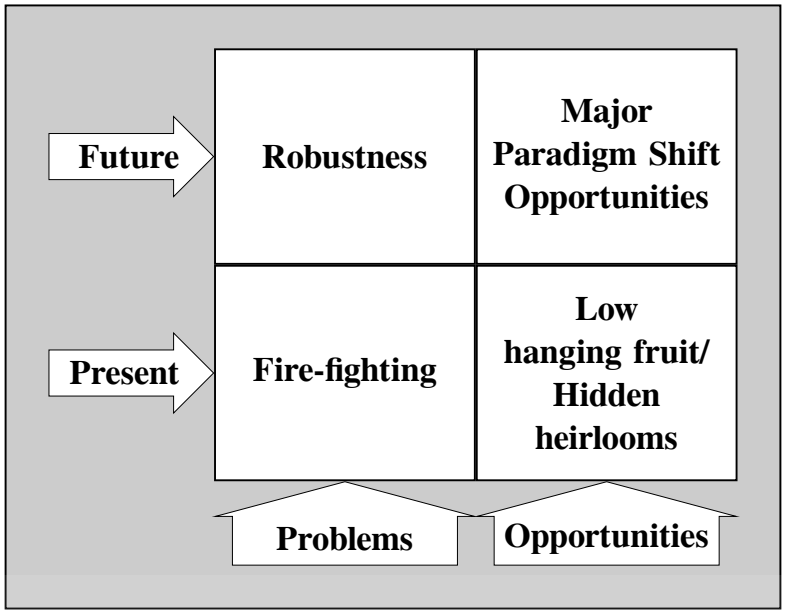

Figure 2.11.: Problems and Opportunities vs Time (redrawn from **Mann** (2007a:33))

The identification of opportunities are in essence about two aspects: a) the activities that an organisation excels at, which are simply accepted as standard practice; and b) activities performed better by outsiders, which the organisation would like to conduct the same way internally. Functional benchmarking is used in both cases to identify potential opportunities. It provides a means to compare the delivery of functions to the market. Through this the opportunities are where the organisation excels and problems are where others excel beyond it (**Mann** 2007a:35).

Opportunities through Trend identification

Mann (2007a:35) indicated that linear and non-linear trends can be used to determine opportunities. This is derived from the concept that systems and subsystems bear the possibility to develop in each of the common trends identified by investigating across different industries.

Evolutionary potential

A system can be evaluated against the evolutionary trends, by evaluating it against the developing trends across industries. The results of the evaluation will indicate in which areas and what level of the evolution can be realised (787 **Mann** 2003:35-37; **Mann** 2007a). This is demonstrated in Figure 2.8.2.6. **Mann** (791-793 2003:35-37, 2007a) applied the same methodology to the business environment to determine in which areas it may further evolve.

[This is in concept a good approach, but not all the technical items in the approach can be directly generalised to business, in many instances it is done by means of merely assimilating the new area.]

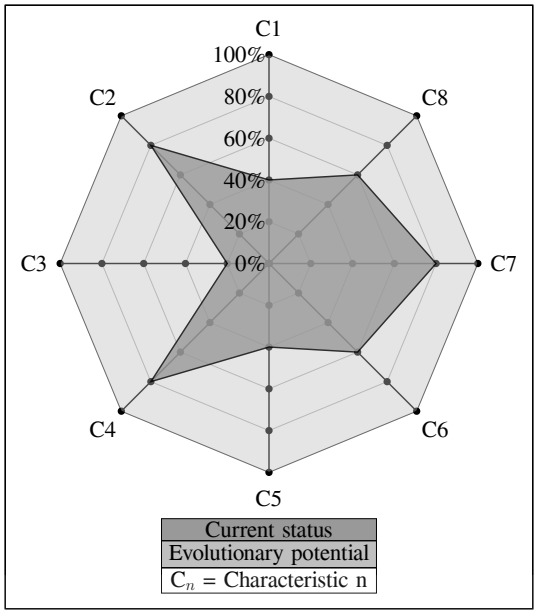

Figure 2.12.: Evolutionary potential (redrawn from **Mann** (2003:782); see also **Mann** (2003:782))

Mann (2007a:36) believes that opportunities exists external to the current system, in that they would expand the system. Opportunities may be found in a pure random way when chance connections are made by people between the current status of capabilities and other outside systems. The possibility of identifying opportunities are maximised through the encouragement and empowerment of all members of the organisation to seek and exploit connections between the current and the outside environment, instead of making it a select few's responsibility.

Through use of the Systematic Innovation Toolkit, **Mann** (2007a:36) reasons one can identify opportunities in a more systematic way through: a) The methodology recognises and classifies knowledge according to the delivery of functions. It provides a mechanism to connect an outside function that could be integrated or identify a current function executed far more effectively than any outside party; and b) The trends that are part of the evolution tools, the concept of evolutionary possibilities, and the resources part of the process provide structured methods to identify opportunities

Short-cut methods

Mann (2007a:37) recommends two short-cut methods for newcomers to Systematic Innovation, which can also be used by people who want to avoid the rigour of the complete methodology. The hazards of using these arise from the possibility that the definition of the problem could be inadequate and resources could be wasted on solving a misinterpreted situation. They could still be used frequently. They are: a) Determining and solving contradictions or conflicts 2.8.2.6; and b) Determination of resources 2.8.2.6.

Resolving conflicts.

Mann (2007a:37) states that 80% of problems occur in the case where a system or one of its components has reached its 'fundamental' limit, which can be effectively exceeded by determining the existing contradictions and resolving them. A set of tools (Appendix B) can be utilised to achieve this. The process consists of: a) Determining desired aspects of improvement; and b) Determination of items that prevent the desired improvements. Conflict resolution is then attempted by applying the conflict elimination methods or even in an accelerated manner directly

the 40 Inventive Principles, both of these as derived for Business and Management (Appendix B).

Using the 40 Inventive Principles for Business and Management improve the idea generation effectiveness of Brainstorm, so that instead of reaching a peak after a few minutes it will still be effective for several hours after it started (**Mann** 2007a:37). The pattern is depicted in Figure 2.13. **Keeney** (2012:306-312) described value focussed brainstorming where the values of the objectives are considered, this is similar to using the 40 Inventive Principles as guidance for the process. The value focussed approach is based on analysis of the problem and not necessarily on any inventive principles.

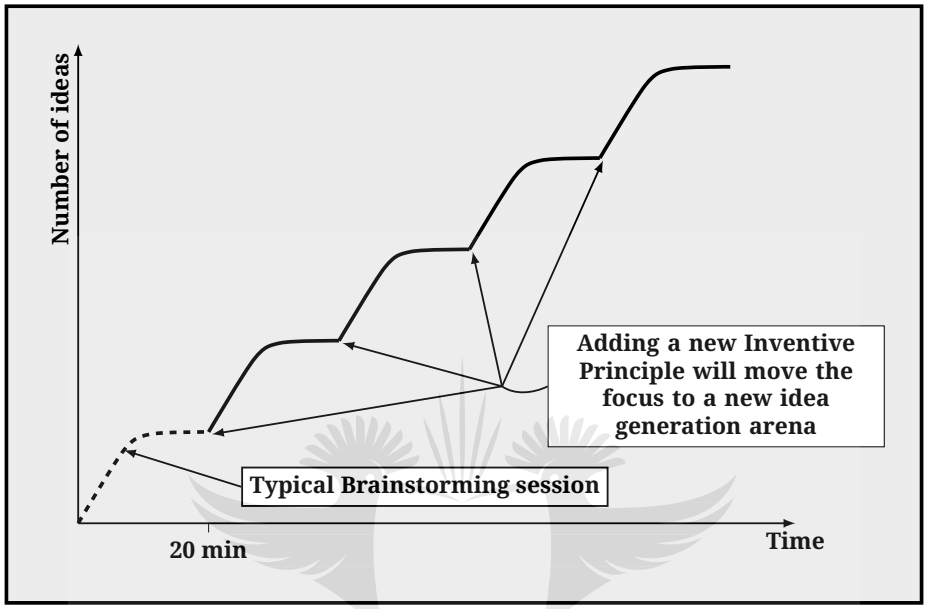

Figure 2.13.: Re-energising Brainstorming with Inventive Principles (redrawn from **Mann** (2007a:37))

Too many ideas can be as big a concern as not having sufficient depth, but using the Inventive Principles leads to a good indication of solutions. The effect is that a large amount of the ideas generated through this approach will tend to useful. The process then calls for the combining of them into a manageable set (**Mann** 2007a:37-38).

Use Resources

The idea in this approach is to determine resources that are not fully utilised. The utilisation is investigated by means of an evolutionary potential analysis. An underutilised resource is an identified opportunity, this renders an almost guaranteed effective short-cut in numerous occasions. Resource check-lists can also be used to identify underused resources (**Mann** 2007a:38).

§2.8.3. Psychology

Mann (2007a:40) reasons that the human mind is mostly in a state to remember how things are done in order to repeat them without thinking about it. This could apply to 99,9% of situations, but it is not an effective state of mind to create new solutions. In a group context it causes the lack of innovation in organisations. It is assumed to be a reason why many innovators are external to industry.

The approach of Systematic Innovation is to assist in the 0,1% situations when an attempt is made to find different methods to do things. This part of the methodology aims at achieving the

correct context to maximise the effectiveness of the innovation methods. It, however, does not subscribe to the view that one utilises a small portion of one's capabilities (**Mann** 2007a:40).

The general approach is to use the concept that a similar problem already has a solution and an external search would find the generic solution. This is contrary to the idea that to solve a problem a person's mind has to be 'unblocked' to find a solution. Emanating from the concept that a similar solution already exists is the argument may be that if one already knows everything that person may be considered ineffective in executing the work at hand. **Mann** (2007a) states that the task for a manager at hand is a full-time occupation and it would be impossible to also be abreast of actions in other disciplines or industries. The idea is not to always accept external views and solutions, but rather to combine the area specialist knowledge with the approach of systematic innovation of a general view world perspective, as depicted in Figure 2.14.

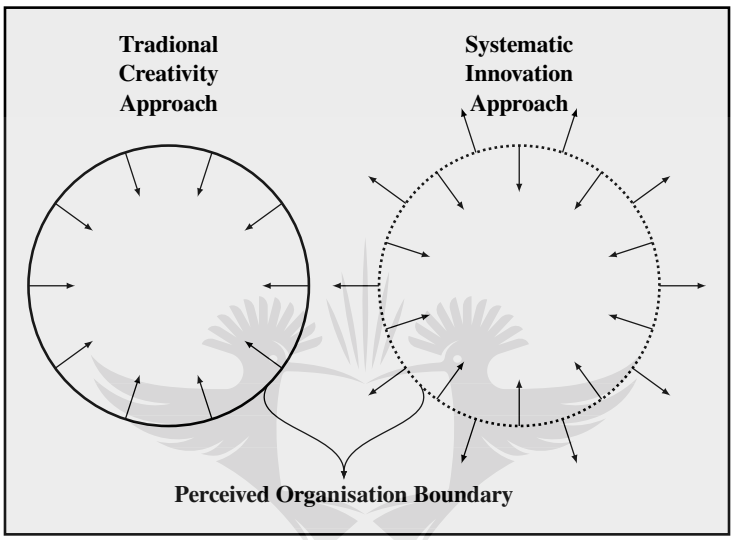

Figure 2.14.: Traditional versus Systematic Innovation Approach (redrawn from **Mann** (2007a:42))

Mann (2007a:41) states that the 'traditional' techniques with the purpose to gain access to the numerous ideas a person has, are very useful. He also believes that if a technique is useful it features somewhere in the tool-kit he provides. [*This is a dangerous claim to make!*] The tool-kit is based on the idea that it is essential to combine external and internal perspectives and apart from this section makes no distinction between them.

The discussion of the relationship between psychology and systematic innovation focuses on five aspects: 1) Psychological Inertia; 2) Interpretation of triggers emanating from systematic innovation; 3) Lateral thinking processes; 4) Structuring of information; and 5) Group Dynamics. The intention is to create awareness of psychological factors that affect systematic innovation. These are not the only ones, but a few to show the importance thereof (**Mann** 2007a:42).

§2.8.3.1. Psychological Inertia

Psychological Inertia is when a solution is sought by exploring deeper within the current boundary of the organisation. It has the effect that the search is confined to the current area and it is in general justified by referring to the current investment of finances and other resources into it. The problem is that the deeper the search continues, the less likely it is to expand the scope to external concepts (**Mann** 2007a:43).

§2.8.3.2. The space between Generic and Specific Solutions

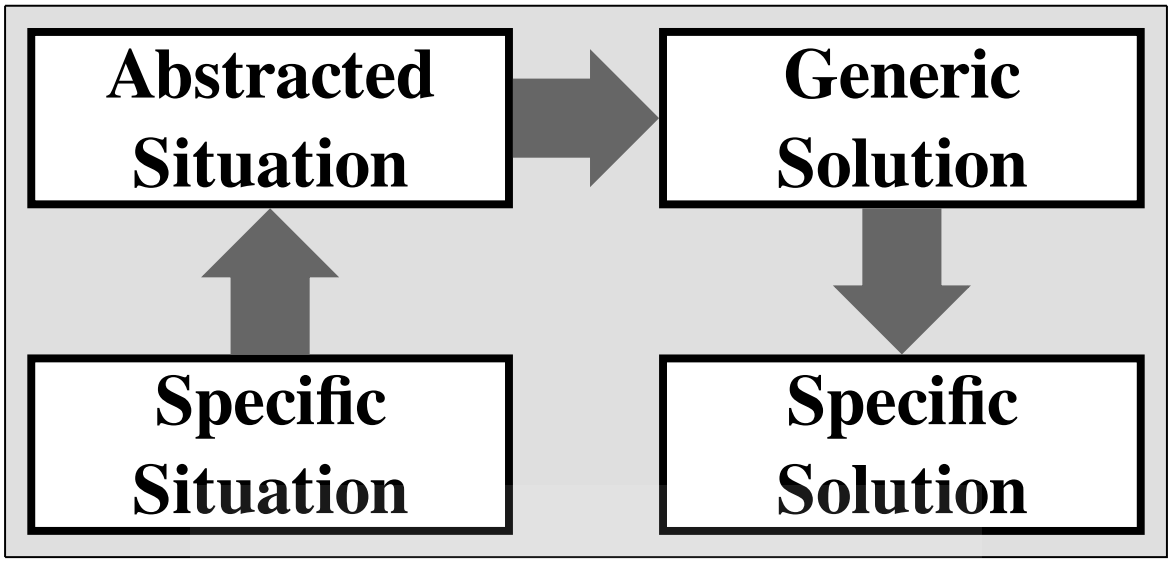

Figure 2.15.: The General Systematic Innovation Abstraction Model (redrawn from **Mann** (2007a:45))

Mann (2007a:45) states that Systematic Innovation consists mostly of the abstraction of a generic or abstracted situation from a specific situation. The idea is that a great possibility exists that the abstracted situation has a generic solution. Included in the generic solution are the 40 Business Principles, the Measurement Standards and the Trends of evolution.

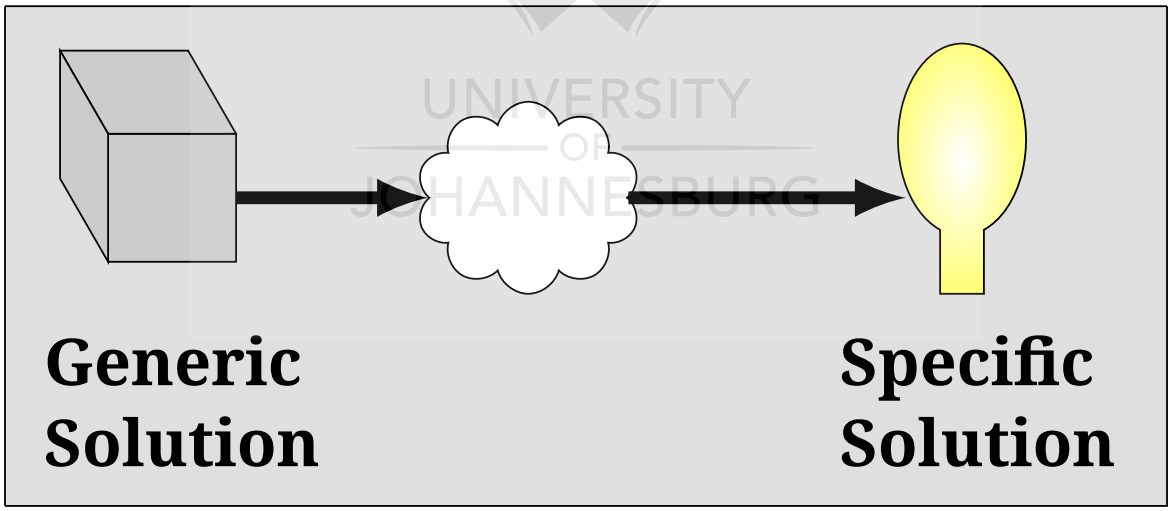

Figure 2.16.: Space between Generic and Specific Solutions (redrawn from **Mann** (2007a:46))

The process to find a specific solution from the generic one is where there are not clear methods defined. **Mann** (2007a:46-48) indicated that the "Contradiction Matrix" and "Inventive Principles", that he adapted from TRIZ (2.6.2) for business, are the means to obtain a specific solution from a generic one.**Kim** and **Park** (2008) researched the establishment of a translated Contradiction Matrix for business and reached the same results.

Mann (2007a:49) stated that one mechanism to cross over from the generic to the specific solution is the inherent ability of people to create associations. This could be between items that are

completely unrelated. He also recommended that one should use the 40 Inventive Principles for business.

§2.8.3.3. Six Thinking Hats

The third approach to overcome psychological inertia and determine a specific solution recommended by **Mann** (2007a:50-56) is to utilise the Six Hats™ approach of De Bono. The basic concepts of the different hats are summarised in Table 2.13 (**Mycoted** 2006c).

Table 2.13.: Six Thinking Hats (**Mann** 2007a:51; **Mycoted** 2006c)

Direction	Description
White Hat direction 	Consideration of facts, figures, information needs and gaps, without debating or proposals.
Red Hat direction 	Consideration of feelings, emotions and intuition. This typically follows after considering facts, figures, information needs and gaps. In this direction the feelings are in general genuine, but the logic spurious.
Black Hat direction 	This entails judgement and caution. It is not meant to be negative, but rather why a suggestion is not suitable.
Yellow Hat direction 	Considering the benefits and why it is a solution now or in the future.
Green Hat thinking 	Being creative, seek alternatives or interesting changes.
Blue Hat thinking 	Consider the process. Perspective that more of a certain hat is required.

§2.8.3.4. Structuring of Information

Mann (2007a:56-57) believes that a problem would occur if one has to work with unstructured information. In order to overcome this he proposes that MindMaps™ should be used. It apparently removes the psychological conflict that simultaneous identification and structuring of information would create.

§2.8.3.5. Group Dynamics

Working in groups to creatively solve problems can be more difficult than working on them alone. If, for instance, the Six Hats™ method is used in a group, some participants could experience difficulty to switch hats. The problem could be resolved by subdividing the group into teams designated for a specific hat colour. It could be useful to select the more creative people to participate in the group, but in general it is not possible (**Mann** 2007a:57-58).

§2.8.4. System Operator (9-Windows)

Gadd (2011:70-73) & **Mann** (2007a:63) provide the System Operator or otherwise called '9-Windows' method as a means to analyse a system in Time and Space. The basic concept of the tool is to study how a system or business method has evolved over time in the systems hierarchy. This is depicted in Figure 2.17.

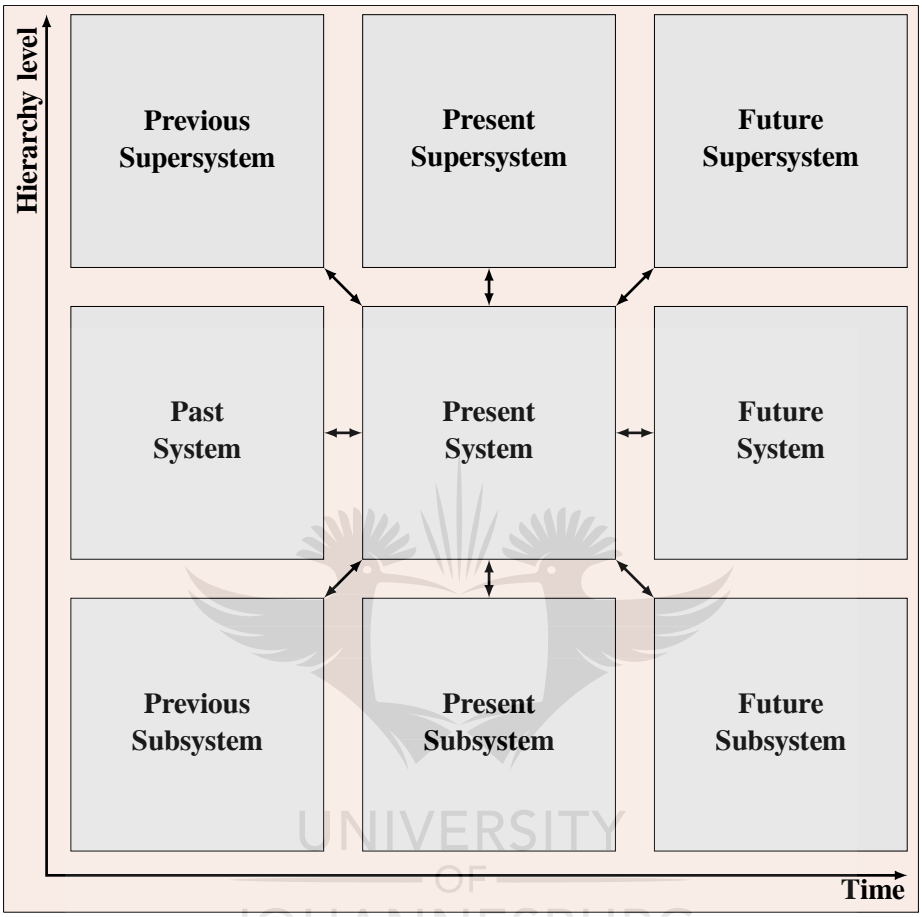

Figure 2.17.: Systems operator — Systems hierarchy vs. Time (redrawn from **Gadd** (2011:70) & **Mann** (2007a:63))

The Systems operator can be extended to a wider time range:

1. Long-term past
2. Mid-term past
3. Near-term past
4. Present
5. Near-term future
6. Mid-term future
7. Long-term future

as well as in terms of the hierarchical level(**Mann** 2007a:65).

Mann (2007a:66-68) demonstrated that the method could be detached from systems and used to illustrate the perspectives of different professions or function to a situation. The idea is to understand that everyone uses different boundaries and the perspective of each are only a partial view of the world.

The direct interaction between areas should also be investigated to obtain a more complete

perspective (**Mann** 2007a:68-70). This is indicated by the thicker arrows in Figure 2.18.

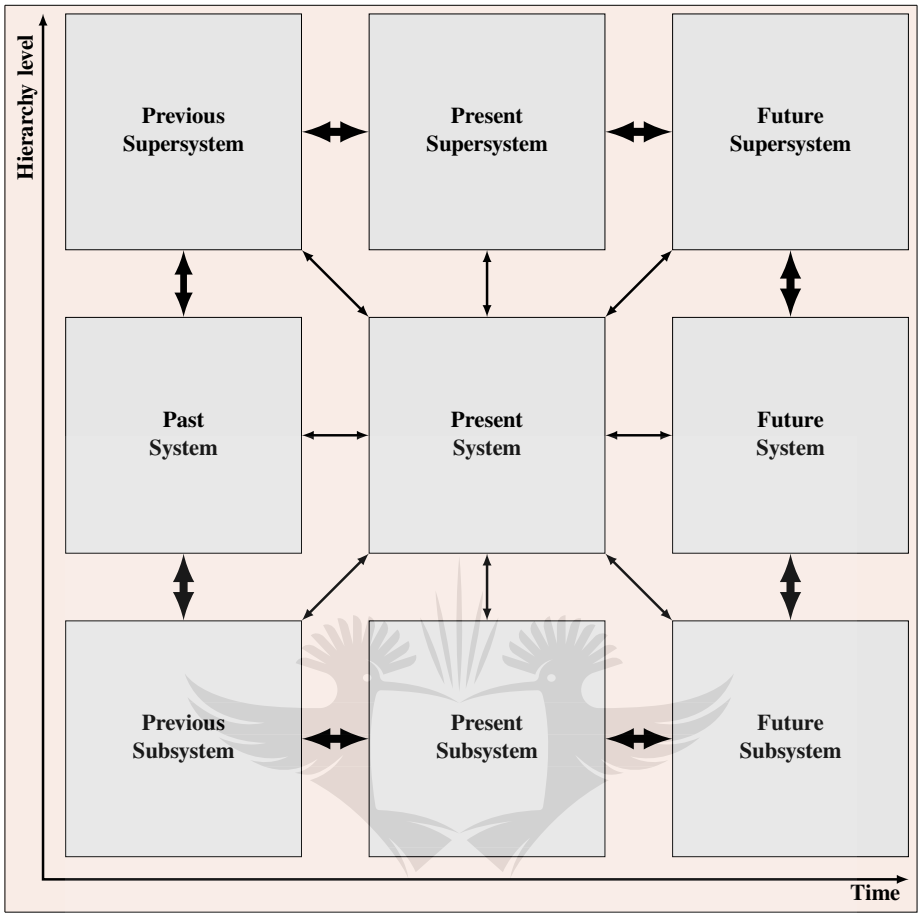

Figure 2.18.: Direct interactions (redrawn from **Gadd** (2011:tbd) & **Mann** (2007a:68))

The method could also be further extended to view different perspectives as layers of a situation (**Mann** 2007a:71):

1. Physical
2. Behaviour
3. Capabilities
4. Beliefs or Values
5. Identity

and the 9-Windows method is then applied to each of the layers.

Integration of other perspectives

Mann (2007a:75) demonstrated how several other methods can be integrated with the 9-Windows analysis technique. The first is the "Value Net" approach. For each item in the Time-Hierarchy grid each of: a) Customers; b) Competitors; c) Suppliers; and d) Complimentary parties are evaluated as is illustrated in Figure 2.19.

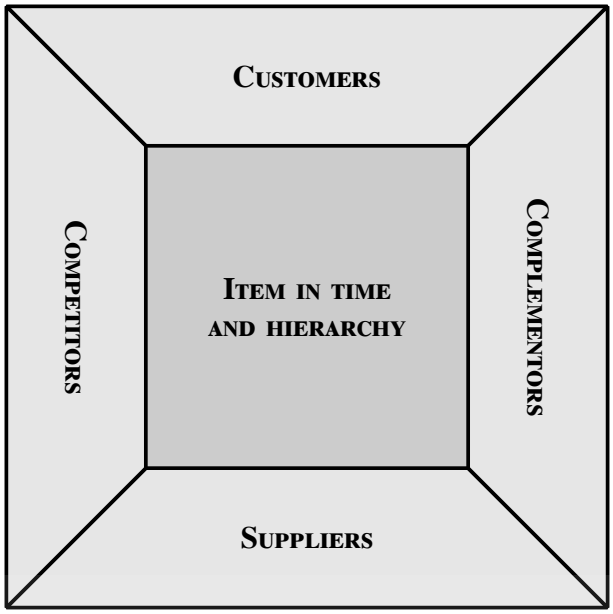

Figure 2.19.: Value Net Concepts (redrawn from **Mann** (2007a:75))

A Strengths, Weaknesses, Opportunities and Threats analysis could also be conducted on each item in the Time-Hierarchy grid. The integration of this approach with the layered analysis is apparently an established practice in Neuro-Linguistic Programming (**Mann** 2007a:75-77).

Mann (2007a:77-78) also showed how the 9-Windows method could be integrated with a VAKOG analysis on each item in the grid. VAKOG is the acronym for Visual, Auditory, Kinaesthetic, Olfactory and Gustatory. The idea is if these sense factors could be recognised for each item a new problem definition could be derived and more solution opportunities could arise.

§2.8.5. Problem Definition

Mann (2007a) discusses the following techniques to define a problem:

1. Problem/Opportunity Explorer
2. Function/Attribute Analysis
3. S-Curve Analysis
4. Perception Mapping
5. Ideal Final Result

§2.8.5.1. Problem/Opportunity Explorer

Mann (2007a:81-90) sees the problem/opportunity exploration of a problem as an essential part of the definition of it. To explore a problem one should do the following analyses on it:

1. Benefit Analysis
2. Exploration of the problem hierarchy
3. Identification of Resources
4. Identification of Constraints
5. Identification of Sensitive Areas
   - 5.1. Efficiency Audits
   - 5.2. Theory of Constraints
   - 5.3. Subversion Analysis

5.4. Root Contradiction Analysis

During the exploration of the problem hierarchy one should determine if the problem is not part of a broader one or even consists of smaller problems (**Mann** 2007a:82-84).

§2.8.5.2. Function/Attribute Analysis

Function analysis is conducted in three sequential steps (**Mann** 2007a:97):

1. Identification and definition of the system elements, they are the generic ones not only physical parts;
2. Determination of the existing useful relationships between the identified elements; and
3. Determination of the negative or undesired relationships between the identified elements.

In the context of this method negative relationships are categorised as being (**Mann** 2007a:98):

1. Harmful — it is undesired;
2. Insufficient — it is underutilised;
3. Excessive — it is overused; and
4. Missing — desired but absent.

A graphical approach to this method is shown in Figure 2.20 (**Mann** 2007a:99)).

Mann (2007a:101) expands the process by adding intangible relationship types as shown in Table 2.14.

Table 2.14.: Intangible Relationship Types (redrawn from **Mann** (2007a:101)).

Positive types	**Negative types**
1. Alliances	1. Deceit/Distraction
2. Attraction/Emotion	2. Fear
3. Brand recognition	3. Inversion of the positives above
4. Commitment	4. Jealousy/Envy
5. Culture	5. Time/Resource wasting
6. Experience	
7. Judgement	
8. Knowledge transfer	
9. Morale	
10. Motivation	
11. Networking with other people	
12. Processes	
13. Relationships	
14. Reputation/Status	
15. Responsibility/Authority	
16. Skills exchange	
17. Trust	

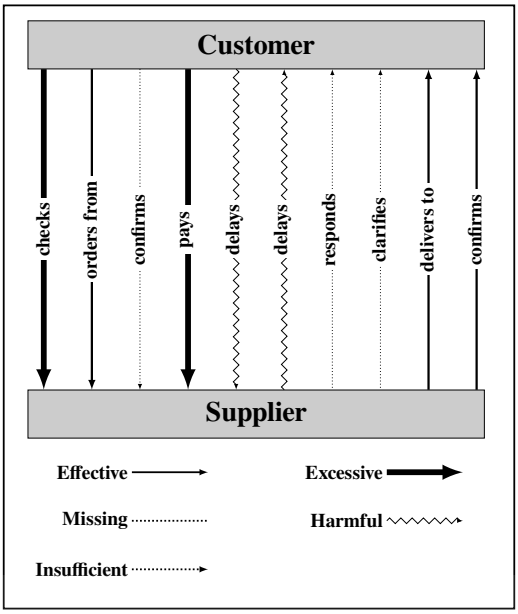

Figure 2.20.: Relationship between elements (redrawn from **Mann** (2007a:99))

Mann (2007a:103) stated that it is also necessary to add time perspectives to the Functional and Attribute analysis as systems are not constant in time. The time perspectives are as follows:

1. Analysis before any problem manifests;
2. Analysis while a problem is present; and
3. Analysis after any problem.

The effect of time perspectives analysis is that the relationships between processes are also evaluated.

The next major part of this method is adding attributes to each of the identified elements. The attributes will depend on the characteristic of the specific element. The idea is to determine attributes that are affected by the relationships identified in the previous steps of the process (**Mann** 2007a:105-107).

The method could be further enhanced by investigation of: a) the hierarchy of functions; b) the relationship matrix (when there is a large amount of elements); and c) cause-effect maps (**Mann** 2007a:107-109).

§2.8.5.3. S-Curve Analysis

Systematic Innovation uses the general S-Curve Analysis differently. It mostly uses ideality (2.8.1.1) on the y-axis as the value under consideration to evaluate systems in terms of evolution. **Mann** (2007a:118-119) also demonstrated how the elements of ideality can each be seen as following the same shape over time. The standard S-Curve is shown in Figure 2.21.

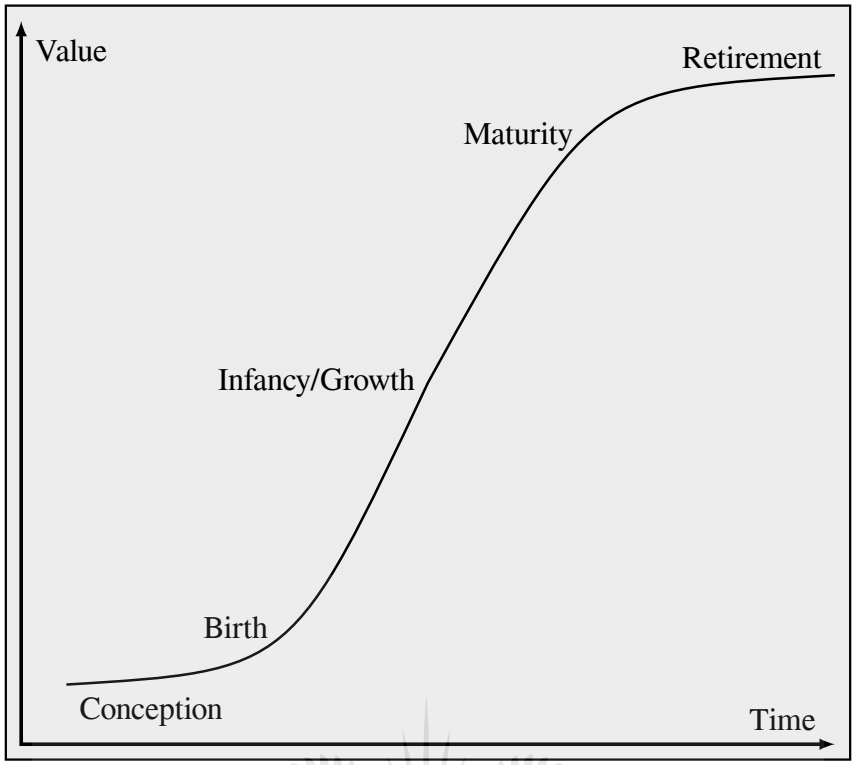

Figure 2.21.: Generic S-Curve (redrawn from **Mann** (2007a:117))

Different perceptions

Mann (2007a:119) stated that every customer has a different perception of the current ideality of a system and that could cause that each view the S-Curve of a system at a different level. The concept is illustrated in Figure 2.22. This is because the definition of ideality is not exact.

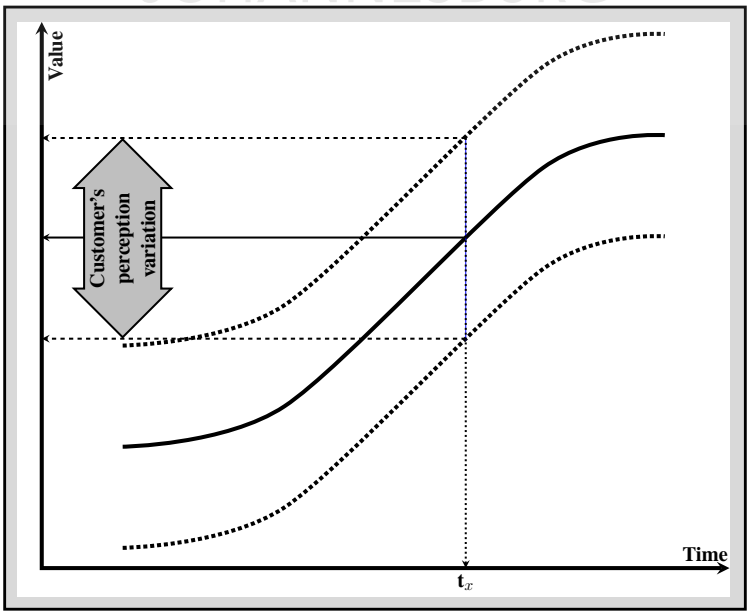

Figure 2.22.: S-Curve: Differing Customer Perceptions (redrawn from **Mann** (2007a:120))

Discontinuous jumps

The shift from one system or technology to the next is characterised by a discontinuity. The different perceptions of customers also play a role at this stage. People who accept systems soon after conception are called 'Early adopters', they are also the ones who provide the funds to grow the new system to higher levels of maturity (**Mann** 2007a:120-121). This is depicted in Figure 2.23.

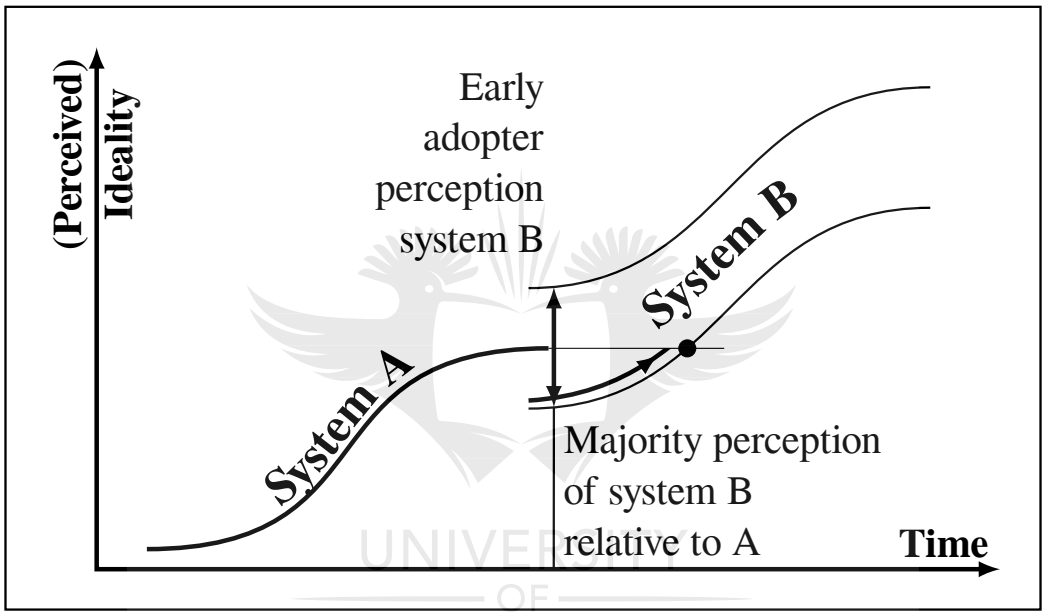

Figure 2.23.: Perceptions at the shift from one system to the next (redrawn from **Mann** (2007a:120))

Overall view

Mann (2007a:121-122) indicated that the S-Curve is applicable to all the subsystems of a system and can also be applied to the sub-processes of a process.

A system as part of a higher system also follows the S-curve. The higher system will continue to grow even though a current system in it may be retired. This is shown in Figure 2.24, where different subsystems are seen to go through all the phases of the S-Curve. It is also seen as the functions and decline of functions relative to a solution. The higher system, although it is still growing and may still not have reached retirement (**Mann** 2007a:122).

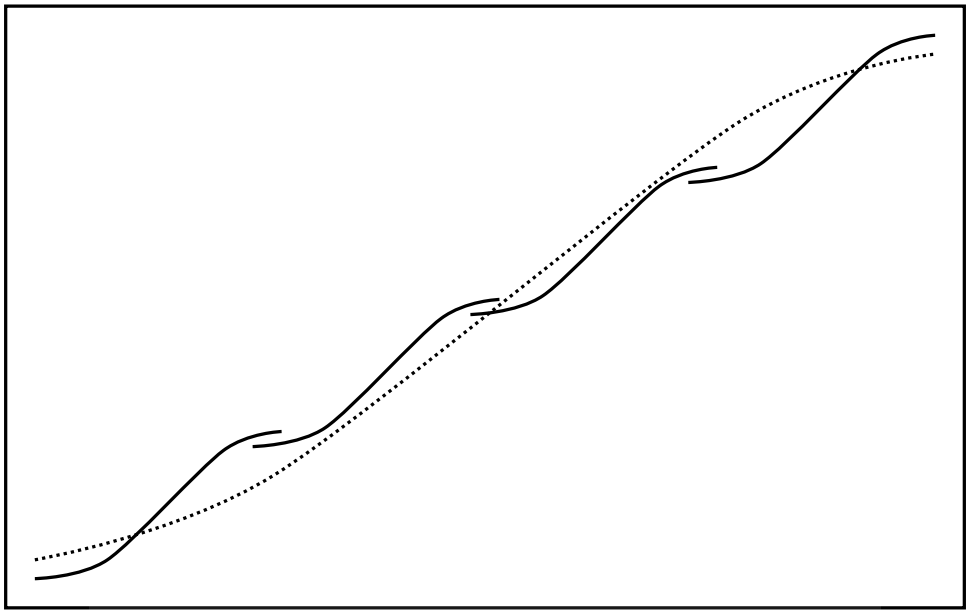

Figure 2.24.: Functions in a solution in relation to growth and decline (redrawn from **Mann** (2007a:123))

Decline phase

In rare instances systems may also go through a 'decline' phase as is shown in Figure 2.25. This could happen if the perception of the system's ideality declines, but the actual ideality is still unchanged. It could also happen if the new/replacement causes the ideality of the current system to drop, for instance when the cost to operate it rises due to the availability of resources (**Mann** 2007a:123).

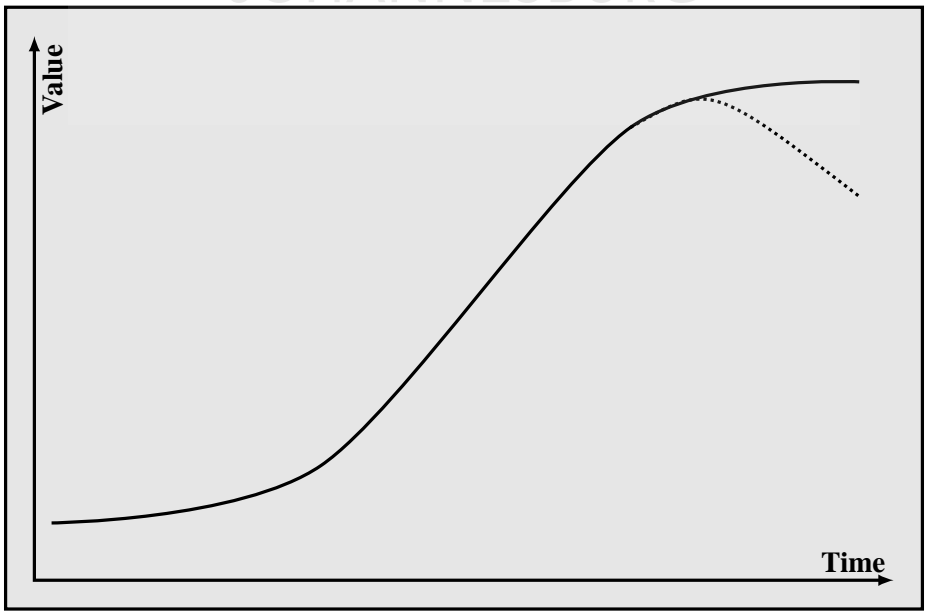

Figure 2.25.: Perceived or real decline in the S-Curve (redrawn from **Mann** (2007a:124))

Position on S-Curve

The S-Curve of a system is used in Systematic Innovation to determine the most appropriate method for generating a solution. It is therefore important to determine where on it is S-Curve a system is situated. There are three focus areas on the S-Curve that are used in the process (**Mann** 2007a:124):

1. At the beginning;
2. At the mature end; and
3. Maximum complexity point.

At the beginning of the S-Curve the majority of the problems involve improvements. When the system is approaching the mature stage, the approach would be to modify the total system. Before the maximum complexity point and after it the approaches are different and could conflict with each other. It is therefore important to know which side of this the system is in to select the correct approach (**Mann** 2007a:125).

There are four characteristics that could be used to determine the position of a system (**Mann** 2007a:125-126):

1. Generation Rate of related Intellectual Property;
2. Focus of Business Attention;
3. Management Processes; and
4. Dynamics of the Market and Competition.

Mann (2007a:126) stated that monitoring the registration of related Intellectual Property (IP) will help to determine when a system enters the retirement phase; as shown in Figure 2.26. This could also be diverted by organisations who either do not register IP or large amounts of 'smoke-screen' IP.

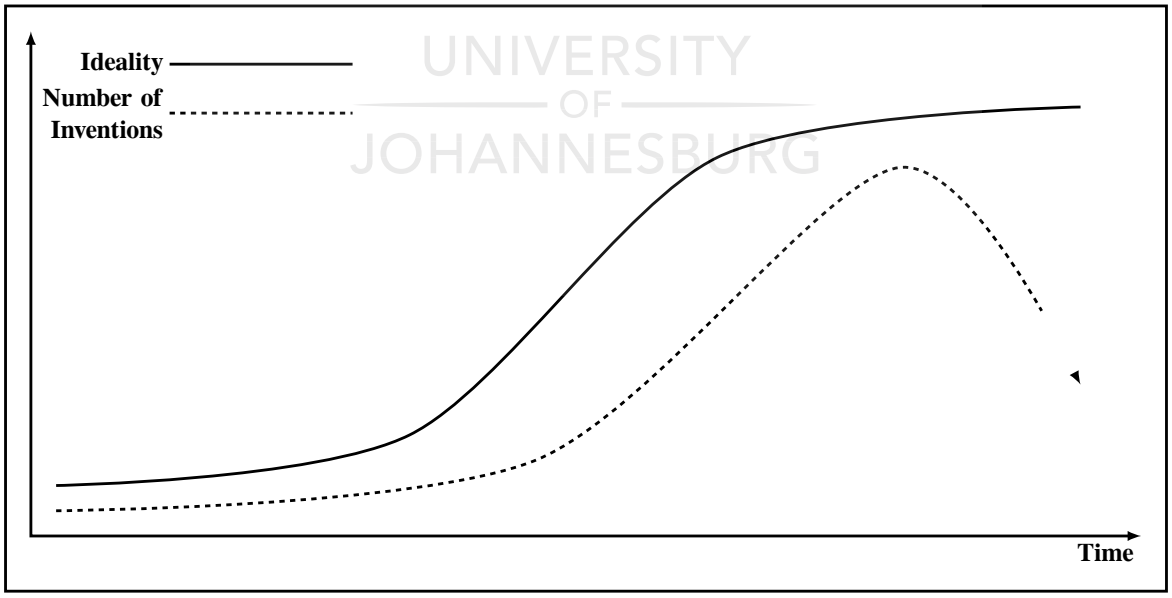

Figure 2.26.: Innovations and Ideality over time (redrawn from **Mann** (2007a:126))

The strategic focus of business attention shows in what stage a system is and by tracking them one can determine in what stage of the evolution a system is at a point in time **Mann** (2007a:127). The relationship between the stages and business focus is shown in Figure 2.27.

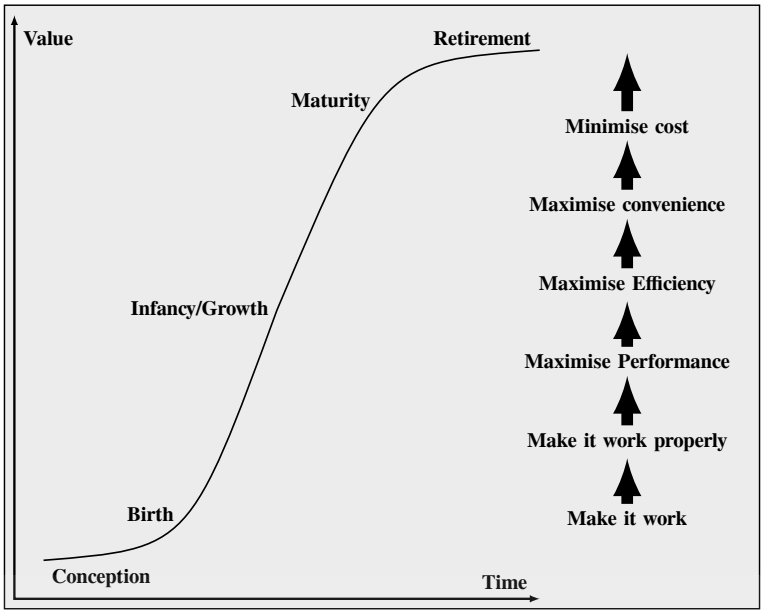

Figure 2.27.: Business focus in relation to evolution stages (redrawn from **Mann** (2007a:127))

Maximum Complexity

Cost reduction initiatives can be seen as indications that a system has reached the point of maximum complexity. The point of maximum complexity can vary in relation to the S-Curve. Systems that consist of many elements will reach the point towards the middle of the S-Curve and simple systems towards the retirement phase. The possible range of this is indicated in Figure 2.28. It means that even if the position of a system has been reliably determined on the S-Curve, the point of maximum complexity cannot be directly derived from that. The clearest indications that a system is beyond that point are when the following initiatives are launched (**Mann** 2007a:127):

1. 'Design for Manufacture';
2. Reduction of the part count;
3. Re-engineering of the business processes; and
4. 'Right-sizing';

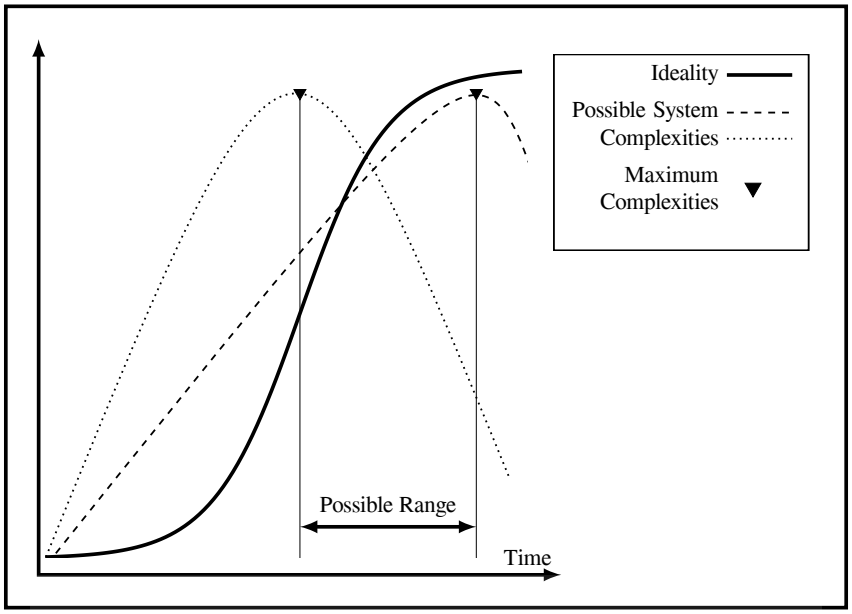

Figure 2.28.: Potential system complexity range (redrawn from **Mann** (2007a:128))

Management perspectives

The aim of management is to minimise costs and maximise outputs driving a system to the top end of the S-Curve as is shown in Figure 2.29 (**Mann** 2007a:128).

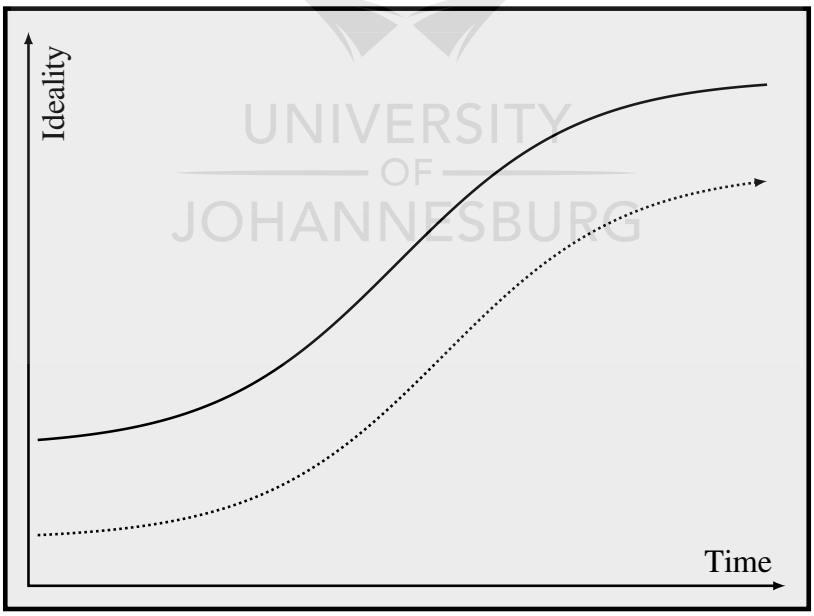

Figure 2.29.: Management drive towards limits of system capabilities (redrawn from **Mann** (2007a:129)).

Mann (2007a:129) stated that the dynamics of the market and competition also show in what evolutionary stage a system is. During the initial phases many participants are active and competing in the market. Towards the end of the evolution the amount of participants is reduced to the minimum. This situation is depicted in Figure 2.30.

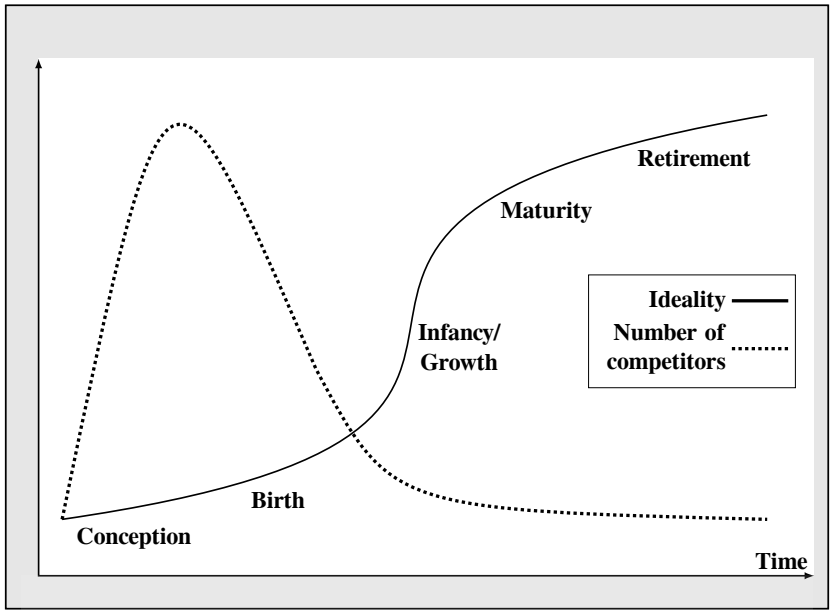

Figure 2.30.: Competition during a system's evolution (**Mann** 2007a:129)

§2.8.5.4. Ideal Final Result

Mann (2007a:131-132) defines Ideality as:

$$\text{Ideality} = \text{Perceived}\left(\frac{\text{Benefits}}{\text{Cost} + \text{Harm}}\right)$$

from this definition it is seen that as a system evolves in term of ideality it progressively renders more benefits, less harmful results and becomes cheaper to operate. If a system is evolved to the maximum it would then only render benefits with no perceived costs or harms and would then achieve the state of Ideal Final Result (IFR). The best approach in Systematic Innovation is to start from the IFR and work towards the status quo. The concept is illustrated in Figure 2.31.

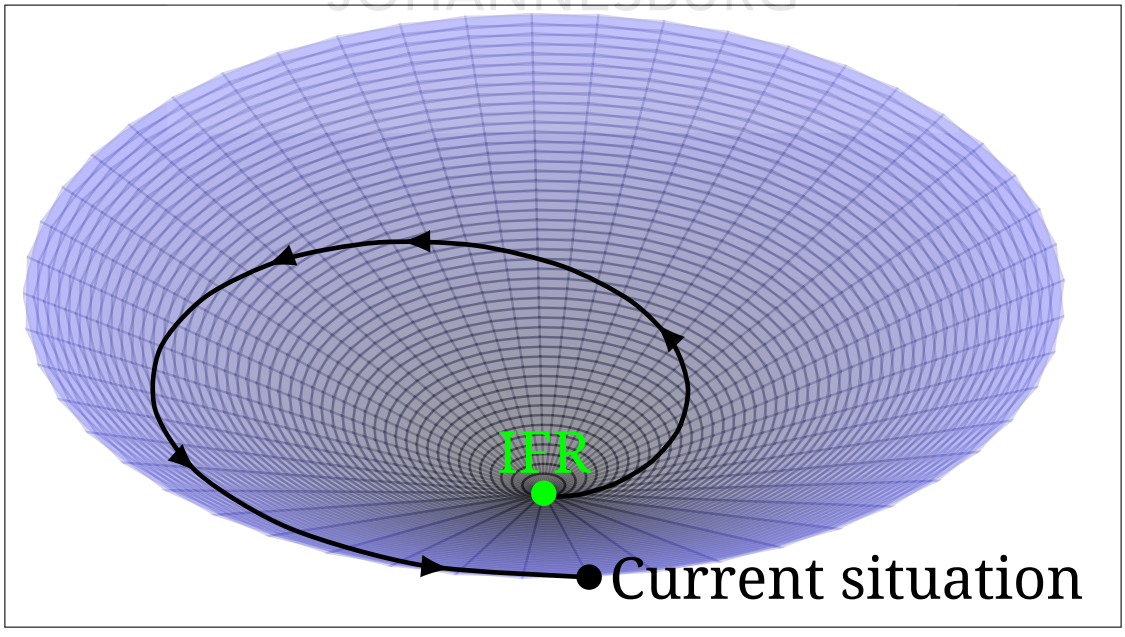

Figure 2.31.: Ideal Final Result (redrawn from **Mann** (2007a:134))

To determine the IFR the following questions are provided by **Mann** (2007a:135):

1. What is the final purpose of the system?
2. What is the IFR effect?
3. What is blocking the attainment of the IFR?
4. Why is it blocking the attainment?
5. How could the blocking barriers be removed?
6. What resources are available to create the required circumstances?
7. Has this problem been solved by anyone else?

One of the major challenges in determining ideality/IFR is to decide the perspective from which it is done. The one perspective is that of the customer who wants a system perfect and absolutely free, the other is the view of the supplier/manufacturer who wants a system that is better than the competition and faster to the market (**Mann** 2007a:141).

The IFR of a system can be analysed by using a template like the one in Figure 2.32 to take the requirements of different stakeholders into account. It is used by determining the attributes and values of each of the stakeholders desired in the product. The contradictions of the attributes are indicated left-hand side where they meet in the diamond-shaped areas. A and B in the figure are examples of that. The idea is to solve at least one of the contradictions or to find an attribute that the competition has not yet introduced (**Mann** 2007a:142-144).

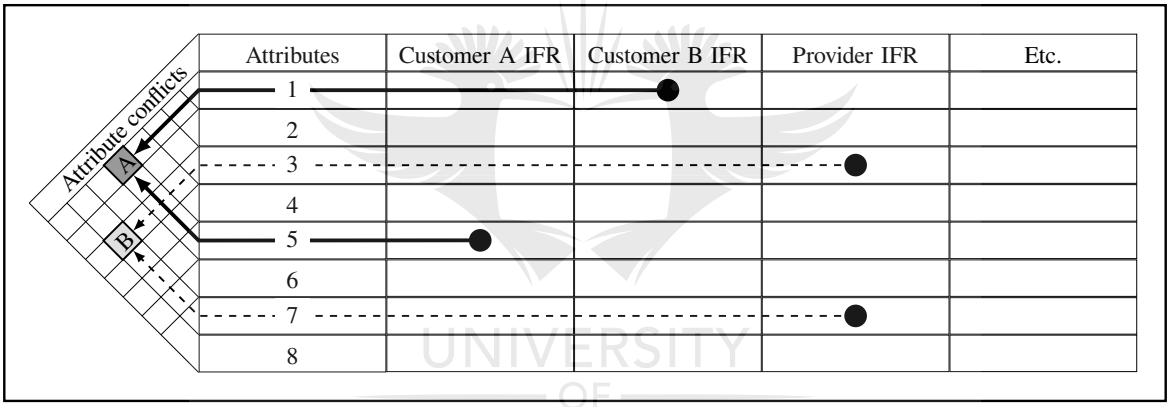

Figure 2.32.: IFR with regard to multiple stakeholders (redrawn from **Mann** (2007a:142))

Mann (2007a:144-145) indicated that IFR must also be considered time dependent. The approach to achieve that is to determine the IFR for a system with the 9-Windows method (2.8.4). The major windows to observe the changes are:

Future Subsystem:- Individual elements will evolve towards their IFR and disappear through transferring of their functions to other elements;

Future Supra-System:- The evolution of other elements of the Supra-System can make the system under consideration redundant; and

Future System:- In the future the IFR of the system could be different from the current perception of the IFR.

§2.8.5.5. Perception Mapping

The different users of a system each has their own perception of it. A better understanding of a problem can be obtained if these perceptions are recorded and their relationship investigated (**Mann** 2007a:149).

The method that **Mann** (2007a:150) provides to map the different perceptions consists of the

following steps:

1. Record as many as possible perceptions about the system/problem under consideration. The minimum recommended amount is ten.
2. Determine links between the perceptions, that are 'leads-to' or'flows-to' of each perception.
3. Select a pair of perceptions that manifests a conflict or contradiction.
4. Compile a graphical map of the perceptions and their relationships.

The graphical representation will show where conflicts/contradictions, loops, chains and collector points occur. This is depicted in Figure 2.33 (**Mann** 2007a:151). In the figure the following can be observed:

1. A chain: N–M–J–A;
2. A loop: D–E–F–G;
3. Collector points: A and H; and
4. Contradiction/conflict: B.

In the problem solution phases the identified conflicts/contradictions, loops, chains and collector points will be utilised to solve problems (**Mann** 2007a:151-166).

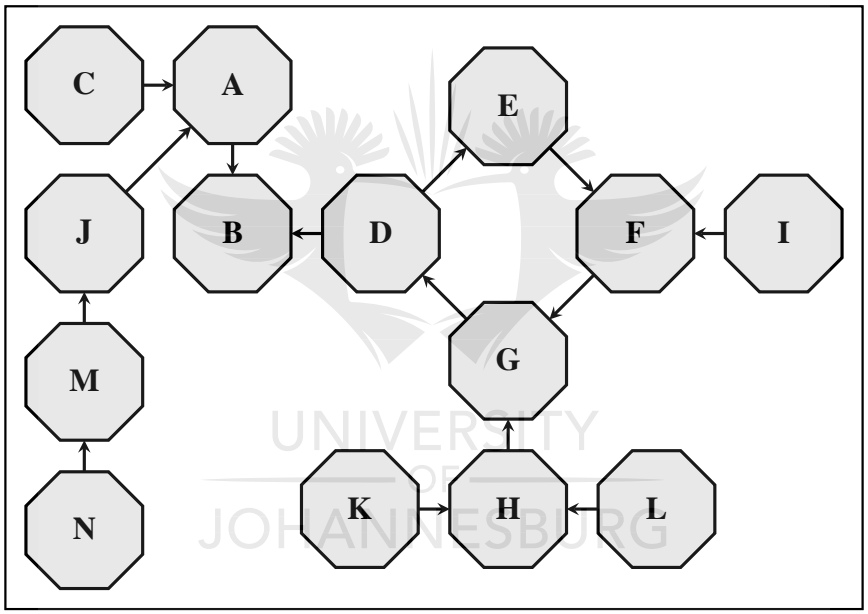

Figure 2.33.: An example perception map (redrawn from **Mann** (2007a:153))

Mann (2007a:166-167) provides the following possible extensions to perception Mapping:

9-Windows:-
a problem and its perceptions can be viewed from different perspectives;

SWOT:-
will generate many perceptions from the perspective of strength;

Six Thinking Hats:-
generates perceptions during the Red and Black Hat perspectives;

Association/Empathy:-
forces one to view a situation from another person's perspective;

Spiral Dynamics:-
ensure that the users view the problem in different thinking modes; and

Contradiction/Problem Hierarchies:-
helps in understanding the relationship between problems.

§2.8.6. Solution Approach Selection

Mann (2007a:169-178) provided the following problem characteristics as basis to select the appropriate solution approach:

1 Selection Approaches:

1. Limiting Contradictions
2. Trade-Offs and Conflicts
3. Contradictions
4. Insufficient, Excessive or Missing Actions
5. System or Function does not exist at the moment
6. Problem Absence
7. Measurement Problems
8. Problems relating to reliability or robustness
9. Cost Reduction
10. Aiming for a discontinuity
11. Targeting Disruptive Innovation
12. Finding Opportunities
13. Marketing
14. Self re-enforcing loops
15. Zero Risk
16. Optimisation
17. Unknown
18. Absence of solutions

2 Prioritisation

§2.8.6.1. Limiting Contradiction

When the assessment of a problem area in the system or an s-curve analysis indicate a limiting contradiction the recommended approach to follow is the elimination of contradictions or conflicts. If both of these have been identified it is advised to start with conflict and trade-off elimination (2.8.7.1) (**Mann** 2007a:169).

§2.8.6.2. Method and selection to solve problems

Mann (2007a:181-498) provides the following methods to solve problems:

1. Conflict Elimination/Inventive Principles (CE/IP) (2.8.7.1)
2. Contradiction Elimination (CoE) (2.8.7.2)
3. Measurement Standards (MS) (2.8.7.3)
4. Linear and Non-Linear Trends of Evolution (ToE) (2.8.7.4)
5. Resources (Res) (2.8.7.5)
6. Knowledge/Effects (K/E) (2.8.7.6)
7. Re-Focus/Re-Frame (RF/RF)
8. Trimming (Tr) (2.8.7.8)
9. Ideal Final Result (IFR) (2.8.7.9)
10. Psychological Inertia Tools (PIT) (2.8.7.10)
11. Subversion Analysis (SA) (2.8.7.11)

These will be discussed in the subsequent section and its subsections as indicated in the list. Abbreviations in parentheses after each are used to link to the Tool Selection Summary table

below (Table 2.15).

Table 2.15.: Tool Selection Choices Summary

Problem/Opportunity Situation	Suggested Solve Tool Choices			
	1st	2nd	3rd	4th
Limiting Contradiction	CE	CE/IP	ToE	K/E
Other Contradictions	CE/IP	CE	ToE	None
Harmful Actions	Tr	CE	Res	None
Insufficient Actions	K/E	ToE	CE, CE/IP	Res
Excessive Actions	ToE	K/E	CE, CE/IP	None
Missing Actions	Res	ToE		K/E
System Doesn't Exist	IFR	Res	K/E	None
System Improvement/'No Problem'	IFR	Tr	CE, CE/IP	None
Measurement Problem	MS	IFR	K/E	CE/IP
Reliability/Robustness Problem	SA	ToE	CE/IP	None
Cost Reduction	Tr	IFR	CE, CE/IP	None
System level 'Discontinuous Shift'	IFR	K/E	ToE	None
Sub-system level 'Discontinuous Shift'	IFR	ToE	K/E	CE/IP
Disruptive Shift	ToE	PIT	None	None
Opportunity Finding	K/E	ToE	None	None
Marketing/Advertising	CE/IP	ToE	None	None
Self-Reinforcing Loops	CE, CE/IP	IFR	None	None
'Zero Risk'	K/E	Res	CE/IP	None
'Optimisation'	OM	None	None	None
'Don't Know'	RF/RF	None	None	None
'No Solutions'	PIT	None	None	None

Notes:
1. Disruptive Shift, 2nd Choice refers 'Omega Life Views'
2. None: See also 2.8.7.1

§2.8.7. Problem Solving Methods

In this section all the problem solving methods provided by **Mann** (2007a:181-498) will each be briefly described.

§2.8.7.1. Conflict Elimination/Inventive Principles

Mann (2007a:181) distinguishes between trade-off or conflicts and contradictions. The first case is when two separate items are in conflict with each other. Contradictions, on the other hand, occur when a single requirement has two opposing desired states.

During the process to eliminate conflicts or compromises it is not generally the total elimination of them that could be achieved, but rather the reduction of the conflict. Successive application of this method could be required as the improvement of one parameter could worsen another. It would be the ideal to eliminate them and some methods aim to do it (**Mann** 2007a:181-498). The aim of trade-off elimination is depicted in Figure 2.34.

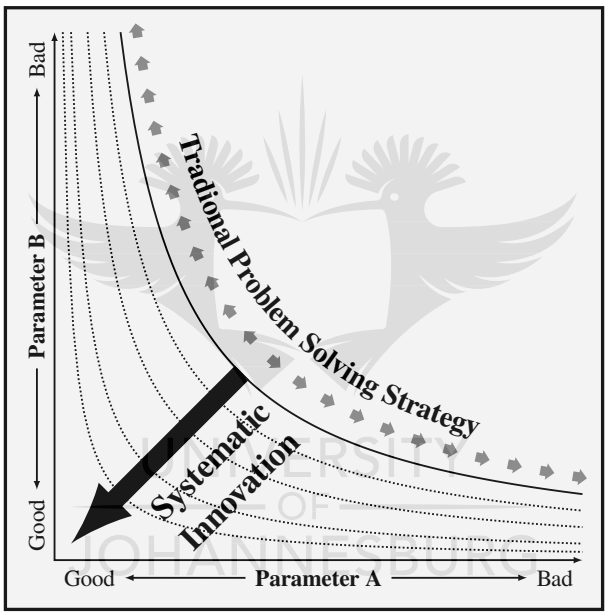

Figure 2.34.: Trade-off Elimination Process (redrawn from **Mann** (2007a:184))

Conflict Matrix for Business

For business purposes **Mann** (2007a:185) developed a 31×31 square matrix consisting of the parameters to improve as rows and the ones that worsen as columns. The business areas covered by the parameters are:: a) R&D; b) Production; c) Supply; d) Support; and e) Customer facets. In each area it covers aspects like:: a) Risk; b) Cost; c) Time; and d) Relationships. At the intersection of each row and column a set of inventive principles is given to apply in an effort to improve a parameter when another normally worsens in the process (or conflicts with the improvement). This is illustrated in Figure 2.35. The complete Conflict Matrix and the Inventive Principles is contained in Appendix B.

The matrix might not directly map to a specific problem. It is recommended to determine the actual item to improve and item(s) that conflicts with the intended improvement. From there it is advised to attempt to find possible connections to the matrix. It is also recommended investigating more than one similar parameter, the suggested Inventive Principles might then also

have common items and they should be tried first (**Mann** 2007a:186).

The process followed is related to the abstraction process as described in §2.8.3.2 and consists of three general steps (**Mann** 2007a:188):

1. Determine a generic situation from the specific situation by translating the problem into terms of the Conflict Matrix;
2. Find the best general solution by obtaining the suggested Inventive Principles from the Conflict Matrix; and
3. Translate and apply the suggested Inventive Principles to the situation at hand to obtain a specific solution.

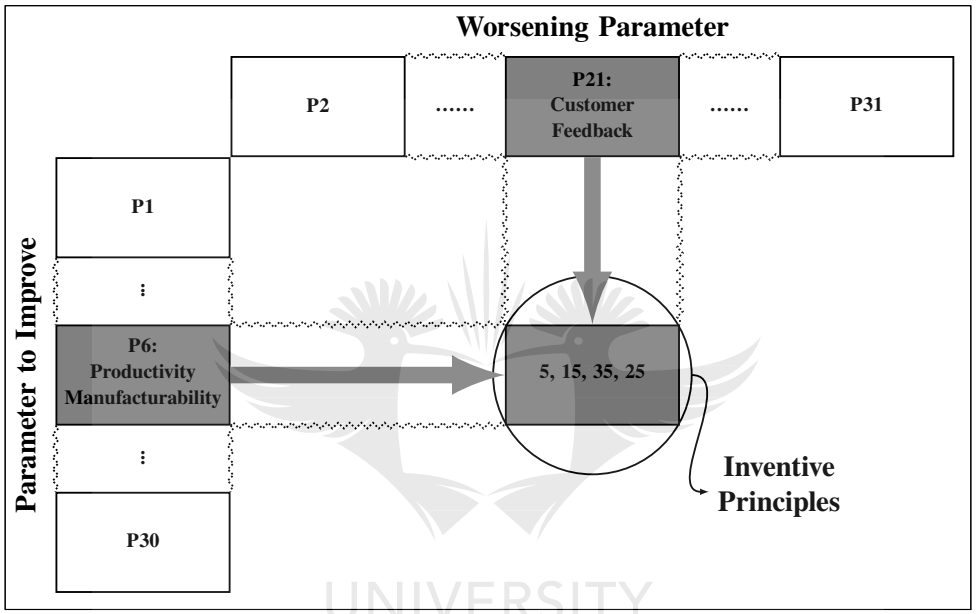

Figure 2.35.: Utilisation of the Conflict Matrix (redrawn from **Mann** (2007a:185))

Conflict Matrix does provide a solution

The Conflict Matrix might not always present a solution to a problem. In that case it os suggested that one should use all 40 of the Inventive Principles in an attempt to find a solution. Four alternative strategies to the complete set of principles are as follows (**Mann** 2007a:197-198):

1. Use a 'most commonly used' sequence;
2. Select the principles closely related to the parameters to be improved;
3. Use the complexity of the system under investigation; and
4. Approach the principles from a completely different perspective.

Most Commonly utilised sequence

Mann (2007a:198) provides the sequence to follow as being the most commonly utilised, based on experience, as is shown in Table 2.16.

Table 2.16.: Most Commonly utilised sequence (**Mann** 2007a:198)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
0	35	2	25	10	13	3	1	15	5	24
+10	6	37	28	7	29	40	19	26	17	27
+20	4	23	11	22	30	12	32	9	31	38
+30	16	14	39	18	20	34	33	8	21	36

Parameters to be Improved

This approach is based on the given additional information of each Improving Parameter (**Mann** 2007a:198-199):

1. To improve the indicated parameter specific Inventive Principles should always be considered; and
2. An averaged list, in order of decreased frequency, that should also be considered if the parameter is to be improved.

Use the complexity of the system

The complexity of a system increases up to the point of maximum complexity and then decreases as the system evolve along its S-Curve. During each of these stages different Principles are more applicable. The ones most suitable during the increase of complexity are: 1, 8, 9, 10, 11, 15, 23, 24, 27, 38 and and the ones when the complexity decreases are: 2, 3, 5, 6, 20, 25 and 40. Some principles are not sensitive to either an increase or a decrease in complexity (i.e. neutral): 4, 12, 13, 14, 16, 17, 18, 19, 21, 22, 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, and 37 (**Mann** 2007a:199-200).

A Completely Different Perspective

A different view on the principles are that they could be grouped into five strategies to change a system, based on space, time and interface (**Mann** 2007a:201):

1. Merge or Segment – change the number of items;
2. Increase or decrease the size of the items;
3. Modify the external form;
4. Modify the internal structure; and
5. Replace the existing structure with something else.

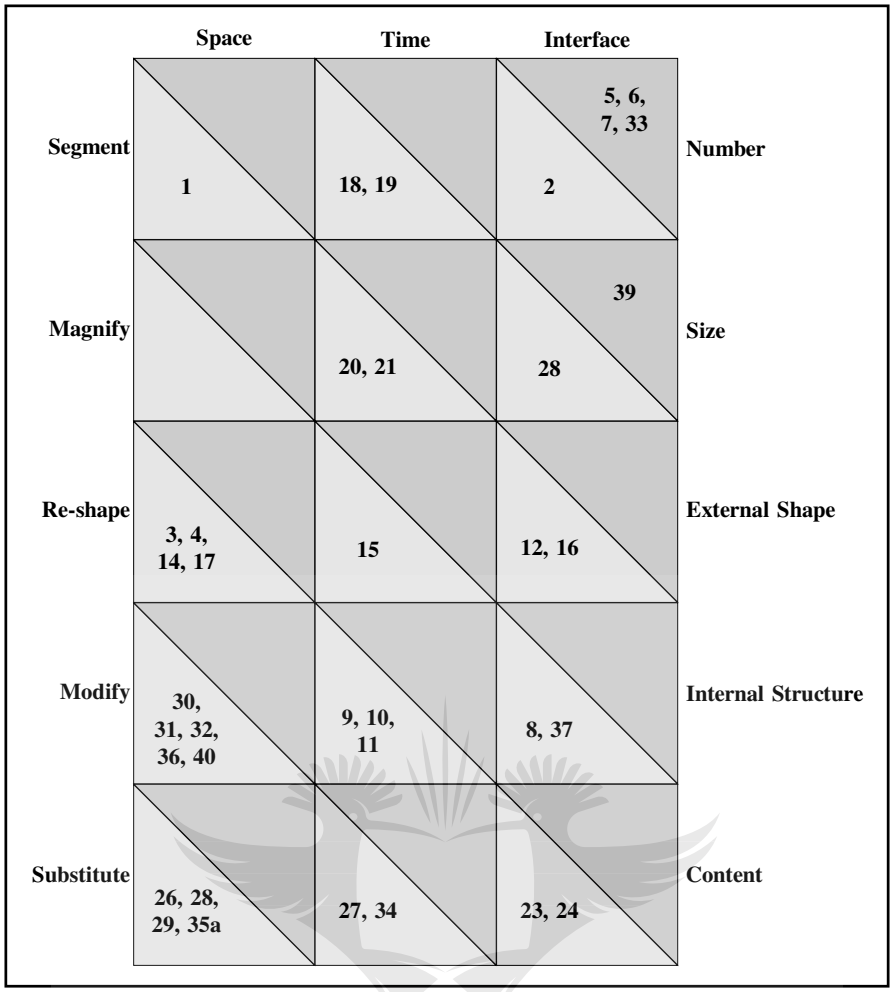

Figure 2.36.: Revised structure of the Inventive Principles (redrawn from (**Mann** 2007a:202))

The result of the different perspective is a 5×3 matrix, as illustrated in Figure 2.36. It divides every cell into a positive and negative sense. Principle 13 – 'The other way round' features implicitly in each cell. Two of the principles did not find their way into the revised structure, they are of a higher philosophical level. They are (**Mann** 2007a:202):

25 Self-Service – it is highly related to the Ideality concept.

22 Blessing in Disguise – it stimulates people to consider the resources aspect of the systematic innovation philosophy.

The revised matrix and other sources indicated that a 'change function' were not incorporated. If it is combined with Principles 22 and 25 it completes the philosophical streams of Systematic Innovation (**Mann** 2007a:203):

Functionality	-	Change Function
Resources	-	Blessing in Disguise
Ideality	-	Self Service
Space/Time	-	New 5x3 Matrix
Conflicts	-	New 5x3 Matrix

The construction of the new approach led to a richer structure, where some of the more physical

principles were expanded to the time-space and interface framework (**Mann** 2007a:203).

Mann (2007a:203) stated that research to correlate the strategies followed to the strength of the solution found that the strength of the solution directly correlates to the number of principles used to obtain it.

§2.8.7.2. Contradiction Elimination

In this section the following aspects related to Contradiction Elimination will be discussed (**Mann** 2007a:291-304):

1. Relationship between Contradiction and Conflicts;
2. Approaches to the Elimination of Contradiction; and
3. Perceived or Real Contradictions;

Relationship between Contradiction and Conflicts

Mann (2007a:291) stated that contradiction elimination is the method to use when there are two contradictory requirements for a element of the system.

Conflict elimination problems (2.8.7.1) can also be handled with this approach. In order to solve that the problem would need to be rephrased as having one parameter that has contradictory requirements. The conversion involves the determination of the core requirement, by asking questions with 'require' in them. The inverse is also possible by taking a contradiction and rephrasing it with questions containing 'because' (**Mann** 2007a:291-292). The process is depicted in Figure 2.37.

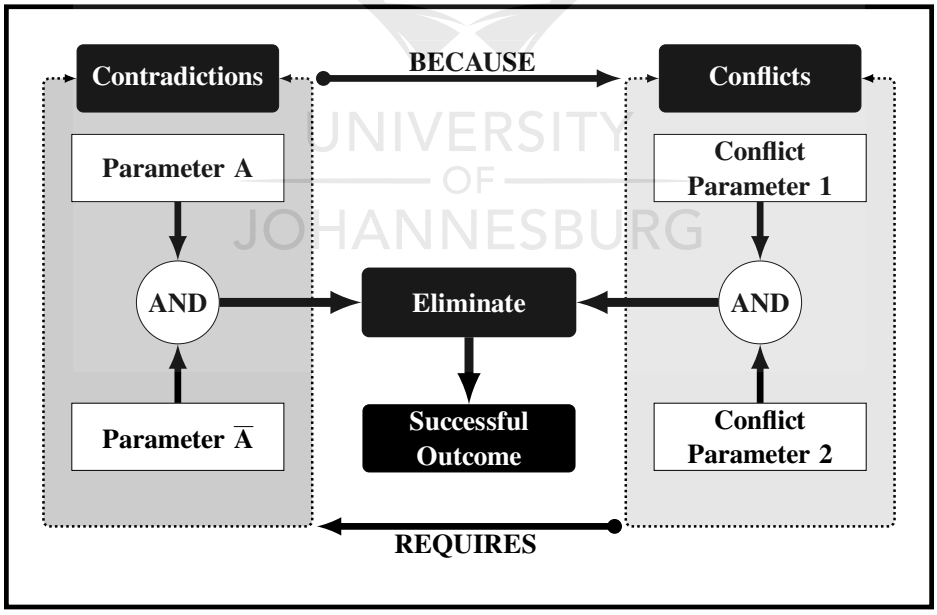

Figure 2.37.: Converting between Conflicts and Contradictions (redrawn from **Mann** (2007a:292))

Approaches to the Elimination of Contradiction

Mann (2007a:293) indicated four separation approaches to the elimination of contradictions:

1. In Space;
2. In Time;

3. On Condition; and
4. By transition to an Alternative System:
   - 4.1. To Subsystem
   - 4.2. To Super-system
   - 4.3. To Alternative System
   - 4.4. To Inverse System

The approaches should be followed in the same sequence as the above list (**Mann** 2007a:293). Ranked Inventive principles have been recommended for each separation strategy as indicated in Table 2.17.

Table 2.17.: Relationship between contradiction elimination approaches and the Inventive Principles (**Mann** 2007a:295)

Inventive Principles		**Ranked Choices for Contradiction Elimination**						
					Transition to alternative System			
No.	**Principle**	**Space**	**Time**	**On Condition**	**To subsystem**	**To super-system**	**To alternative system**	**To inverse system**
1	Segmentation	1st		3rd	1st			
2	Taking Out/Separation	2nd		6th				
3	Local Quality	3rd						
4	Asymmetry	9th						
5	Merging					1st		
6	Universality					2nd		
7	'Nested Doll'	7th						
8	Counter-Balance							2nd
9	Prior Counter-Action		11th					
10	Prior Action		2nd					
11	Prior Cushioning		4th					
12	Remove Tension				5th			
13	'The Other Way Around'	5th						1st
14	Curvature	6th						
15	Dynamisation		1st					

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Inventive Principles		Ranked Choices for Contradiction Elimination						
					Transition to alternative System			
No.	**Principle**	**Space**	**Time**	**On Condition**	**To subsystem**	**To super-system**	**To alternative system**	**To inverse system**
16	Slightly Less/Slightly More		5th					
17	Another Dimension	4th						
18	Resonance		8th					
19	Periodic Action		3rd					
20	Continuity of Useful Action		12th					
21	Hurrying		6th					
22	'Blessing In Disguise'					4th		
23	Feedback					3rd		
24	Intermediary	10th						
25	Self-Service				2nd			
26	Copying	11th	7th	2nd				
27	Cheap Disposable						1st	
28	Another Sense			10th				
29	Fluid			11th				
30	Thin and Flexible	8th						
31	Holes			7th				
32	Colour Changes			4th				
33	Homogeneity				4th			
34	Discarding and Recovering		10th					
35	Parameter Changes			1st				
36	Paradigm Shift			5th				
37	Relative Change		9th					

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Inventive Principles		Ranked Choices for Contradiction Elimination						
					Transition to alternative System			
No.	Principle	Space	Time	On Condition	To subsystem	To super-system	To alternative system	To inverse system
38	Enriched Atmosphere			8th				
39	Calm Atmosphere			9th				
40	Composite Structures				3rd			

The aim of contradiction elimination is to achieve ideality, not only adequate solutions as in the case of optimisation methods (**Mann** 2007a:301).

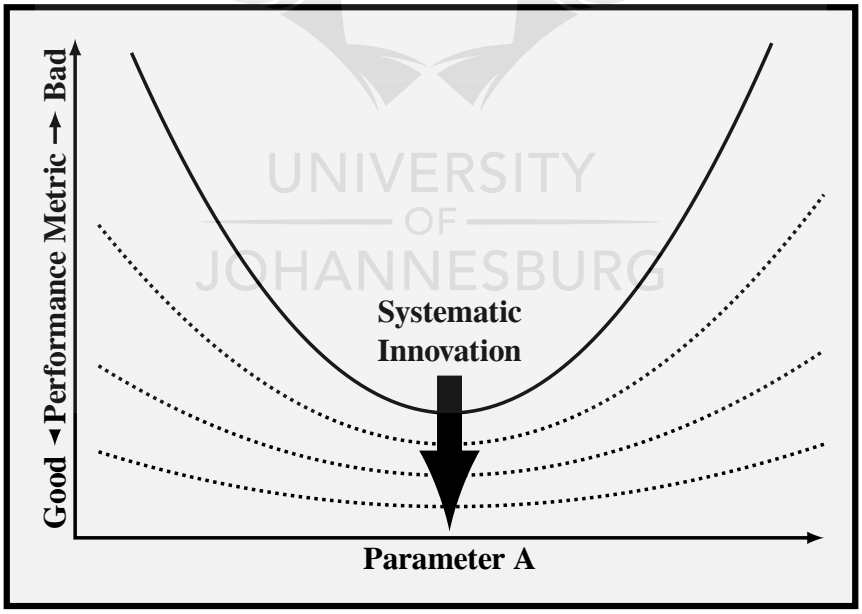

Figure 2.38.: Aiming for ideality with Contradiction Elimination (redrawn from **Mann** (2007a:301))

Perceived or Real Contradictions

In some cases a contradiction can be identified that is only based on perceptions. **Mann** (2007a:303) provides a test to determine if they are real or not. If for instance the contradiction parameter is A and the presence of it can be converted to conflict parameter 1(CP1), where the absence of A (i.e. $\overline{A}$) can be translated to conflict parameter 2(CP2). The following

test can be used to determine if the contradiction is real:

1. Determine why CP1 requires A to be in place;
2. Determine why CP2 requires $\overline{A}$ to be in place;
3. Determine why a successful outcome requires CP1 to be true; and
4. Determine why a successful outcome requires CP2 to be true.

If any of the four tests invalidate the assumption about the tested relationship a successful outcome can be generated by challenging perceptions and perceived realities (**Mann** 2007a:303-304).

§2.8.7.3. Measurement Standards

Strategies to handle Measurement Problems

Mann (2007a) provides the following strategies to overcome measurement problems:

1. Change the system to eliminate the need for measurement or detection;
2. Use a copy, image or replica to make the measurements or detections;
3. Change the problem so that successive measurement of changes would be sufficient;
4. Introduce a new item to make a measurement on that correlates to the required one;
5. If the system cannot be changed, introduce a measurable element for proximity measurements;
6. If a measurable element cannot be introduced to the proximity of the system, measure by detecting something else in the close environment;
7. Utilise psychological effects to assist with the measurement;
8. Utilise emotional effects to assist with the measurement; and
9. Utilise the opposite or inverse system to make measurements on.

§2.8.7.4. Linear and Non-Linear Trends of Evolution

Overview

The use of trends in the evolution of systems are useful in predicting the direction of systematic innovation. It also provides guidance for business on the way technology will progress (**Mann** 2007a:319).

Gadd (2011:253) states that as systems develop over time they show the following trends:

1 Increase Ideality: reducing inputs and undesired effects and increase the desired outputs;
2 Follow S-curves: systems evolve from inception to retirement;
3 Decreased human involvement: increased automation;
4 Non-uniform development of parts: different stages of development for subsystems and parts;
5 Simplicity => complexity => simplicity:- initially simple, becoming more complex until the maximum and gets simplified again;
6 Increasing dynamism, flexibility and controllability: more segmentation that leads to more parts and needs more control.
7 Increased segmentation and utilisation of fields:– size of the parts decreases until they are so small that they together become a field effect.
8 Matching and mismatching of parts:– function and functionality are matched for all parts to all the requirements, not only the prime output to render a system that meets all requirements not only some of them.

Mann (2007a:319) states that most business trends are non-linear as they display discontinuous jumps and only two of the above items are applicable to business. In his view they are:

1. Mono-Bi-Poly, which is similar to item 5 in the list; and

2. Trimming

The Mono-Bi-Poly trend is when a system expands from single items to eventually a multitude of items. It shows three different manifestations. The first is where similar things are increasing, the second when different ones increase and the last is when systems invert to deliver positive and negative functions. This is also qualified to be useful only until the system reaches the point of maximum complexity (see 2.8.5.3). Adding items to a system could also invariably increase the cost and if the benefits of the system does not increase the ideality will be lowered (**Mann** 2007a:324).

Trimming is when a system evolves to contain lesser subsystems. In business, it translates to better utilisation of less resources. This is not always the case in business, it is not generally viable. For business the point where trimming starts to be applicable is rather when the system has reached its maximum viability, after which managers are forced to produce the same results with fewer elements (**Mann** 2007a:324).

Use of linear trends in Systematic Innovation

There are many frequently published trends in the media. However, the best to use is scenario planning, as it attempts to bridge the gap between the trends and a future perspective. This also fails in many instances as the extrapolation into the future gets difficult and then an approach of oversimplifying it is taken. The Systematic Innovation approach to the difficulties is to look for when conflicts in the trends appear and then solve them (**Mann** 2007a:325).

Problem solving with non-linear trends

All the non-linear trends are jumps from one stage through a discontinuity to the next stage.

For example 'Process Thinking' is seen to have the following stages (**Mann** 2007a:359):

1. Trial and Error;
2. Process Mapping;
3. Multiple Processes; and
4. Process of Processes.

The definition of the second to fourth stages of 'Process Thinking' is as follows (**Mann** 2007a:359):

Process Mapping:- Each task is defined by a set of processes;

Multiple Processes:- The process for a certain operation or function is designed for each specific situation;

Process of Processes:- A standard master process to design processes that are adaptive to fit changing situations; with the abilities to adapt to changes in the environment and self optimisation.

Mann (2007a:359) indicated the reasons for changes between the stages of 'Process Thinking' as follows:

1. From 'Trial and Error' to 'Process Mapping':
   1.1. Reduction in one or all of: time or cost or risk;
   1.2. End results of higher quality;
   1.3. Improved communications;
   1.4. Improved progress monitoring; and
   1.5. Accreditation or certification requirements.
2. From 'Process Mapping' to 'Multiple Processes':
   2.1. Bettering adaptability to change;
   2.2. Bettering communications;

   2.3. Quality improvement;
   2.4. Customer response improvement; and
   2.5. Portfolio management improvement.
3. From 'Multiple Processes' to 'Process-of-Processes':
   3.1. Improving adaptability;
   3.2. Improving change management;
   3.3. Improving ability to handle crises;
   3.4. Improving customer response;
   3.5. Improved portfolio management;
   3.6. Improving quality;
   3.7. Employee empowerment; and
   3.8. Improved systems' 'ownership'.

Non-linear trends are typically used in systematic innovation in the following ways (**Mann** 2007a:329):

1. Determine new S-curves;
2. Improving excessive or insufficient actions; and
3. Improving the attributes of a subsystem or process.

The use of non-linear trends in determining a solution seems to bypass part of the abstraction process (2.8.3.2) by directly moving from the specific situation to the specific solution. It means that once a trend has been used to determine the next evolutionary stage, by following the complete abstraction process to obtain a specific solution, the connection can be used for other similar trends. The important part is not to determine why a trend is connected to a system, but rather why the answer is a solution (**Mann** 2007a:329-331).

Combinations of non-linear trends

The individual non-linear trends, each on their own, are useful to generate ideas, but using them in isolation introduces a risk of less understanding of the background or the situation. **Mann** (2007a:331-332) provides four methods of using them in combinations:

1. Radar plots of potential evolution;
2. Combining Trends;
3. Global/Industry-wide Benchmarking; and
4. Consideration of changes in evolutionary potential over time.

For radar plots of evolution a system is evaluated on the status on each of the applicable trends. It then shows areas where a system could be enhanced further. This method could be utilised for any business model, structure, scenario or process (**Mann** 2007a:332-337).

Mann (2007a:338) indicated that radar plots of the own system of an organisation can be compared to that of its competitors to do benchmarking. If the radar plot of an industry is used, it would become a global benchmarking.

The interactions between different trends could also be investigated, especially if potential for further evolution exists. The result would then be the possible combination of trends (**Mann** 2007a:337).

Radar plots of the evolutionary potential at different times will show the rate of change between discontinuities. It will depend on the industry of the business, in some industries the changes could be over decades while others again show multiple jumps per year. This analysis provides an indication to the timing of innovation (**Mann** 2007a:338-339).

Non-linear Trend Timing Effect

Mann (2007a:339) states that the primary driver of business innovation is the difference between the expectations ('demands') of customers and the ability of organisations to meet them ('supply'). This difference creates a primary driving force that determines the success of innovation. If the driving force is large an innovation will be accepted very fast, if it is low the innovation will fail. Hidden failures occur when the customer is unaware of an unmet requirement. The systematic innovation methodology can find unmet needs by means of non-linear trends and sub-version analysis. It can also be detected by using Quality Function Deployment (QFD).

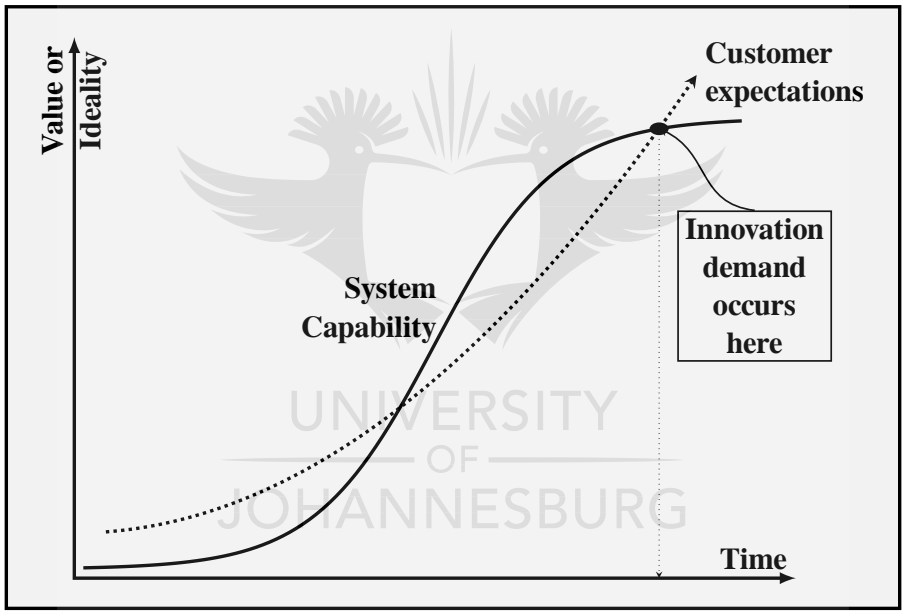

Figure 2.39.: Customer need exceeds System Capability (redrawn from **Mann** (2007a:341))

Customer expectations can exceed the system's capabilities, as illustrated in Figure 2.39. This is called an administrative contradiction. It happens when the customers get more familiar with systems and is a driver of innovation. The lag can be met with Conflict or Contradiction Elimination or by utilising the non-linear trends (**Mann** 2007a:341-342).

The other situation than can occur is when the system capabilities exceeds the customer expectations, as shown in Figure 2.40. This is the perfect time for disruptive technologies to enter the market. The non-linear trends could predict this situation (**Mann** 2007a:342).

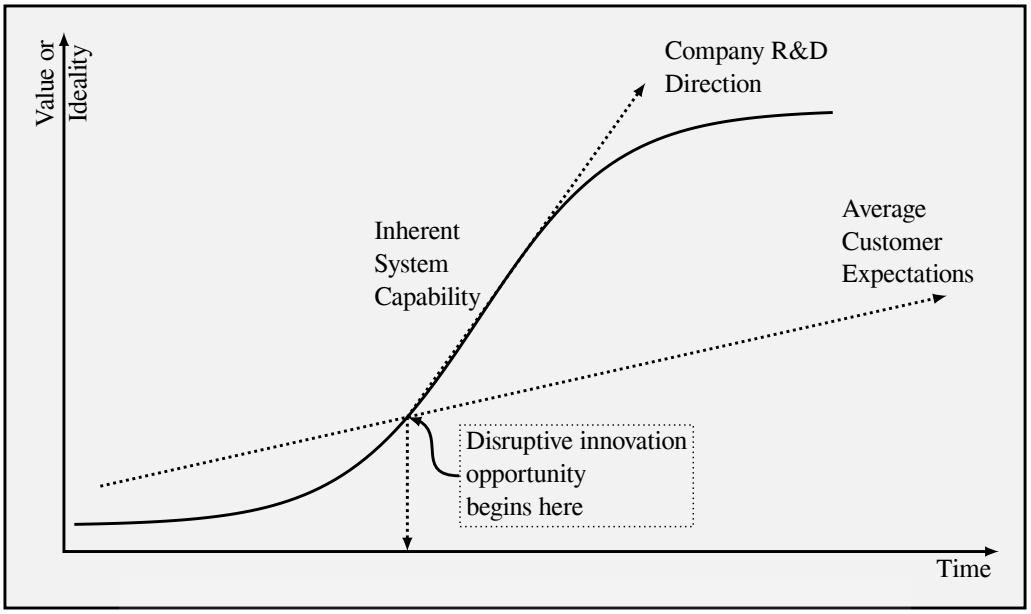

Figure 2.40.: System Capability Exceeds Customer Needs (redrawn from **Mann** (2007a:342))

Special linear and non-linear trend rules

Mann (2007a:346) stated that there are situations in which systems evolved in the opposite direction than what the listed non-linear trend predicted. It occurs in two cases:: a) according to the 'Law of non-uniform' evolution; and b) market anomalies.

Non-uniform evolution occurs because when the ideality of one subsystem decreases to increase the overall system's ideality. **Mann** (2007a:347) states it as: "The rate of evolution of different elements of a system and its subsystems is not uniform". It is more prevalent in complex systems. Due to this one must careful when analysing the trends of the subsystems in a system, as the ideality of some of them might have to decrease to increase the overall ideality.

Market anomalies can cause a temporary reverse in evolution. The most prevalent cause of this is when 'form follows fashion' phase starts in the market. The shifts in evolutionary patterns as result of these phases cannot be easily predicted, although these phases are often part of predictable cycles (**Mann** 2007a:348).

According to **Mann** (2007a:349) the most common anomaly is when cost suddenly receives all the attention in terms of ideality, at the expense of harms or benefits. It is when the reduction of costs cause the benefits to decrease that a reverse pattern of evolution would occur. This is often temporary, until the general economic situation returns to emphasise the benefits again. This could be approached by resolving the contradictions between benefits and costs plus harms.

List of non-linear trends

Below is a summary list of the non-linear trends provided by **Mann** (2007a:350, 352-394) in Table 2.18. For each is indicated the hierarchical level in the areas of time, space and interface.

Table 2.18.: Hierarchal List of non-linear trends (redrawn from **Mann** (2007a:350))

Trend	**Space**		**Time**		**Interface**	
	Use	Rank	Use	Rank	Use	Rank
Action Co-ordination			Y	1st		
Asymmetry					Y	18th
Boundary Breakdown					Y	17th
Competency					Y	5th
Connections					Y	16th
Customer Expectation					Y	1st
Customer Purchase Focus					Y	2nd
Damping			Y	7th		
Degrees of Freedom	Y	7th				
Design-Point					Y	8th
Dynamization	Y	8th				
Feedback and Control			Y	8th		
Generations					Y	24th
Horizontal/Vertical Business Cycles					Y	19th
Human Involvement	Y	9th				
Increasing Dimensionality	Y	6th				
Interaction with Others					Y	20th
Knowledge					Y	4th
Listening/Communication					Y	21st
Market Research					Y	22nd
Mono-Bi-Poly (Inc.Diff.)	Y	3rd			Y	11th
Mono-Bi-Poly (Similar)	Y	1st	Y	3rd	Y	9th
Mono-Bi-Poly (Various)	Y	2nd	Y	4th	Y	10th
Nesting	Y	5th	Y	6th		
Nesting	Up	11th			Down	13th
Non-Linearity			Y	9th		
Process Thinking					Y	6th
Rhythm Co-ordination			Y	2nd		
Segmentation	Y	4th	Y	5th	Y	12th

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Trend	Space		Time		Interface	
	Use	Rank	Use	Rank	Use	Rank
Self-Organisation Awareness					Y	3rd
Sense Interaction					Y	14th
Spiral Dynamics					Y	23rd
System Robustness					Y	7th
Transparency					Y	15th
Trimming	Y	10th				

§2.8.7.5. Resources

Mann (2007a:395) defines a resource as any item around or in a system that is not being utilised to its maximum capability. The aim is to find resources to determine solutions by utilising items that are already there.

By using radar plots to identify untapped evolutionary potential it can be determined where a system can still evolve. The areas of potential evolution are regarded as resources (**Mann** 2007a:396).

Mann (2007a:396-406) provides checklists to determine resources in the following areas:

1. Internal;
2. External;
3. Human or associated with humans;
4. Low-cost; and
5. Unexpected and Obtaining Good from Harm.

Complementors are a special case of external resources. They are organisations with whom the organisation has no current interaction in terms of customers, suppliers or competitors. Collaboration with complementors may be once off or a continued relationship, the interaction should result in a win-win for the organisation and the external party. It could also result in the merging of organisations. An example would be the co-branding of two products, which result in broader marketing, or selling unused 'wasted' outputs to an organisation that uses it as raw materials (**Mann** 2007a:399).

Mann (2007a:406) indicated that the use of checklists could be less creative in the process to determine resources. A useful approach is to investigate the less likely items as to find methods to turn them into useful resources. The same approach could also be followed with items that are considered harmful to the system. The assumptions made about a system and its contents should also be challenged.

§2.8.7.6. Knowledge/Effects

Accessing Knowledge

Businesses should research technical databases that are ordered and arranged by functions to be aware of opportunities and threats as far as technical issues are concerned. The approach to

search for business related information should be focussed on functionality. In the search process it is important to understand the context of a function as the transplant of functions without consideration to the context is deemed to result in failure (**Mann** 2007a:413-415).

Mann (2007a:415-418) provides lists of action search words in the following categories:

1. Accomplishment;
2. Creative;
3. Clerical or Detail;
4. Communication;
5. Financial;
6. Helping;
7. Management;
8. Research;
9. Technical; and
10. Negative (to use for positive ideas).

The use of action words or verbs in searches are more supportive of Systematic Innovation than would the case with only items or nouns. With the action word items could be added to further narrow it down, but the action words already serve as a filter and as way to bridge across different item terminologies (**Mann** 2007a:413-415).

Emerging Knowledge Tools

Mann (2007a:420-421) stated that there are four significant classes of tools to search for knowledge:

1. Search engines
   The ones that uses the distance between the keywords to determine the relevance of the returned information should be preferred. Google currently uses this method.
2. Semantic Search Tools
   Semantic search tools analyse sentences and then search based on the analysis. The results will also contain information based on synonyms and functional analysis of the input.
3. User-Defined-Context Search Tools
   These tools search within a user defined context.
4. Intelligent Agent-Based Search Tools
   These tools monitor the user's behaviour and connect his searches to this. Their advantage over the previous ones is that they need little knowledge or experience of search contexts to build a user profile.

Context and Wisdom

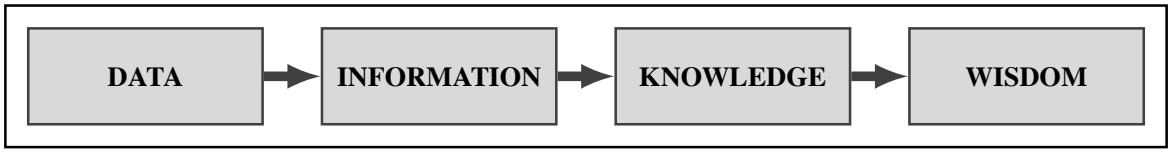

Figure 2.41.: The Wisdom Evolution Trend (redrawn from **Mann** (2007a:422))

According to **Mann** (2007a:421-422) are there discontinuity jumps between data and knowledge, as shown in Figure 2.41. Some context based tools will make the transition easier from knowledge to deployable wisdom. Wisdom is considered the successful application of knowledge into the unique and specific context of the situation.

§2.8.7.7. Re-Focus/Re-Frame

According to **Mann** (2007a:425-426) are there rare cases in which basic systematic innovation fails to render a solution. In these cases the Re-Focus/Re-Frame method should be used. It would, therefore mean all other methods have been used to no avail.

The method consists of the following steps (**Mann** 2007a:425-429):

1. Determine the 'mini-problem':
   The completed Function/Attribute Analysis (cf. 2.8.5.2) is used to identify a single key relationship that is either harmful or insufficient or excessive. It must be close to the overall system's Main Useful Function(MUF).
2. Determine the problem space, time and interface scope:
   The operational space, interval and interfaces of the key problem are determined; these must preferable only be in the proximity of the selected problem. The purpose is to define the operational boundaries of the selected problem.
3. Determine a conflict pair:
   The negative aspect within the operational boundaries of the problem and the most useful function related to the MUF are considered as a conflict pair.
4. Determine the contradiction:
   One conflict pair is chosen from step 3. and used to define a contradiction. It is recommended to use the negative aspect as the point of departure for the definition of a contradiction. The contradiction should be defined in terms of space, time or interface when it is required and when it is not.
5. Determine the IFR:
   Determine the IFR for the defined contradiction.
6. Determine the X-Element:
   Determine an imaginary element close to the negative aspect that would solve the problem. This should take the format of a specification.
7. Analyse the resources:
   Analyse the resources in and around the system to determine if any of them could be used to achieve the requirements of the X-Element (6.). The process is started from the key element and expanded until the all resources of the overall system has been considered. If a resource has been identified, the problem is probably solved.
8. Change the resources:
   The resources are then considered from the same starting point as in step 7., given that one has not been identified that could solve the problem, but in this step two other considerations are used on each considered resource:
   a) Could it be changed to deliver the X-Element? or
   b) Could it be combined with another resource to achieve the desired result?
   If a changed resource or a combination of resources has been identified, the problem is again probably solved.
9. Utilise principles for removing contradictions:
   Use the approach described in the Contradiction Elimination methods (§2.8.7.2) to solve the contradiction defined in step 4..
10. Utilise principles for removing conflicts
    Utilise the approach described in the Conflict Elimination/Inventive Principles methods (§2.8.7.1) to solve the contradiction defined in step 3..
11. Utilise Knowledge:
    Examine the contradiction in terms of the relationship between the useful function and the undesired/negative aspect to determine if knowledge (2.8.7.6) from other areas exits that can retain the useful part and remove the existence of the negative aspect.
12. Absence of solution

If this step is reached it is recommended to return to explore another option from steps 3. or 4. and repeat the steps from there. Should all the options from these steps be exhausted it is advised to return to the original Function/Attribute Analysis and determine an alternative negative relationship to utilise with the whole process again.

§2.8.7.8. Trimming

This method links to the 'Trimming' trend mentioned in §2.8.7.4. The trend shows the evolution of systems by decreasing the amount of included elements and still maintaining its functionality or even in some cases increasing it. Trimming is only suitable while the system has not reached maturity, as is shown in Figure 2.42 (**Mann** 2007a:437).

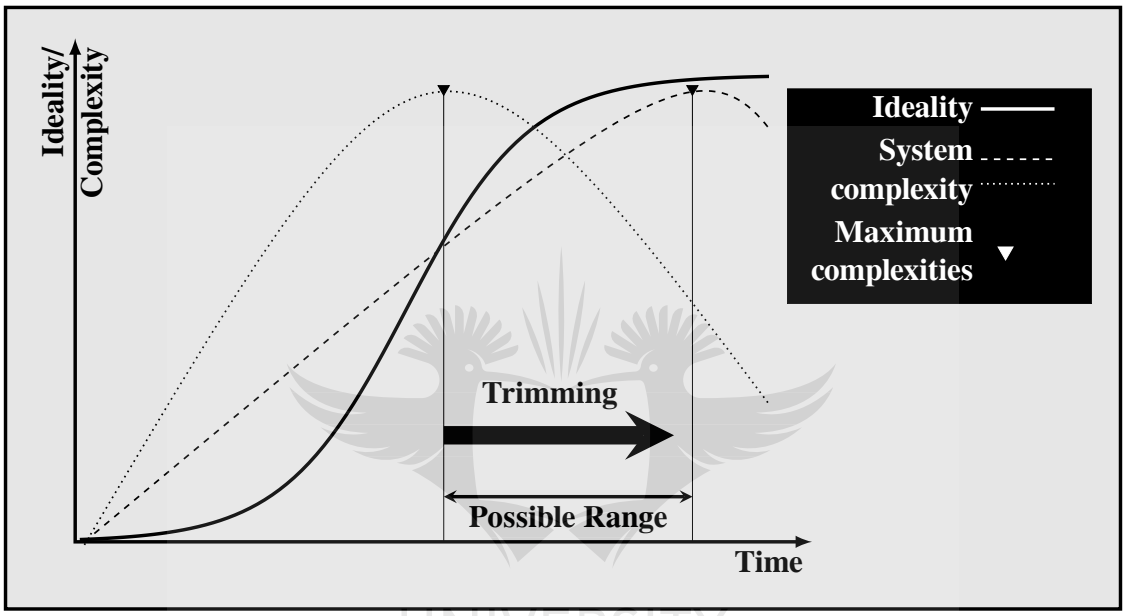

Figure 2.42.: Trimming versus System Evolution (redrawn from **Mann** (2007a:437))

Trimming Tool

The Trimming must be done after a complete Function/Attribute Analysis (cf. 2.8.5.2) has been done to avoid creating problems. The basic steps of Trimming are (**Mann** 2007a:437):

1. Verify the requirement of functions;
2. Consider transferring functionality to other elements;
3. Consider modification of another element to render the useful functionality;
4. Consider transferring the function to an element or resource in the environment;
5. Consider modifying an element or resource in the environment to render the useful functionality;
6. Consider combining elements to perform the functions.

If the system being evaluated is process based the steps are as follows (**Mann** 2007a:441):

1. Verify the requirement of functions performed by the process step;
2. Consider transferring the functionality to other steps;
3. Consider modifying of another step to render the useful functionality;
4. Consider introducing a new, simpler step to perform the same function(s);
5. Consider the modification of a step from a different existing system to render the same functionality;

6. Consider combining other steps to perform the functions.

Mann (2007a:441-442) gives the following recommended hierarchical sequence to select items or processes for trimming:

1. Elements with the biggest number of inadequate, excessive or harmful characteristics;
2. Elements with the highest relative value;
3. Elements higher in the functional hierarchy; and
4. Elements that render the least amount of useful functions.

Higher level view of Trimming

In using the Trimming Tool there are three higher level aspects to consider in determining the viability of it. They are:

1. Function capture;
2. Viable system evaluations; and
3. Situations when the functionality of elements are connected.

Function Capturing

Mann (2007a:442) recommends the use of the 9-Windows tool (2.8.4) to ensure that the relationships around a function that is considered for trimming are taken into account. This is illustrated in Figure 2.43.

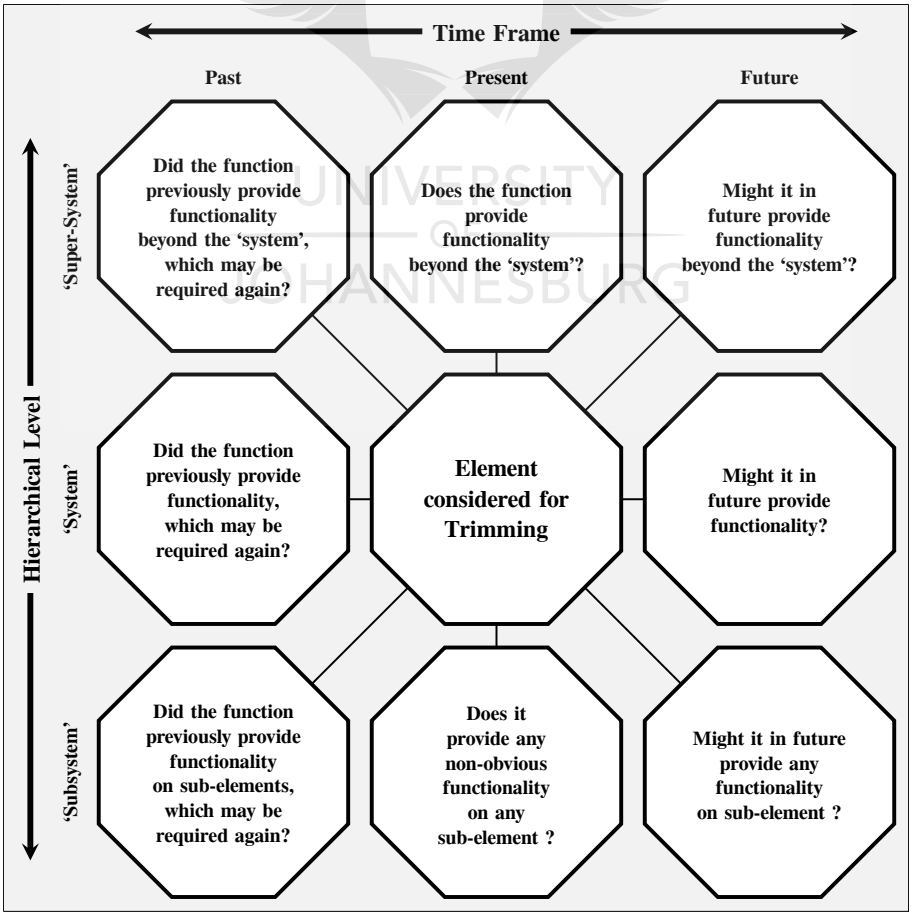

Figure 2.43.: 9-Windows Functionality Capturing (redrawn from **Mann** (2007a:442))

Viable System Model

According to **Mann** (2007a:443) are there five necessary conditions for a system to be viable:

1. Implementation
   The parts of a system responsible for providing the primary functionality of the system. Its subsystems' responsibilities are to provide the value-adding functions of the system under consideration.
2. Co-ordination
   Systems to coordinate the interfaces of the value-adding functions. In this framework it also requires common values and standards.
3. Intelligence
   This is the two-way link between a system's primary activity and its external environment. The first part of it is feedback from the external market place and other external factors. The second part is projected image and identity of the system in the environment.
4. Control
   This is the two-way communication between the entities in the system.
5. Policy
   This provides clear direction, values and purpose to the system.

Connect Functional Requirements

Mann (2007a:445) states that when organisations survive and grow through several discontinuous evolutions Trimming could be influenced by coupling effects. In these organisations complexity will go through a repeated increase decrease trend as in illustrated in Figure 2.44, which is called autopoietic (self-maintaining and self-regulating). From the figure it can be seen that the overall level of complexity effectively increase over time.

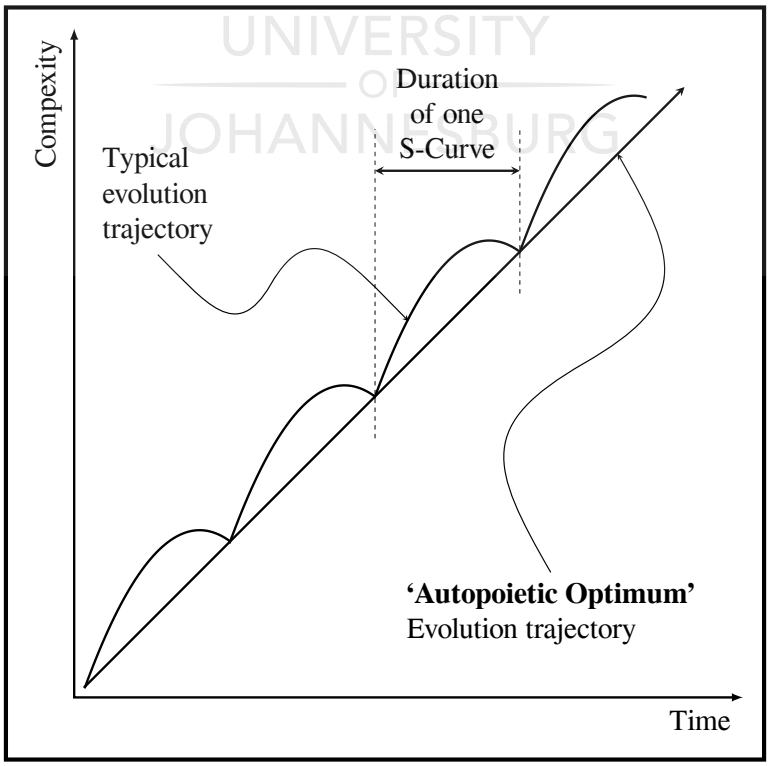

Figure 2.44.: System and Complexity Evolution (redrawn from **Mann** (2007a:445))

The 'control' element of a viable system is the one that is most likely to be trimmed. The result is that management of organisations are trimmed with the aim to instil self-organising into the remaining personnel. The danger is that the organisation may go below its autopoietic ability level and not recover from the trimming. The recommended approach is to recognise the coupling that exists between different functions to the higher-levels of the organisation (**Mann** 2007a:445). This is illustrated in Figure 2.45.

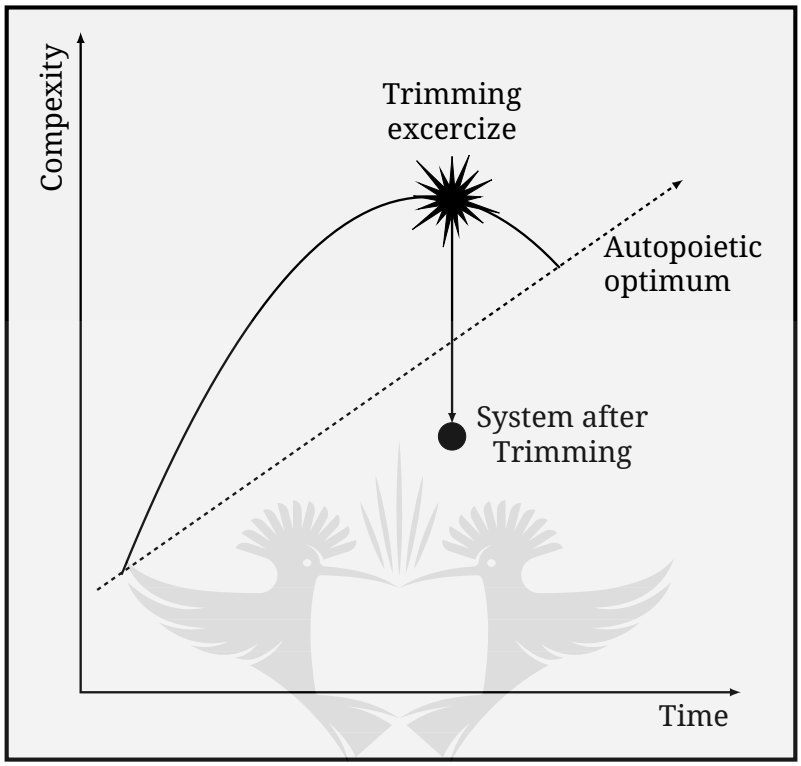

Figure 2.45.: Below autopoietic level Trimming (redrawn from **Mann** (2007a:445))

§2.8.7.9. Ideal Final Result

Ideality and IFR are also utilised to solve problems, i.e. to generate solutions. Two aspects that provide problem solving tools are (**Mann** 2007a:453):

1. 'Self' solution trigger; and
2. Connecting to the resources and system hierarchy.

'Self' Solution Trigger Tool

According to **Mann** (2007a:453) is it important for systems to include solutions that have a 'self' property, as in self-managing, self-correcting and self-organizing in their relationship to ideality. It is vital to seek the inclusion of self-x into the fundamental design of a system. The ideal concept is to achieve a state in systems where they solve problems by themselves.

There is a difference between the classical and ideality approaches to system evolution, as is illustrated in Figure 2.46. In the classical approach the complexity is increased until the point of maximal complexity and then decreased. In technical systems this can be ascribed to lack of knowledge that is potentially also partially true for businesses. The main reason for it to occur in business is the absence of consideration for existing systems, which can be avoided if the right foundation is used at the start (**Mann** 2007a:454).

The ideality-driven approach will attempt to have systems that render useful functions 'by themselves', with the result to avoid some wastage that inevitably comes with the extravagant rise in complexity suggested by the trend. It is not an approach that is limited to the start of the s-curve, it can also be introduced anytime, the most benefit can be expected before the point of maximum complexity (**Mann** 2007a:455).

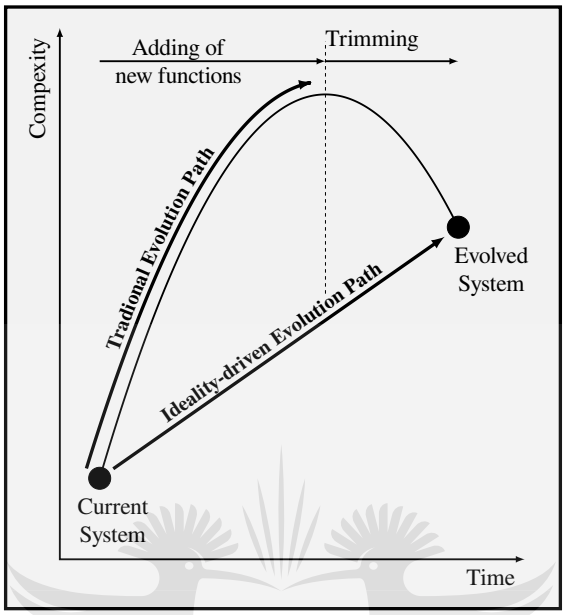

Figure 2.46.: Traditional versus Ideality-driven Evolution (redrawn from **Mann** (2007a:454))

'Self' and the problem at hand

The concept of IFR, and the idea of finding for solutions that have 'self' properties is a very powerful aspect of systematic innovation. Overlap exists with the contradictions elimination and Inventive Principle 25, 'Self-Service'. Combining 'self' and the specifically IFR concept creates more holistically valid solutions. If the IFR method presents a problem it is recommended to define the IFR and then work back. The IFR approach will first define the desired function and then find a way to render it by using the resources and without increasing the complexity as is common in the traditional approach (**Mann** 2007a:460).

Resources and System Hierarchy

Ideality is closely linked to the identification and maximal utilising of the resources within a system. The core concept of improving ideality is to get the same or more functionality with always fewer resources. Three methods exist to identify resources:: a) resource trigger databases (2.8.7.5); b) evolutionary potential (2.8.7.4); and c) system hierarchy (**Mann** 2007a:460-461).

Defining the IFR of an element at a high level is not useful for identifying resources, but defining it at the lower levels, can be useful. It provides the opportunity to determine other items that already exist in the system that would enable fulfilling the function of the element that is being attempted to evolve to its IFR. This is tied to Trimming (2.8.7.8), where evolution happens at the lower levels by achieving the IFR of the elements and then they disappear from the system (**Mann** 2007a:460-461).

§2.8.7.10. Psychological Inertia Tools

According to **Mann** (2007a:465) psychological inertia (PI) breaking tools are utilised in two main scenarios:: a) difficulty is experienced in obtaining a solution; and b) the tools suit the particular way of solving the problem. The first is the only one discussed further. In both cases the idea is to force thinking from a different perspective about a problem by means of a systematic shift to a position where the probability of finding a solution is high.

The tools presented have had demonstrably beneficial impact in the context of solving management problems. Five techniques are recommended (**Mann** 2007a:465):

1. 9-Windows (with specific application as a psychological inertia breaking technique);
2. Least-Ideal Final Result;
3. Size-Time-Interface-Cost;
4. Why-What's Stopping Analysis; and
5. Omega Life View.

9-Windows

Mann (2007a:465-467) states that to use the 9-Windows as a means to break psychological inertia each of the eight neighbouring windows to the system being considering is filled with question: "Is the REAL problem or SOLUTION here?". This shown in Figure 2.47.

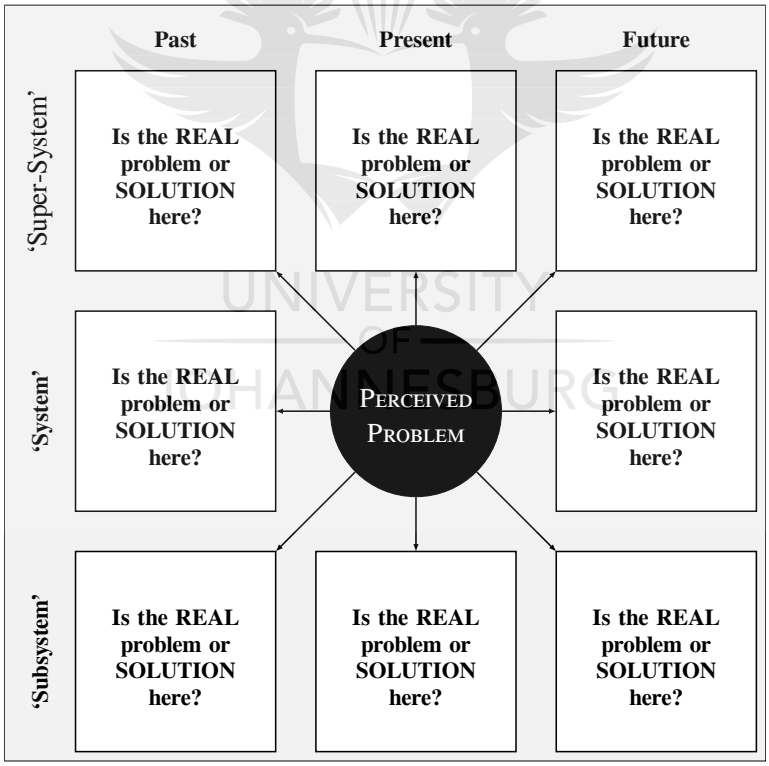

Figure 2.47.: 9-Windows as Psychological Inertia Breaking Tool (redrawn from **Mann** (2007a:467))

Least-Ideal Final Result

The combination of IFR with the Mono-Bi-Poly (Increasing Differences) trend leads to the idea of a negative Ideal Final Result (-IFR), or Least Ideal Final Result ($\overline{\text{IFR}}$) (**Mann** 2007a:468). It can be considered as the polar opposite of IFR, as illustrated in Figure 2.48.

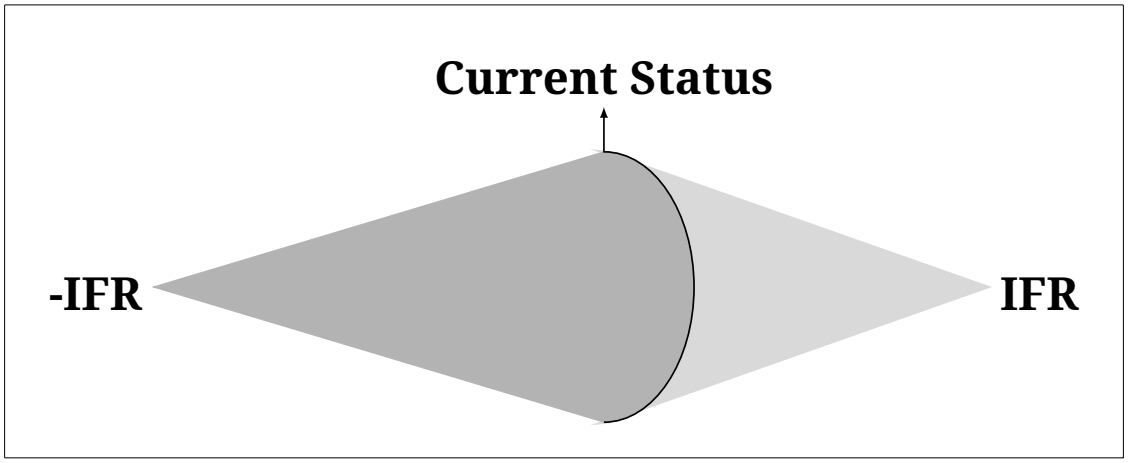

Figure 2.48.: Ideal Final Result vs Least Ideal Final Result (redrawn from **Mann** (2007a:468))

Mann (2007a:468) defines Least Ideal Final Result as all the undesired characteristics in the system, like zero reliability, infinite cost, etc. This approach forces the participants to break Psychological Inertia by moving away from a normally positive view. The results of this process is then inverted to obtain a desired state or IFR.

Size-Time-Interface-Cost Tool (STIC)

This approach is an extension of the size-time-cost method that appeared in some original TRIZ texts. The inclusion is to add an interface perspective. The concept of the approach is to move from the current values of these parameters to their extremes: 0 and ∞ as shown in Table 2.19. From these perspectives a better solution may be found (**Mann** 2007a:469-470). The current values is seen as the centre in a graphic representation as in Figure 2.49. To avoid stagnation the participants could be split into smaller groups and the different perspectives divided between them.

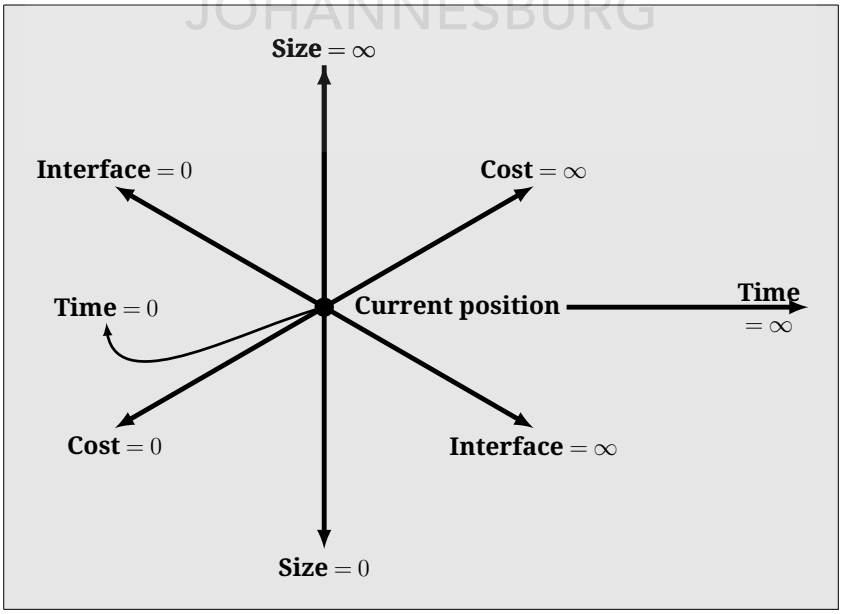

Figure 2.49.: Size-Time-Interface-Cost shifting to a different perspective (redrawn from **Mann** (2007a:470))

Table 2.19.: Parameter Extremes (**Mann** 2007a:470)

Physical Size (S) was	Zero	Infinite
Time (T) to deliver function was	Zero	Infinite
Number of Interfaces (I) was	Zero	Infinite
Allowable Cost (C) was	Zero	Infinite

Why-What is Stopping

Mann (2007a:472) stated that this approach was brought to systematic innovation from other fields. The purpose of it is to establish a hierarchy problem statement, as stated in §2.8.5.1. This is important as in many instances it could be discovered that the problem started with is not the one that should be solved. As a method to break psychological inertia it would be used after a solution could not be found with the use of all the systematic innovation steps.

The approach provides a structure to visualise a problem statement in its broader and narrower contexts. The common situation that it should overcome is when the definition of the problem starts with: "The problem is …" and within a short span of time a full description of how to solve the problem is developed; the validity of the definition has not been verified (**Mann** 2007a:472). This process is depicted in Figure 2.50.

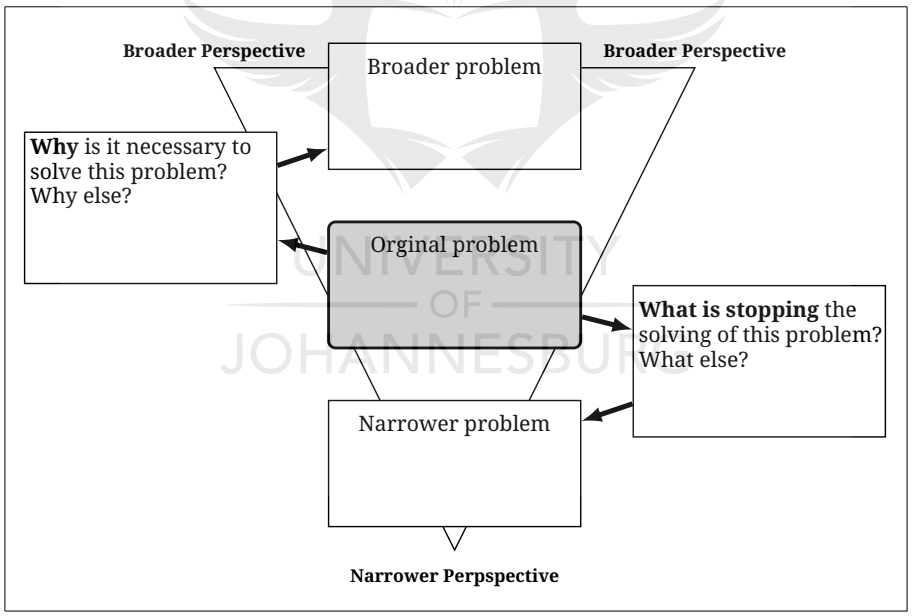

Figure 2.50.: 'Why-What is Stopping?' Framework (redrawn from **Mann** (2007a:472))

According to **Mann** (2007a:473) this process can be continued to higher and lower levels. It can also be useful to combine it with the 5W+H method (**Mycoted** 2006a), by asking Who, What, When, Why and How at each level (see also 2.5.1). To break psychological inertia, however, it would be better to stay with: "Why and What".

Omega Life View

This method is used especially to determine potential disruptive innovation opportunities. It is intended to solve a problem from another person's perspective and to shift ones view of a problem

to the perspective of someone else can be very effective. It must be used carefully as the amount of other people's perspective could become impractical. It should be limited to seven or eight other views (**Mann** 2007a:475).

Furthermore, one could easily only focus on the most useful profiles as a point of departure, like that of the average customer and disregard the extremes. Using this profile would result in being about the same as the competitors or being followed quickly by them. It could also be reasoned that by catering for the majority, the potential loss of customers is about 1% and that is not important. By focussing on the extremes or Omegas, however, one will find ways to displace the normal way of doing things and discover disruptive innovation opportunities (**Mann** 2007a:475-476).

The method has been designed to improve the rate of success in finding disruptive innovation without focussing on the wrong Omegas. The first element is to determine which Omegas to use in the process and the second element is to ensure the suitability of the disruptive solution (**Mann** 2007a:477).

The process consists of the following steps (**Mann** 2007a:477):

1. Determine the aspect to be improved;
2. Determine a range of Omegas, preferable at both extremes, i.e. possible customers that at the moment lie on the outsides of the normal curve;
3. Compile a list of aspects they would consider ideal from their perspective;
4. Determine the common ideal requirements and conflicts between all the Omegas;
5. Investigate if any of the commonalities suggests possible disruptive opportunities;
6. From the common aspects also determine what stops the current process from providing in these requirements to determine other conflicts; and
7. Investigate methods to eliminate all or at least some conflicts.

§2.8.7.11. Subversion Analysis

The aim of this section is to show methods to build business solutions that are more robust. This would create businesses that have a longer life expectancy. This was derived from the approach used by engineers to design systems for hostile environments (**Mann** 2007a:481).

Robustness Definition

Dickinson (2006) defined robustness in terms of product performance as being insensitive to variation, both in manufacturing and utilisation. **Cho** and **Eppinger** (2005) see process robustness of a product development project as being less sensitive to variance of project parameters, leading to less variance of project lead time. **Dieter** and **Schmidt** (2009:21, 41, 325) stated that it refers to the consistency in excellent performance of components due to variations introduced during manufacturing or under variable conditions of the intended utilisation environment. *In all cases it shows that the end-result is insensitive to variation in construction and the environment it operates in.*

Kazi, **Wohlfart** and **Wolf** (2007:435) states that the important factors to achieve a high level of business robustness are as follows:

1. Knowledge of the organisation's strong capabilities and distinguishing characteristics, i.e. it is identity;
2. The flexibility to adapt to changes in the market and to capitalise on them, i.e. an adaptable organisational strategy and organisation;
3. Flow of information, a learning culture and teamwork, i.e. the internal environment enables

adaptability; and
4. Implementing successful methods to monitor important tendencies and evolution, i.e. proficient forecasting.

Unruh (2016) states the secret of business resilience is not a condition of any single factor. It is a systems condition, a community condition and a condition of interdependence, but not independence.

Mann (2007a:482) states that robustness is the same as the concept of reliability in the framework of engineering. History also shows that it is generally only considered at a late stage in the evolution of systems, during the maturity stage of the system just before an attempt is made to minimise the costs. The problem is it is too late at that stage and it is then an add-on to the system instead of a core characteristic of it.

Robustness is defined as the probability that a system will perform (**Mann** 2007a:482):

1. Without failure to a specified standard,
2. For a given time,
3. In a defined environment,
4. When operated correctly.

It is a probability, therefore it is number between 0 and 1.

It can also be seen as (**Mann** 2007a:483):

$$\text{Robustness} = 1 - \text{Failure}$$

The robustness of a system depends upon the relationship between the tasks the functions is expected to perform and the capacity and capability corresponding to the elements assembled to render the required result. Tasks and capability both will show a degree of variability. The aim is to design the system so there is no interference between the distributions of these as depicted in Figure 2.51. It means that the most testing task will always be within the system's capabilities (**Mann** 2007a:483).

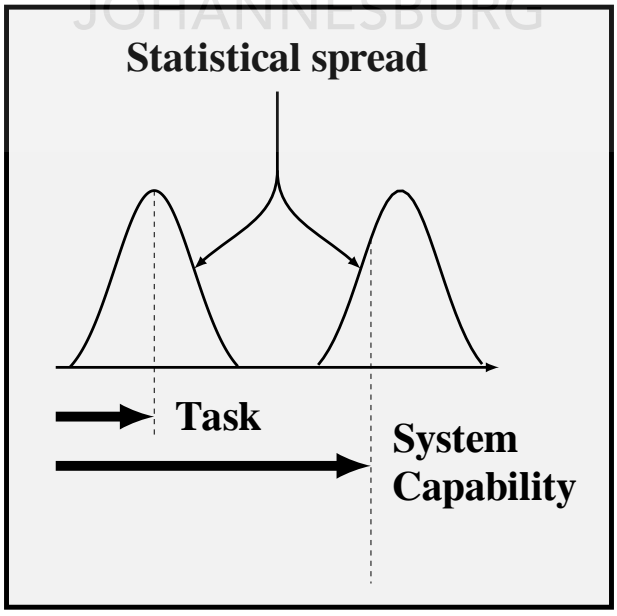

Figure 2.51.: Task-Capability distributions without interference (redrawn from **Mann** (2007a:483))

According to **Mann** (2007a:482-483) in reality interference occurs as indicated in Figure 2.52. The overlap indicates that the system is lacking capability on some tasks, which means that system failure will consequently occur. This typically happens, in terms of ideality, when the drive to generate benefits move the tasks to the right and the result of competition drive the capability to the left. In reality an attempt is made to trim the capability by means of inspection and testing and trim the tasks by limiting the customer in terms of demands. The contradiction in both instances is that it is the limits and measures introduced that create robustness problems, as they tend to fail. It is a case of solving one set of problems by introducing new ones.

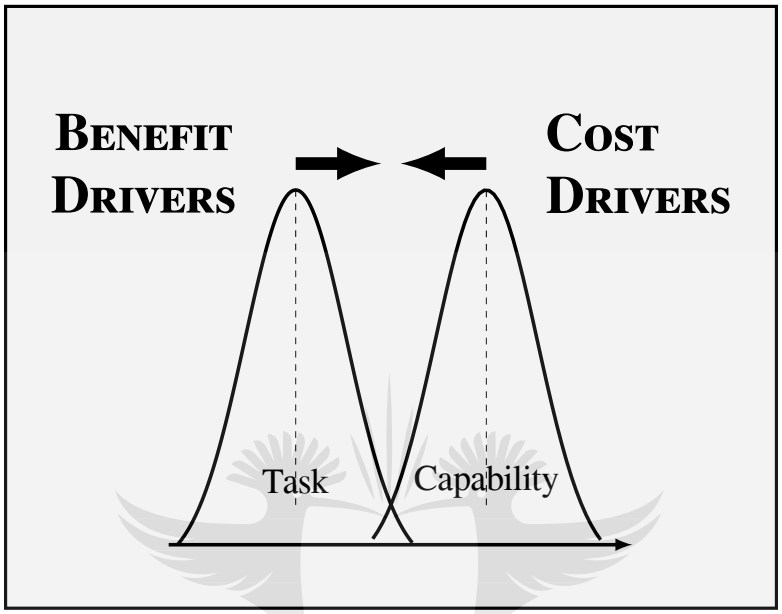

Figure 2.52.: Task-Capability distributions with interference (redrawn from **Mann** (2007a:483))

The contradiction typically occurs because the initial system was over-engineered and then due to competitive pressures it is shrunk. Managers are driven to obtain more output from the available inputs, but due to repeated shrinking the system is driven beyond its capabilities and it eventually fails (**Mann** 2007a:484).

Strategies and Tools to improve Robustness

Mann (2007a:485) discusses five techniques and tools that can be used to create more robust systems:

1. Top-Down System Analysis
2. Bottom-Up System Analysis
3. Red/Blue Teams Subversion Analysis
4. Robustness Trend Patterns
5. Robustness Contradictions

Top-Down System Analysis

To analyse a business by means of a Top-Down method would require the developing of a fault tree. It involves asking "How could this failure occur?" while identifying potential causes of failure during the design of the system. The steps to conduct a fault tree analysis are as follows (**Mann** 2007a:485-486):

1. **System definition:** compile process flow charts and Function/Attribute Analysis (FAA)

models.

2. **Select main events.** Main events are operational system failures. These may be partial or complete failures. It is important to select the events that would have the most severe consequences and specifically the ones most likely to happen.
3. **Construct a fault tree.** By pursuing the FAA models from the main event along the paths of the functional relationships, these events may be connected to more basic ones. The events are connected by means of logic gates, OR gates if only one input is required and AND gates if all the events are needed for the failure. Simple models will consist only of OR gates, if a system contains redundancy it will have AND gates.
4. **Primary events.** Every branch of the fault tree must end in a primary event that represents a basic element that needs no further investigation. Primary events should be completely independent and analysis of them should determine the most probable reason for the main event's failure. If the failure of the main event is considered catastrophic, it should be desirable that no single primary event be the only cause of it. Multiple redundancy could be deployed to ensure that the failure occurs only when several primary events fail simultaneously.
5. **Probability analysis.** The probability of a primary event is defined as the probability that it occurs at least once during the intended life of the system. Estimates or other data can be utilised. This step is executed if a quantifiable assessment is required, which can be used to determine relative improvement and as an indication of the risk associated with an organisation.

Bottom-Up System Analysis

This method is considered the complementary approach to the Top-Down Analysis, except it is started from the bottom layers and built-up to the top of the system. It corresponds with the question: "What happens if this item fails?". It is most useful when applied to systems without redundancy. It is based on the 'Failure Modes and Effect Analysis' (FMEA) method. This process is tiresome and time-consuming and consists of the following steps (**Mann** 2007a:486-487):

1. **System definition.** Compile a Function/Attribute Analysis (FAA) model.
2. **Failure mode analysis (FMA).** All possible failure modes for each element and operational sequence is determined and if possible the relative frequency of occurrence may be compared.
3. **Failure effects analysis (FEA).** The impact of each identified failure of each element is determined on its function and on the system and its operation. In the worst case of the consequences of each should be identified and the severity of it determined from being critical to being minor to the rest of the system.
4. **Criticality analysis (CA).** Every identified possible failure may then be ranked in terms of the probability and severity of its occurrence. If insufficient data is available, it may also be done qualitatively. This may be plotted on a graph with severity and frequency of occurrence as the axes. Other aspect may also be included in the severity factor, like the cost/difficulty of monitoring, maintenance cost. Robustness may be improved by duplication, redundancy, improved item design or changes in the system design. The condition of critical items may also be monitored to provide indications of deterioration or impending failures.
5. **Documentation.** The details of the FMEA/FMECA process should be recorded with remarks.

Limitations of FTA and FMEA

Mann (2007a) indicated the following limitations of Fault Tree and Failure Mode and Effect analyses:

1. Both are tiresome time-consuming processes on large systems. The Pareto Principle is commonly applied, by concentrating on the failures of the main events with the highest

occurrence or severity.
2. They do not positively determine main events or failure modes or effects and some may be overlooked. FMEA tends to give attention mostly to the physical structure and can overlook the impact of external dangers such as errors introduced by operators or unknowingly by customers. Problems due to intangible factors can be difficult to detect and mitigate against. FTA may completely miss the existence of significant classes of system failures by failing to take into account their likeliness.
3. It is not simple to combine the robustness of elements that operate in parallel and series especially when their relationships are periodic or temporary.
4. It is not simple to accommodate the gradual degradation of processes, especially where intangible factors are involved.
5. Published historical data is lacking and as business systems are complex it would be difficult to use historical data.

Red/Blue Teams Subversion Analysis

This process works by giving the Red Team the purpose to actively try to 'put' the Blue Team out of business. The Red Team can be a small group of people who have to try to find the competitors might do before the what competitors themselves have the opportunity to do it (**Mann** 2007a:487).

Subversion Analysis is done along the same lines by requiring users to try to creatively and with divergent ways show how they could destroy the system. A robustness problem expressed in this way is changed into an inventive one and the systematic innovation processes can be utilised to determine a 'solution'. From this perspective there are in accordance with ideality four aspects to consider determining threats to the system (**Mann** 2007a:488):

1. Systems that render more benefits;
2. Systems that cost less to operate;
3. Systems that possess less 'harmful' effects; and
4. Systems where the customers perceive the ideality to be higher.

According to **Mann** (2007a:488-489) are there, apart from ideality, three other main aspects that must exist before a solution is a threat:

1. A solution must be producible in sufficient quantities, else it is not a threat;
2. A path or route to the market must exist, which is mostly the logistics, but also any ability or requirement required to move it from the supplier to the market; and
3. A demand must exist for the ideal solution.

The total requirements for a competitive threat is graphically depicted in Figure 2.53.

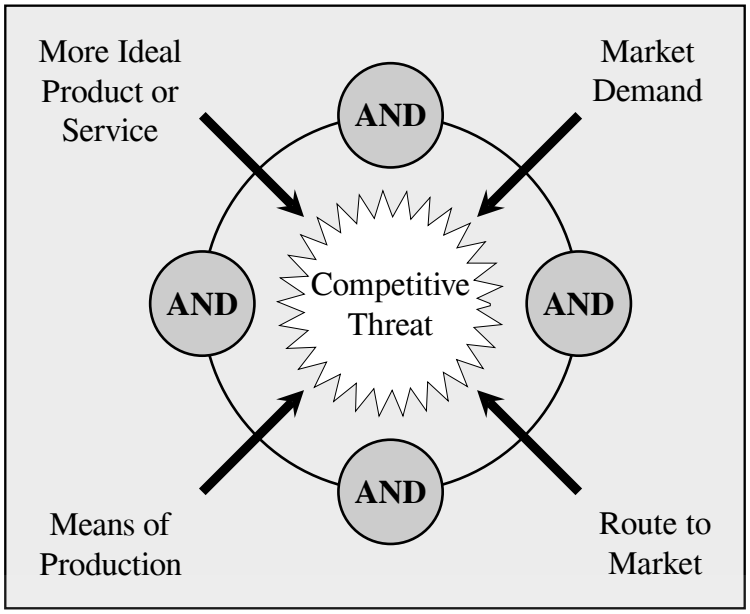

Figure 2.53.: Essential Attributes of a Competitive Threat (redrawn from **Mann** (2007a:489))

While considering these attributes it must be remembered that different customers have different perceptions if ideality. For robust businesses disruptive innovation is of special concern and due to that the 'more ideal' test in a competitive analysis would fail. The disruptive innovation may be more ideal to people who are not currently customers of the business as they view ideality from a different framework as the current ones do. Disruptive innovations have the potential to destroy a system (**Mann** 2007a:489).

The 9-Windows approach is used to determine where and when threats may emerge. It may also indicate that threats to robustness might as well emerge from inside the system. The four threats should be evaluated in all the windows, because if one of them is lost the robustness is under threat (**Mann** 2007a:489).

Robustness Trend Patterns

The trends of robustness is the pattern that emerges when observing a series of discontinuous jumps that occur when robustness capabilities are progressively developed and proven. This shown in Figure 2.54. Every new curve represents a discontinuous jump in the system design capability. Only the top portion of each is shown, because the shift from one method to improve system robustness will only fully happen when the new capability is an improvement so the lower portion of each curve is not relevant. If the applied design strategy is not at the end of a progression, unused evolutionary potential is available that could be exploited to improve robustness. The figure also shows the design steps that robustness follows (**Mann** 2007a:490-491).

Mann (2007a:490-491) stated that the jumps comprise the following:

1. **Basic Design:-**
   A system that is designed and build to provide certain functionality. It could be due to a set of fundamental requirements or on a trial-and-error basis.
2. **Steady-State:-**
   At this stage the system will contain sequential steps and processes. This is a basic requirement for minimal survival.
3. **Near-Term Transients:-**
   The likelihood that the system requires changing over time is taken into account.

4. **Slow Degradation:-**
   The focus is shifted from a short term view towards the longer term.
5. **Cross-Coupling:-**
   During this stage cross-coupling effects are designed into the business and the failure rate is likely approaching 10^{-3}. It involves the identification of the failure modes of individual items, like in the preceding models, and investigating the impact of combinations of them. This is when the worst case scenarios are considered.
6. **Design for Murphy:-**
   The leading-edge robust design capabilities are based on the premise that if something can go wrong with the system, it will happen. It does not mean that everyone of these will be mitigated, but they must be at least studied.

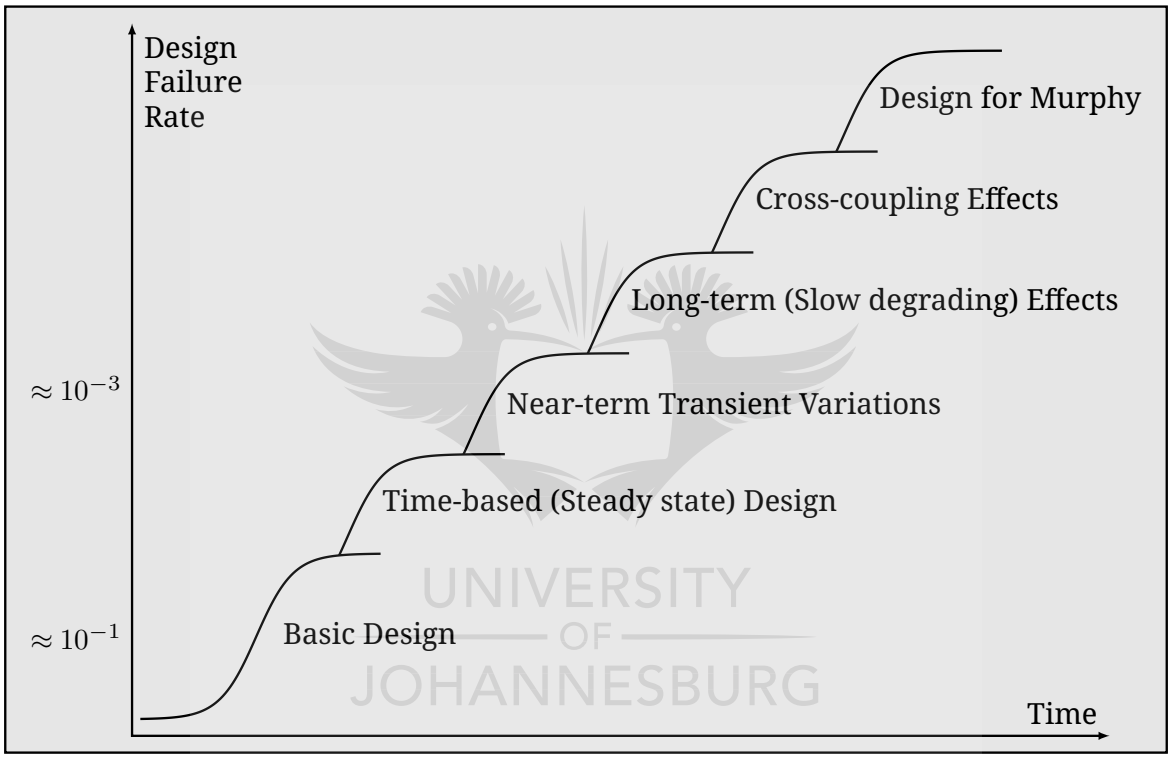

Figure 2.54.: S-Curve Progression for Design for Robustness Paradigm (redrawn from **Mann** (2007a:490))

Robustness Contradictions

According to **Mann** (2007a:492) it could be possible to do an analysis a system for robustness without determining the cause of a robustness problem. The detail of some factors may be unknown and for practical and cost reasons unknowable. It is in these cases that the determination of a contradiction could improve the robustness. This is based on the concept that the best improvements in reliability are the ones that don't use optimisation founded on compromise, but instead focus on changing the paradigm. The idea that systems will eventually reach a fundamental limit of improving robustness and decreasing the rate of failure is shown in Figure 2.55. It is easier to find a root contradiction than it would be to determine a root cause and solve it with the methods describe in §2.8.7.2.

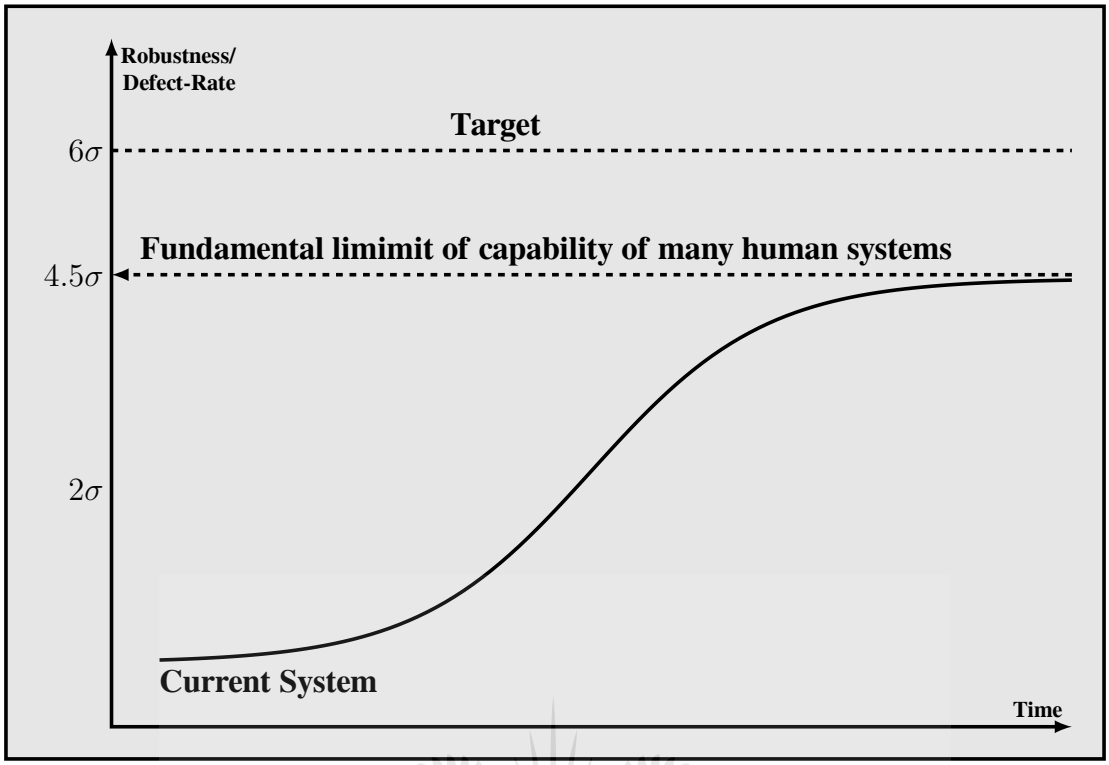

Figure 2.55.: Fundamental Limit and System Robustness (redrawn from **Mann** (2007a:493))

The Business Contradiction Matrix (2.8.7.2) does not have a parameter called 'Robustness'. It is required to translate it into parameters that are closely related. Stability is in general the closest, but other possible mappings include:: a) Quality; b) Risk; c) System Complexity; and d) Tension/Stress (**Mann** 2007a:492).

As an alternative to utilising the Business Contradiction Matrix, all 40 of the Inventive Principles could be used to create solutions. **Mann** (2007a:493) states that the ones that are, however, the most useful ones are as follows:

10 – Prior Action
'If your system is subjected to harmful factors, create conditions that will protect the system from those harmful factors beforehand.'

3 – Local Quality
Make the system non-uniform, make the environment non-uniform, if multiple functions are to be performed, divide the object into parts according to those functions.

15 – Dynamization
If a system, or process is rigid or inflexible, make it movable or adaptive.

2 – Taking Out
Separate an interfering part or property from a system, or single out the only necessary part (or property).

23 – Feedback
Introduce feedback (referring back, cross-checking) to improve a process or action.

25 – Self-Service
Make a system serve itself by performing auxiliary helpful functions.

Robustness Checklists

Mann (2007a) provides checklists to ascertain the robustness of a business. They are aimed at:: a) Internal Threats; and b) External Threats.

A method to challenge the norms is also recommended. It consists of challenging convergent statements by changing them to divergent ones (**Mann** 2007a:496). Some of these are shown in Table 2.20.

Table 2.20.: Convergent phases versus Divergent phrases (redrawn from **Mann** (2007a:496)).

'Convergent'		'Divergent'	
Word(s)	Example	Word(s)	Example
But	This would work, but...	And	This would work, and...
Either/Or	It's either A or B...	And	A and B...
The	The solution...	A/An	A solution...
Is	A bottle is...	Leads To	But could lead to...
Only	...is the only way	A/An	...is a way
True/False	It is true that...	Often/Maybe	It is often true that...
Always/Never	We always...	Often/Maybe	Maybe we...
Must/Cannot	We must...	Convention/Typically	Conventionally...
Maximum/Minimum	That is the maximum...	Convention	Conventionally...
Law	The law says...	Convention	Conventionally...

§2.8.8. Evaluation of the Solution

1 Best Selected

Mann (2007a:499-503) stated that Multi Criteria Decision Making is a systematic method of evaluating the selected solution. In doing that one should consider the following:

1. Quantitative or measurable factors:
   - 1.1. Financial aspects: Cost, Revenue, Profit and Return on Investment;
   - 1.2. Accuracy;
   - 1.3. Efficiency or Wastage;
   - 1.4. Expected life;
   - 1.5. Impact on the environment;
   - 1.6. Liability and Safety;
   - 1.7. Productivity;
   - 1.8. Risk;
   - 1.9. Robustness; and
   - 1.10. Time.
2. Non-measurable or qualitative factors;

2.1. Aesthetics;
2.2. Compatibility;
2.3. Convenience;
2.4. Durability;
2.5. Flexibility;
2.6. Predictability;
2.7. Social Impact (negative and positive);
2.8. Stability; and
2.9. The capability of the solution to be:
  2.9.1. Adapted;
  2.9.2. Controlled;
  2.9.3. Customised;
  2.9.4. Protected;
  2.9.5. Supported and Maintained; and
  2.9.6. Transported;

The factors are weighted and scored. The solution with the highest aggregated value is then seen as the best solution.

It is normally rare to be able to determine all the values required to evaluate all or the majority of the indicated factors. The role of the undetermined factors are then evaluated through sensitivity analysis **Mann** (2007a:503-504).

Mann (2007a:505) distinguished robustness analysis in contrast to sensitivity analysis as the method to determine which of the factors has the highest impact on the solution. The results could show that there are specific factors that have a major impact on the solution and it is then suggested that the innovation process should be repeated.

2 Most Suitable

Immaterial of the results of the previous steps **Mann** (2007a) indicated that it is required to repeat the Systematic Process to ensure that psychological inertia did not have an effect on the results.

The following tests are given to determine if the most suitable solution has been reached:

a Trimming

The essence of this evaluation is to evaluate the ratio of useful abilities per element of the solution. The higher this ratio is, the better the solution is (**Mann** 2007a:506).

The easiest calculation is:

$$\textbf{Ratio} = \frac{\sum \textbf{Useful functions}}{\sum \textbf{Elements}}$$

with the minimum being 1(one). The ideal is get it as high as possible; the problem is that improving one element may degrade the performance of another.

b Subsequent Contradiction(s)

The idea is to investigate the solution for subsequent conflicts or contradictions, which could result in an even better solution (**Mann** 2007a:506).

c Resource Assessment

The extent of utilisation of all the resources in the solution is determined. Potentially some resources could be used even more to provide an even better solution. A spider diagram is one way of gaining insight into this (**Mann** 2007a:506-507).

d Combinations

Some solutions that were not selected to be the most suitable during the earlier steps of the evaluation may have features that are not present in the selected one. The most suited solution could be more enhanced by attempting to incorporate the absent features present (**Mann** 2007a:507).

§2.8.9. Summary of the systematic innovation process

Figure 2.56 show a graphical summary of the systematic innovation process as provided by **Mann** (2007a).

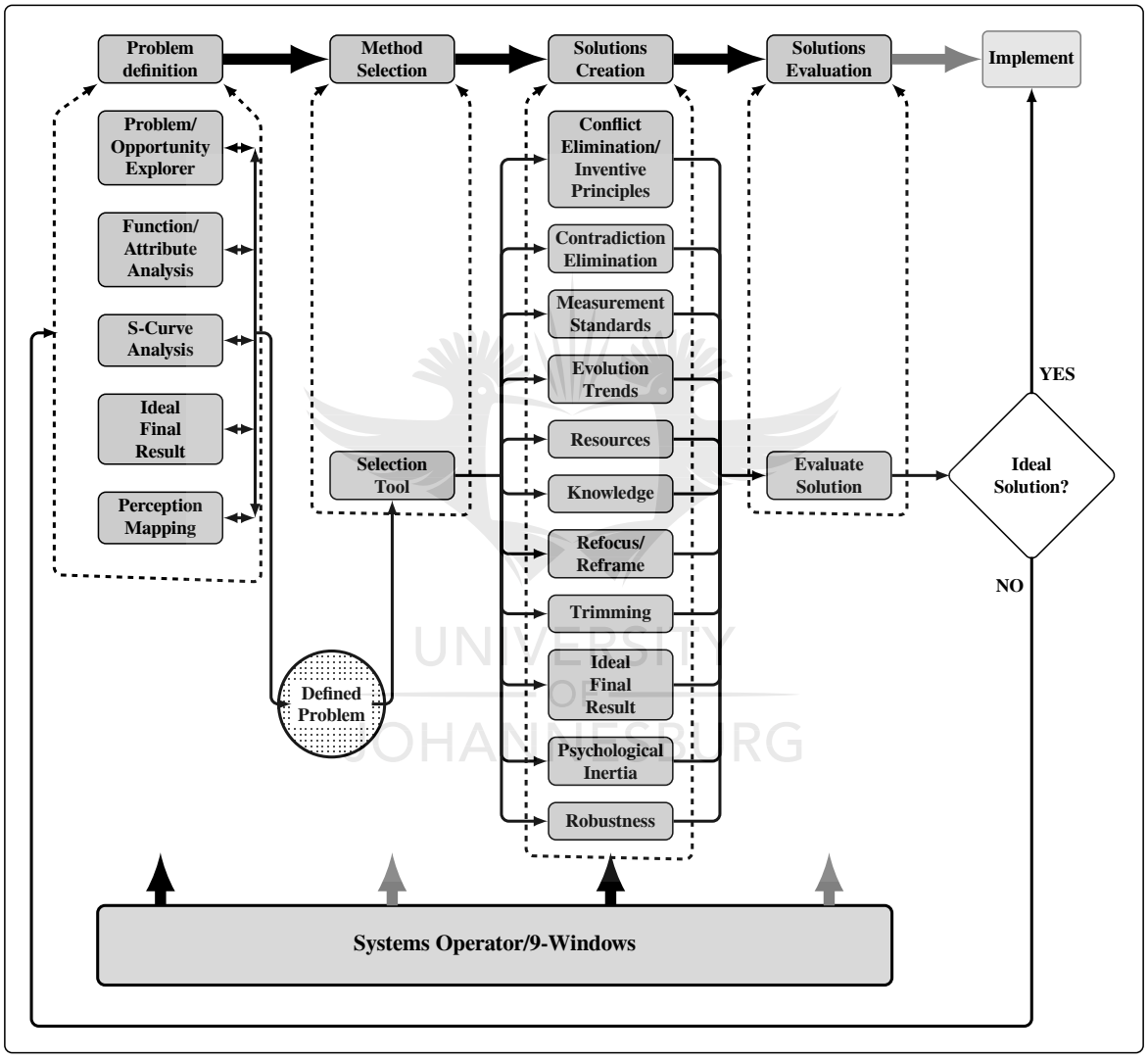

Figure 2.56.: Summary of the systematic innovation process

§2.9. Summary

In this chapter the literature on systematic innovation was examined.

The definition of innovation was provided to have a common reference when it is referred to in the rest of the document. Related terminology was also given to clarify possible confusion that

may occur.

The aim of innovation is to solve problems or act on opportunities that exist. This was examined and it was found that gaps may also be regarded as opportunities for innovation.

The first method of innovation that was examined is Trial-and-Error or as it is otherwise known as Learn-by-Example. This method is well-known, but it could be costly to achieve the best result. It is a possible method for the physical world, but could not be well suited to business and management.

A set of systematic innovation processes called structured creative processes was examined. The core method amongst them is Brainstorming or Brainwriting as the written variant of it. It also includes methods like 5WH or checklists. This class of processes was criticised as being convergent in the final stages by **Altšhuller** (1998), as they finally weigh the solutions against the available resources and preferences of the organisation.

Systematic innovation in the physical world according to the processes developed by **Altšhuller** (1998) was examined. The reason being that TRIZ is important during the analysis of the generalisation of it for business and management as provided by **Mann** (2007a). This analysis will be presented in the next chapter.

Mann (2007a) published a comprehensive set of processes for innovation of business and management. In the next chapter an analysis of this approach will be conducted.

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Chapter 3

Analysis of Systematic Innovation

§3.1. Introduction

The relationship between Engineering Management (EM) and business and management will be indicated, as this research was conducted under the supervision of the Postgraduate School of Engineering Management that is part of the Faculty of Engineering and the Built Environment.

Several approaches to systematic innovation for business and management were detailed in the previous chapter. In this section some aspects of them that were not analysed in the literature will be discussed.

For the analysis of aspects of systematic innovation for business and management it is required to define the core business processes.

A comprehensive development plan (*National development plan.* (NDP)) was compiled for the Republic of South Africa (RSA) and published in 2011. One aspect of this will be treated to evaluate if there are clear indications that it was identified as a factor that could lead to meaningful results if its aim is realised.

§3.2. Definitions and Framework

§3.2.1. Engineering Management

In order to analyse the Systematic Innovation methods given in the previous chapter and to ensure the focus thereof lies sufficiently within in the field EM definitions of EM and related concepts are required.

Some definitions are:

BD (2017) "A field that concentrates on the application of engineering principles for the effective planning and efficient operations of managing manufacturing or industrial operations."

NCES (2000) Definition of the training given in EM: "A program that focuses on the application of engineering principles to the planning and operational management of industrial and manufacturing operations, and prepares individuals to plan and manage such operations. Includes instruction in accounting, engineering economy, financial management, industrial and human resources management, industrial psychology, management information systems, mathematical modelling and optimisation, quality control, operations research, safety and health issues, and environmental program management."

KU (2017) "Engineering Management is a specialised form of management that is required to successfully lead engineering or technical personnel and projects. The term can be used to describe either functional management or project management"
This definition is explained further as a form of management that focusses on the leading of engineering or technical projects and personnel, which could either be project or functional management. Engineering managers required to be trained in the engineering discipline of the team to be managed as well as in general management. They must also have the skills

to successfully manage technical personnel and that is different from the requirements of personnel in other fields.

CS (2017) states: "Engineering management is the discipline where engineers combine management skills with technical expertise to coordinate work in various technical fields such as product design, development, and manufacturing. The aim of the field is to combine practical knowledge of the business side of engineered things — including the financial side of the business, as well as human resource management, communications, and other things that impact the overall success of the product as a commercial entity — with technical knowledge of design and engineering."

Lannes (2001:109-110) investigated the definition for the perspective of stages in the career of a typical engineer. The engineering management stage is seen as the period from five to 25 years into engineers careers. During this stage they are involved in large projects that include complex designs and interdisciplinary skills. At this stage technical skills only are no longer sufficient for success. Other issues have to be handled as well, such as human resources and organisational issues. The knowledge and skills required to handle this phase best are:

1. Project management;
2. Interpersonal and communication skills;
3. Human resources;
4. Finance and marketing as Interdisciplinary skills; and
5. Other organisational skills.

EM is the growth path of an engineer from pure technical skill, through interdisciplinary skill to integrative business skills (**Lannes** 2001:109).

In essence one could then combine the above into a view that Engineering Management involves the general management of engineering or technical processes and people. This is contained in the above definitions and means that it is not only general management, but also contains technological insight. From this also follows that EM is also concerned with business processes and not only technical or production processes.

§3.2.2. Business Processes

Appian (2017), **Siegel** (2008), & **Techopedia** (2017) states that business processes affect the path of actions that are followed to ensure progress towards an enterprise's goals.

Business processes are divided into the following classes (**Appian** 2017):

1. Management class,
2. Operational class, and
3. Support class.

The management class of processes is defined as (**Veyrat** 2016):

1. Established formally,
2. Coordinator of the primary (operational) and support processes' activities,
3. Aimed at obtaining efficiency and efficacy for the enterprise,
4. Monitoring, measuring and controlling of all other processes, and
5. Provides no direct value to the customers or clients.

Veyrat (2016) sees the main aspects of the Operational (or Primary or Essential) class as:

1. The most important processes of an enterprise;
2. Being in direct contact with the customers;
3. Rendering direct value to the customers;
4. Meeting or exceeding the enterprise's standards; and

5. Always in consideration of the total value chain.

The supporting class of processes has according to **Veyrat** (2016) the following characteristics:

1. Established formally;
2. Provides supports to the primary processes;
3. Without contact to customers; and
4. Renders no direct value to customers.

Anderson (2013) identified the following ten core business processes:

1. Marketing that covers Market Strategy and Customer Relationships;
2. Sales
3. Employee Administration, Development and Satisfaction;
4. Quality that includes Process Improvement and Change Management
5. Financial Administration that also includes Analysis, Reporting, and Capital governance;
6. Financial Accounting;
7. Management Responsibility;
8. Development of Products or Services;
9. Delivery of Products or Services; and
10. Technology administration

The list provided by **Anderson** (2013) omitted the following processes which are also core processes:

1. Procurement of material; and
2. Either Production of products or Rendering of services or both. It could also be seen as included in the Delivery of Products and Services, but then that also includes the outbound logistics of the process. In subsequent section this will be referred to as Rendering of Products or Services.

§3.2.3. Value Chain

Porter (1991:102) states that an enterprise consists of a collection of distinct, but interconnected economic activities such as products being built, sales personnel making customer calls, and orders being prepared.

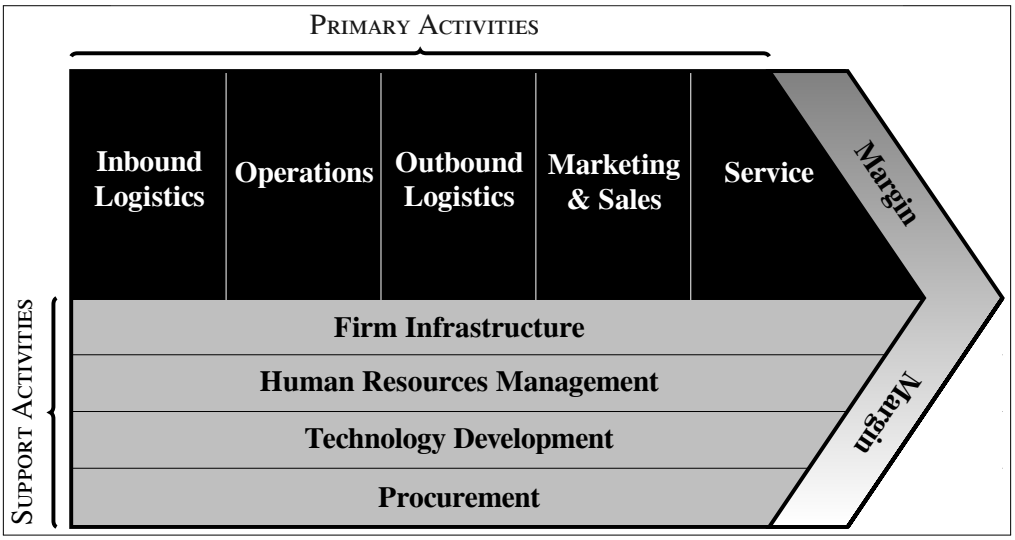

Figure 3.1.: Value chain model of an enterprise [redrawn and adapted from **Schilling** (2013:115)]

The activities in a firm can be schematically represented in what **Porter** (1991:102) called the value chain, as shown in Figure 3.1 The value refers to the customer perception, from this the enterprise derives its profit.

§3.2.4. Summary

From the preceding section is then derived that Engineering Management is concerned with all the general business processes with a technical background. It also means that Systematic Innovation for business and management form part of EM. It could be of even more importance in the case of technological entrepreneurship, where engineering is used as the basis of a new venture.

Systematic Innovation for business and management should in general be applicable in all areas of business and could bring innovation to the total value chain of an enterprise.

§3.3. Evaluation of Systematic Innovation Methods

In 2 several Systematic Innovation Methods were discussed. The main approaches were:

1. Trial-and-Error;
2. Structured Creative Processes; and
3. Systematic Innovation Processes in general, with a specialised set of processes dedicated to Business and Management.

§3.3.1. Trial-and-Error

Kim et al. (2008) stated that problems in business context are in general more abstract than physical problems.

§3.3.2. Structured Creative Processes

When this stream of processes was examined in Chapter the advantages and disadvantages of the processes was also mentioned as stated in the literature.

§3.3.3. Systematic Innovation Processes for Business and Management

Mann (2007a) make extensive use of two sets of parameters to solve contradictions in businesses and management and in other areas of the set of suggested processes for innovation in business and management. They are the contradiction parameters and the innovative principles. These two sets of will be analysed in the section.

§3.3.3.1. Contradiction Parameters for Systematic Innovation in Business and Management

Mann (2007a) provided 31 contradiction parameters. They are given as potential sources of contradictions. In the contradiction matrix for Business and Management as shown in Appendix B in Table B.2 they are used to find potential solutions when two of these are determined to be in conflict.

Analysis of these parameters show that they can be grouped according to their area of applicability in the groups as shown in Table 3.1. R&D

Table 3.1.: Grouped Contradiction Parameters for Business and Management[adapted from **Mann** (2007a)]

Group	P#	Parameter
Customer	21	Customer Feedback
Engineering	1	R&D Capability
	2	R&D Cost
	3	R&D Time
	4	R&D Risk
	5	R&D Interfaces
Information	22	Amount of Information
	23	Communication Flow
Mixed/general	26	Convenience
	30	Tension/Stress
Production	6	Productivity Manufacturability
	7	Production Cost
	8	Production Time
	9	Production Risk
	10	Production Interfaces
Supply	11	Supply Means
	12	Supply Cost
	13	Supply Time
	14	Supply Risk
	15	Supply Interface
Support	16	Product Reliability
	17	Support Cost
	18	Support Time
	19	Support Risk
	20	Support Interfaces

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Group	P#	Parameter
Systems	24	System Affected Harmful Effects
	25	System Generated Harmful Effects
	27	Adaptability/Versatility
	28	System Complexity
	29	Control Complexity
	31	Stability

Comparison to the Value Chain Activities

The relationship to value chain activities are shown in Table 3.2.

Table 3.2.: Value chain activities addressed by contradiction parameters

Category (Count)	Value Chain Activity
Customer (1)	Marketing and Sales
Engineering (5)	Technology Development
Information (2)	Across and between activities
Mixed/general (2)	Several activities
Production (5)	Operations (not provision of a service)
Supply (5)	Inbound Logistics
Support (5)	Service
Systems (6)	Firm infrastructure and systems in general

The parameters do not clearly address the following activities in the value chain:

1. Firm infrastructure
2. Human resources management
3. Outbound logistics

Areas like Marketing and Sales and the flow of information show only limited contradictions according to this set of parameters.

Kim et al. (2008) conducted cluster analysis on 540 business cases using the 31 parameters. Their linkage relationship was to assign 1 to a parameter if used in an investigated business case and zero otherwise. Twenty useful clusters were found based on their similarity indices. The relationship to the Value Chain is described in Table 3.3.

Table 3.3.: Clusters related to the Value Chain (**Kim** and **Park** 2008)

No.	Description	Value Chain relationship.
1	R&D Production/Supply/-Support Interface	Outside of the value chain on the support side.
2	Customer Revenue/Demand/-Feedback	Marketing/Sales
10	R&D Spec/Capability/Means	In the support area, but not clearly indicated in which lane.
12	Production Risk	Operations
14	Support Risk	In the support area, but not clearly indicated in which lane.
17	Tension/Stress	Outside of the value chain on the Primary side.
18	Support interfaces	On the border between Primary and Support Activities.

The thirteen other useful clusters were not related to the Value Chain (**Kim** et al. 2008). There were also 30 other clusters that did not show sufficient correlation to evaluate them further.

Coverage of the top business processes

In section 3.2.2 the following core business processes were identified:

1. Marketing that covers Market Strategy and Customer Relationships (MS);
2. Sales (S);
3. Procurement of material (B);
4. Rendering of Products or Services (RPS) ;
5. Development of Products or Services (PSD) ;
6. Technology administration (TA);
7. Employee Administration, Development and Satisfaction (EADS);
8. Quality (Q) including Process Improvement and Change Management;
9. Financial Administration (FA) that includes Analysis, Reporting, and Capital governance;
10. Financial Accounting (FR); and
11. Management Responsibility (MR).

Sales is an important business process, but it is considered part of the Marketing process. For the purpose of this research it is assumed that product or service delivery refers to the production or rendering of them and the transport to customers as required; else the processes does not cover these aspects at all.

Table 3.4.: Business processes relationship to contradiction parameters

Category (Count)	M(+S)	B	RPS	PSD	TA	EADS	Q	FA	FR	MR
Customer (1)	M1		R1	**Adequately covered**	**No distinct relationship**		Q1	**No distinct relationship**		
Engineering (5)	M2		-							
Information (2)	M4	B1	R2							
Mixed/general (2)	M3	B2	R3							
Production (5)	M5	B3	R4							
Supply (5)	-	B4	-							
Support (5)	M6		R5							
Systems (6)	Maybe as systems in general									

Coverage in the areas of Marketing and Sales

M1 Customers
- M1-1 Customer feedback is important in marketing.

M2 Engineering
- M2-1 R&D Time is in terms of time from concept to the market is very crucial in marketing.

M3 Mixed/general items
- M3-1 Convenience is desired by customers
- M3-2 Tension/Stress is not desired by customers, but could be a state that is desired for sales people.

M4 Information
- M4-1 Amount of Information: Insufficient information or on the other hand too much information could be problematic in marketing.
- M4-2 Communication Flow: Not reaching the correct segment of the market could be fatal to marketing or not hearing "the voice of the market".

M5 Production
- M5-1 The time and cost to produce a product is important for marketing, but they fall under Product/Service Delivery.

M6 Support
- M6-1 Product Reliability could be a concern of marketing, but fall under Product/Service Development and Delivery.
- M6-2 The other factors in support are typically not the concern of marketing, but rather the focus of the support department.

The factors in the group of Supply and Systems (in general) do not show any distinct relationship to marketing and are also not areas of their concern.

There are other aspects of marketing which are not clearly covered by the parameters. According to **UK Essays** (2013) are the core aspects of marketing: a) Product; b) Price; c) Place; and d) Promotion. The parameters show some relationship to the product in terms of its acceptance through feedback from customers and the time and cost of its manufacturing. Marketing maybe be involved in the development although the parameters do not clearly show that. The aspects of Price, Place and Promotion are not present in them.

Coverage in the area of Procurement of material

B1 Information

- B1-1 Amount of Information: Insufficient information or on the other hand too much information could cause problems in procurement.
- B1-2 Communication Flow: Slow flow of information could hamper procurement.

B2 Mixed/general
- B2-1 Convenience could be related to procurement of materials.
- B2-2 Tension/Stress in terms of having the required materials on time could be an aspect of procurement.

B3 Production Procurement plays an important role in production cost, delays and risk. These parameters could therefore be considered as related.

B4 Supply All parameters in the supply group have a distinct relationship to procurement.

The engineering of products have a relationship with procurement, but it is not clear in the parameters.

Nathan (2018) identified the following elements of procurement:

1. Requirement Identification;
2. Specification;
3. Source Selection;
4. Price, Terms and Quoting;
5. Purchasing;
6. Expediting;
7. Delivery or Collection;
8. Receipt and Inspection of Purchases;
9. Invoice Approval and Affecting Payment and
10. Records.

The relationship between these elements and the parameters that relate to procurement is not clear, but they should also be open to systematic innovation.

Coverage in Rendering of Products or Services

R1 Customers
- R1-1 Customer feedback is important in the quality of the delivery of products and services.

R2 Information
- R2-1 Amount of Information: Insufficient information or on the other hand too much information could be problematic.
- R2-2 Communication Flow: Not getting the information about the requirements or being overflowed could hamper the delivery of products and services.

R3 Mixed/general items
- R3-1 Convenience is desired by customers
- R3-2 Tension/Stress is not desired by customers.

R4 Production
- R4-1 All the parameters have a direct relationship to delivery of products and services.

R5 Support
- R5-1 All of these parameters have a relationship to Product/Service Delivery.

Coverage in Products or Services Development

The parameters cover this business process adequately. In the group of customer related ones, there could be more coverage; but only one parameter is provided. The coverage is expected to be good as this method was derived from TRIZ.

Coverage in Quality Processes

In terms of Quality Processes only customer feedback is directly related. The parameters of process/service development could also be applied to achieve process improvement. Expansion of the parameters could easily cover this process group.

Process Areas without distinct relationships

The relationships to the parameters are not clear in the following business process areas:

1. Technology Administration;
   One could reason that the development process is involved with creation of technologies and the delivery process utilises them. There is, however, no parameter that address the management and administration of technologies.
2. Employee Administration, Development and Satisfaction;
   Employees are a core part of any business, but the parameters have no clear relationship to this group of business processes.
3. Financial Administration that includes Analysis, Reporting, and Capital governance;
   The cost of R&D, Supply and Production are addressed and are financial aspects, but the other important aspects of financial administration are not covered.
4. Financial Accounting; and
   There is no relationship between the parameters and financial accounting, it could be included in the parameters related to systems, but that is a generic coverage.
5. Management Responsibility.
   The only place that parameters could relate to management responsibility is in relation to systems, but as with financial accounting is this generic.

Conclusion

According **Kim** et al. (2008) is the focus of the first twenty parameters: R&D, Production, Supply and Support. The other eleven were added as supportive parameters. Taking this into account would explain why some parts of the value chain were not covered and the relationship to the core business processes in four areas is not clear. The cluster analysis also focussed on supply chain management cases.

In section 2.8.7.1 it was also indicated that it could be necessary to find the parameter that is closest to the situation, which indicates that the set of parameters is not a definitive set.

§3.3.3.2. Inventive Principles for Systematic Innovation in Business and Management

Table 3.5.: Inventive Principles for Business and Management (**Mann** 2007a) vs. the ones from TRIZ (**TRIZ-Journ.** 1997).

№	Inventive Principle	
	For Business and Management	From **TRIZ**
1	Segmentation	Segmentation
2	Taking Out/Separation	Taking Out

Continued on next page...

Table 3.5 – continued from previous page

№	Inventive Principle	
	For Business and Management	From **TRIZ**
3	Local Quality	Local Quality
4	Asymmetry	Asymmetry
5	Merging	Merging
6	Universality	Universality
7	“Nested Doll”	“Nested Doll”
8	Counter-Balance	Anti-weight
9	Prior Counter-Action	Preliminary Anti-Action
10	Prior Action	Preliminary Action
11	Prior Cushioning	Beforehand Cushioning
12	Remove Tension	Equipotentiality
13	‘The Other Way Around’	‘The Other Way Around’
14	Curvature	Spheroidality - Curvature
15	Dynamisation	Dynamics
16	Slightly Less/Slightly More	Partial or Excessive Actions
17	Another Dimension	Another Dimension
18	Resonance	Mechanical Vibration
19	Periodic Action	Periodic Action
20	Continuity of Useful Action	Continuity of Useful Action
21	Hurrying	Skipping
22	“Blessing in Disguise”	“Blessing in Disguise”
23	Feedback	Feedback
24	Intermediary	Intermediary
25	Self-Service	Self-Service
26	Copying	Copying
27	Cheap Disposable	Cheap Short-Living Objects
28	Another Sense	Mechanics Substitution
29	Fluid	Pneumatics and Hydraulics
30	Thin and Flexible	Flexible Shells and Thin Films
31	Holes	Porous Materials

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Table 3.5 – continued from previous page		
№	Inventive Principle	
	For Business and Management	From **TRIZ**
32	Colour Changes	Colour Changes
33	Homogeneity	Homogeneity
34	Discarding and Recovering	Discarding and Recovering
35	Parameter Changes	Parameter changes
36	Paradigm Shift	Phase Transitions
37	Relative Change	Thermal Expansion
38	Enriched Atmosphere	Strong Oxidants
39	Calm Atmosphere	Inert Atmosphere
40	Composite Structures	Composite Materials

Comparison of the two sets show only the names of the following have been changed when **Mann** (2007a) compiled the Inventive Principles for Business and Management:

Table 3.6.: Changed Names

№	**Inventive Principle**	
	For Business and Management	From **TRIZ**
8	Counter-Balance	Anti-weight
12	Remove Tension	Equipotentiality
15	Dynamisation	Dynamics
18	Resonance	Mechanical Vibration
21	Hurrying	Skipping
28	Another Sense	Mechanics Substitution
29	Fluid	Pneumatics and Hydraulics
30	Thin and Flexible	Flexible Shells and Thin Films
31	Holes	Porous Materials
36	Paradigm Shift	Phase Transitions
37	Relative Change	Thermal Expansion
38	Enriched Atmosphere	Strong Oxidants
39	Calm Atmosphere	Inert Atmosphere
40	Composite Structures	Composite Materials

The changes in the case of numbers 9, 10, 11, 14, 16 and 27 could be regarded as unimportant, therefore only fourteen of them had their names changed.

Further analysis show that in the cases in Table 3.7 the Inventive Principles have a different amount of descriptive definitions. Ten less are available.

Table 3.7.: Difference in Descriptive Definitions

№	**Inventive Principle** (**Mann** 2007a:271-289)	TRIZ	Business and Management	Δ
2	Taking Out/Separation	2	1	-1
14	Curvature	4	2	-1
18	Resonance	4	1	-3
28	Another Sense	4	1	-3
38	Enriched Atmosphere	4	2	-2

There are two major differences between the two approaches:

1. TRIZ was developed based on registered patents for use in the physical world; and
2. The Inventive Principles for Business and Management should be directed at socio-economic problems.

Table 3.8.: Comparison of Descriptive Definitions: **Mann** (2007a:271-289) vs. TRIZ.

Description	**Unchanged**	**Reworded/-Rephrased/-Enhanced**	**Changed**	**Omitted**
Principle 1. Segmentation	1			
A. Divide a system or object into independent parts.	1			
B. Make a system or object easy to disassemble.	1			
C. Increase the degree of fragmentation or segmentation.	1			
Principle 2. Taking Out/Separation	1			
A. Separate an interfering part or property from a system or object, or single out the only necessary part (or property).				
B.				1
Principle 3. Local Quality	1			

Continued on the next page

Table 3.8 – continued from the previous page

Description	**Unchanged**	**Reworded/-Rephrased/-Enhanced**	**Changed**	**Omitted**
A. Change the structure of an object or system from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.	1			
B. Make each part of an object or system function in conditions most suitable for its operation.	1			
C. Make each part of an object or system fulfil/ a different and useful function.	1			
Principle 4. Asymmetry	1			
A. Change the form of a system or object from symmetrical to asymmetrical.	1			
B. If a system or object is asymmetrical, change its degree of asymmetry.	1			
Principle 5. Merging	1			
A. Bring closer together (or merge) identical or similar systems or objects, assemble identical or similar parts to perform parallel operations.	1			
B. Make operations contiguous or parallel; bring them together in time.	1			
Principle 6. Universality	1			
A. Make an object or structure perform multiple functions; eliminate the need for other parts.	1			
Principle 7. "Nested Doll"	1			
A. Place one system or object inside another; place each, in turn, inside the other.	1			
B. Make one thing pass through another.	1			
Principle 8. Counter-Balance		1		
A. To compensate for the tendency of a system or object to deviate from a desired path merge it with others that provide a re-stabilising effect.		1		
B. To compensate for the deviation tendency of a system or object, make it interact with global/macro-scale phenomena.		1		
Principle 9. Prior Counter- Action		1		

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Table 3.8 – continued from the previous page

Description	Unchanged	Reworded/-Rephrased/-Enhanced	Changed	Omitted
A. If it will be necessary to perform an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects in advance.	1			
B. Create beforehand stresses in a system or object that will oppose known undesirable working stresses later on.	1			
Principle 10. Prior Action		1		
A. Perform the required change of a system or object (either fully or partially) before it is needed.		1		
B. Pre-arrange elements such that they can come into action from the most convenient place and without losing time for their delivery.	1			
Principle 11. Prior Cushioning	1			
A. Prepare emergency means beforehand to compensate for the possible problems that might occur later.		1		
Principle 12. Remove Tension			1	
A. Where harmful tensions may exist, create conditions to compensate, reduce or eliminate them			1	
Principle 13. The Other Way Around'	1			
A. Invert the action(s) used to solve a problem.	1			
B. Make movable parts (or the external environment) fixed, and fixed parts movable.	1			
C. Turn the system, object or process 'upside down'.	1			
Principle 14. Curvature		1		
A. Turn flat or straight things into curved ones.		1		
B. *None provided.*				1
C. Go from linear to rotary motion.			1	
Principle 15. Dynamization			1	
A. Allow (or design) the characteristics of a system, object, external environment, or process to change to be optimal or to find an optimal operating condition.	1			
B. Divide a system or object into parts capable of movement relative to each other.	1			

Continued on the next page

Table 3.8 – continued from the previous page

Description	**Unchanged**	**Reworded/-Rephrased/-Enhanced**	**Changed**	**Omitted**
C. If a system, object or process is rigid or inflexible, make it movable or adaptive.	1			
Principle 16. Slightly Less/Slightly More			1	
A. If 100 percent of an objective is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.	1			
Principle 17. Another Dimension		1		
A. If a system or object uses only one or two dimensions; make use of the unused dimensions.	1			
B. Use a multi-storey arrangement instead of a single-storey arrangement.	1			
C. Tilt or re-orient the system or object, lay it on its side.	1			
D. Use 'another side' of a given system or object.	1			
Principle 18. Resonance			1	
A. *None provided.*				1
B. Find and use the 'resonant frequency' of a system or object.				
C. *None provided.*				1
D. *None provided.*				1
Principle 19. Periodic Action	1			
A. Instead of continuous action, use periodic or changing actions.	1			
B. If an action is already periodic, change the periodic magnitude or frequency.	1			
C. Use pauses between actions to perform a different action.	1			
Principle 20. Continuity of Useful Action	1			
A. Make parts of a system or object work at optimal conditions continuously.			1	
B. Eliminate all idle or intermittent actions or work. ,	1			
Principle 21. Hurrying			1	

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Table 3.8 – continued from the previous page

Description	Unchanged	Reworded/-Rephrased/-Enhanced	Changed	Omitted
A. Conduct a process, or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.	1			
Principle 22. "Blessing in Disguise" or "Turn Lemons into Lemonade"	1			
A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.	1			
B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.	1			
C. Amplify a harmful factor to such a degree that it is no longer harmful.	1			
Principle 23. Feedback	1			
A. Introduce feedback (referring back, cross-checking) to improve a process or action.	1			
B. If feedback is already used, change its magnitude or influence.	1			
Principle 24. 'Intermediary'	1			
A. Use an intermediary carrier article or intermediary process.	1			
B. Merge one system or object temporarily with another (which can be easily removed).	1			
Principle 25. Self-Service	1			
A. Make a system or object serve itself by performing auxiliary helpful functions	1			
B. Use waste (or lost) resources, energy, or substances.	1			
Principle 26. Copying	1			
A. Instead of an unavailable, expensive, or vulnerable object, use simpler and inexpensive copies.	1			
B. Replace a system, object, or process with optical or virtual copies.		1		
C. If copies are already used, move to an out of the ordinary illumination and viewing perspective.		1		
Principle 27. Cheap Disposable			1	

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Table 3.8 – continued from the previous page

Description	**Unchanged**	**Reworded/-Rephrased/-Enhanced**	**Changed**	**Omitted**
A. Replace an expensive system or object with a multiple of inexpensive alternatives, comprising certain less-important qualities (such as service life, for instance).		1		
Principle 28 Another Sense			1	
A. Replace or supplement one sensory means with another (visible, touch, acoustic. taste or smell)		1		
B. *None provided.*				1
C. *None provided.*				1
D. *None provided.*				1
Principle 29. Fluidity			1	
A. Make solid things into 'fluid' things.			1	
Principle 30. Thin and Flexible			1	
A. Use thin and flexible structures instead of large, three-dimensional ones	1			
B. Isolate a system or object from a potentially harmful environment using thin and flexible structures.			1	
Principle 31. Holes			1	
A. Add 'holes' to a system or object.			1	
B. If a system or object already has holes, use them to introduce a useful substance or function.			1	
Principle 32. Colour Changes	1			
A. Change the colour of an object or its external environment.	1			
B. Change the transparency of a system, object or an external environment.	1			
Principle 33. Homogeneity	1			
A. Make systems or objects interact with others of a similar form or with similar properties.		1		
Principle 34. Discarding and Recovering	1			
A. Make portions of a system or object that have fulfilled their functions go away or modify them directly during an operation.		1		

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Table 3.8 – continued from the previous page

Description	Unchanged	Reworded/-Rephrased/-Enhanced	Changed	Omitted
B. Conversely, restore consumable parts of a system or object directly in operation.	1			
Principle 35. Parameter Changes	1			
A. Change an object's physical state (e.g. from physical to virtual).		1		
B. Change the concentration or consistency.	1			
C. Change the degree of flexibility.	1			
D. Change emotional and other parameters.			1	
Principle 36. Paradigm Shift			1	
A. Use phenomena occurring during disruptive shifts in an economy. (Awareness of macro-scale business phenomena)			1	
Principle 37. Relative Change			1	
A. Use the relative differences that exist in an object or system to do something useful			1	
B. Make different parts of a system act differently in response to changes			1	
Principle 38. Enriched Atmosphere			1	
A. Replace a normal atmosphere with an enriched one.			1	
B. Expose a highly enriched atmosphere with one containing potentially 'unstable' elements.			1	
C. *None provided.*				1
D. *None provided.*				1
Principle 39. Calm Atmosphere		1		
A. Replace a normal environment with an inert one.	1			
B. Add neutral parts or elements to a system or object.	1			
Principle 40. Composite Structures	1			
A. Change from uniform to composite (multiple) structures, be aware of and utilise combinations of different skills and capabilities.)		1		
Totals	71	19	26	10
% of Total	56, 3%	15, 1%	20, 6%	7.9%

TRIZ was developed and documented in Russian. During the translation terms like 'Anti-weight'

was recorded, but it could as well have been Counter-balance. In several of the items that were reworded it was only a change from 'object' to 'system or object'.

Table 3.9.: Discussion of the examples of the descriptive definitions of the inventive principles

TRIZ Definitions	**Business and Management Definitions**
1: Segmentation	
1. Divide an object into independent parts.	1. Divide an object into independent parts. 1.1. Split business into separate entities for each product 1.2. Autonomous centres of profit 1.3. For large products use work breakdown structures (WBS) 1.4. Segmentation of Marketing 1.5. SWOT analysis 1.6. Recognise the differences between 'common' and 'special' causes of failures 1.7. Use Kano diagrams for product attributes 1.8. Use Blue Team vs. Red Team approach for the preparation of proposals (**Mann** 2007a:271)
Discussion: a) The first two examples have a clear link to segmentation and the divisions could be somewhat independent, but not totally as they typically share the support streams as in the Value Chain as depicted in Figure 3.1. b) The work packages in a WBS are not necessarily independent work packages, they are only distinct sets of activities. They are typically sequenced in project networks and in many cases a relationship exists between packages that need to be completed before a particular package can be started. A simple example would be to consider the build of a house in terms of a WBS. Three of elements of the WBS are typically: building of the walls, roofing the house, the carpeting of the floors. These three steps are not independent. c) Marketing could be segmented, but they should share the core values of the organisation. The independence is not clear, although the segments may focus on different segments of the market. d) During a SWOT analysis four aspects of an organisation are considered, but they are not independent. Strengths and opportunities are used to counter Weaknesses and Threats. e) **Mann** (2007a) provides for the use of the Kano diagrams for investigating the Excitement, Performance and Threshold product parameters as detail to this descriptive definition. Products and services are the core of business, but the systematic innovation model is intended to focus on business and management. These parameters of a product are different perspectives to consider during the development (**Verduyn** 2014). f) The use of a Blue and Red team to work independently on a proposal is not an independent division. The approach is to let the Red Team attack the system/product and the Blue Team defend it, after which the results are combined (**Docherty** 2017; **Miessler** 2017). g) In summary most of the examples are not in line with the descriptive definition.	

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Table 3.9 – continued from previous page

TRIZ Definitions	**Business and Management Definitions**
2. Make an object easy to disassemble.	2. Make an object easy to disassemble. 2.1. Make pensions flexible 2.2. Utilise temporary people for short duration projects 2.3. Make use of flexible systems for manufacturing 2.4. Allow customers to 'mix' and 'match' with modular accounts 2.5. Shipping in containers 2.6. Hot-desking/modular offices (**Mann** 2007a:271)
Discussion: a) Flexibility of pensions and flexible manufacturing systems do not clearly indicate the ability to disassemble. The same applies to providing of modular accounts. b) The other examples show the ability to disassemble clearly. c) Other examples that could have been used in this case are: (a) Detachable sections of departments, like having a finance and human resource section within each department that renders products or services. (b) Modular manufacturing sections that could easily receive inputs from many other production units. (c) Project personnel that could be switched between projects, typically when their skill sets are no longer required on the current project. (d) Rotate managers frequently across the organisation.	
3. Increase the degree of fragmentation or segmentation.	3. Increase the degree of fragmentation or segmentation. 3.1. Mass customisation through 'segment of one' advertising 3.2. Remote working as in virtual offices 3.3. Determine special economic areas 3.4. Creative segmenting of products (**Mann** 2007a:271)
Discussion: a) The examples all relate to the descriptive definition, but could be expanded. b) Other possibilities are: (a) Placing detached supporting activities as in the Value Chain close to the primary activities, operating under the same corporate policies and procedures. (b) At certain points in the progression a project could move to another department, while retaining core functions. (c) Train certain levels of the technical personnel in supporting activities to enhance the activities.	

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Table 3.9 – continued from previous page

TRIZ Definitions	**Business and Management Definitions**
7: "Nested doll"	
1. Place one object inside another; place each object, in turn, inside the other.	1. Place one object inside another; place each object, in turn, inside the other. 1.1. One store in another store 1.2. Organisation containing different profit centres 1.3. ATMs servicing several banks 1.4. Hierarchy of organisation structure 1.5. Four levels of knowledge included in effective organisational training: a) Basic skills; b) Know-how; c) Process management; and d) Strategic vision. (**Mann** 2007a:273-274)
Discussion: a) The examples all relate to the descriptive definition, but could be expanded.	
2. Make one part pass through a cavity in the other.	2. Make one part pass through a cavity in the other. 2.1. Expose inward facing employees to external environment in the market 2.2. Automatic counting of customer movement to do market profiling 2.3. Internet 'navigator' companies (**Mann** 2007a:274)
Discussion: a) The examples does not relate clearly to the descriptive definition.	
8: Anti-weight vs. Counter-Balance	
1. To compensate for the weight of an object, merge it with other objects that provide lift.	1. To compensate for the tendency of a system or object to deviate from a desired path merge it with others that provide a stabilising effect. 1.1. In the amalgamation of organisations the stronger features of the one makes the result stronger 1.2. Improve flagging sales by integrating with other rising items 1.3. Attaching the word 'new' to consumer goods is a powerful way of improving the sales 1.4. Recruit and utilise 'champions' to help with change initiatives (**Mann** 2007a:274)
Discussion: a) The examples all relate to the descriptive definition, but could be expanded.	

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Table 3.9 – continued from previous page	
TRIZ Definitions	**Business and Management Definitions**
2. To compensate for the weight of an object, make it interact with the environment (e.g. use aerodynamic, hydrodynamic, buoyancy and other forces).	2. To compensate for the deviation tendency of a system or object, make it interact with global/macro-scale phenomena. 2.1. An external transport network lifts a small business to compete with larger ones. 2.2. Connecting to popular causes help to boost political parties' ratings 2.3. Connect marketing to business and customer driving forces (**Mann** 2007a:274)
Discussion: a) The examples all relate to the descriptive definition, but could be expanded.	

In summary all the inventive principles were analysed in terms of the extent to which each addresses the top business areas:

1. Marketing and Sales (M+S)
2. Supply (Su)
3. Rendering of Products or Services (RPS)
4. Development of Products or Services (DPS)
5. Management Responsibility and General management (MR)
6. Financial Administration and Records (Fin)
7. Employee Administration, Development and Satisfaction (EADS)
8. Technology Administration (TA)
9. Quality (Q)

In the previous section finances were seen as two separate processes.

A score of one was assigned for each example in each area, if it was unclear whether it applied to any area the score went to unclear(U). One example was found to be questionable (X). The detail is contained in Appendix C.

Table 3.10.: Addressing of Business Areas by Inventive Principles (**Mann** 2007a)

№	Principle	Count	M+S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
1	Segmentation	21	5, 5	0	3	3	7	0, 5	0	0	1	1	0
2	Taking Out/ Separation	13	2, 5	0	1	2	7	0	0, 5	0	0	0	0
3	Local Quality	18	3	0	0, 5	2	7, 5	0	5	0	0	0	0
4	Asymmetry	13	5	0	1	2	3, 5	0	0, 5	0	1	0	0
5	Merging	17	3, 5	0, 5	7	2	4	0	0	0	0	0	0
6	Universality	9	2	0	2, 5	1	3	0	0, 5	0	0	0	0
7	"Nested Doll"	8	2, 5	0	2	0	3	0	0, 5	0	0	0	0
8	Counter-Balance	7	4	0	1	0	2	0	0	0	0	0	0
9	Prior Counter-Action	10	2, 5	0	0	2, 5	1, 5	1	1, 5	0	0	0	1
10	Prior Action	18	3	1, 5	5, 5	2, 5	3, 5	1, 5	0, 5	0	0	0	0
11	Prior Cushioning	9	1	0	1	1	6	0	0	0	0	0	0

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Table 3.10 – continued from the previous page

№	Principle	Count	M+S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
12	Remove Tension	8	0	0	0, 5	0, 5	4	0	3	0	0	0	0
13	The Other Way Around	25	6	0	5, 5	3	5, 5	0	0	0	1	4	0
14	Curvature	8	1	0	2	0	2	1	0	0	1	1	0
15	Dynamization	19	4, 5	0	4	0, 5	8	0	0	0	1	1	0
16	Slightly Less/ Slightly More	7	2	0	0	0	4	0	0	0	1	0	0
17	Another Dimension	19	1, 5	0, 5	1, 5	1, 5	11, 5	0	0	0	0, 5	2	0
18	Resonance	6	0, 5	0	0	0, 5	5	0	0	0	0	0	0
19	Periodic Action	15	1, 5	0	4, 5	0	6, 5	0	0, 5	0	1	1	0
20	Continuity of Useful Action	12	0, 5	0	3, 5	0	1, 5	1	2, 5	0	1	2	0
21	Hurrying	7	0	0	0	5	2	0	0	0	0	0	0
22	Blessing in Disguise	13	4	0	1	3	3	0	0	0	0	2	0
23	Feedback	20	7	0	0	3	8	0	0	0	2	0	0
24	Intermediary	16	4	0	4, 5	0, 5	4, 5	1	0, 5	0	0	1	0
25	Self-Service	14	6	0	1	1	3, 5	0	0, 5	0	2	0	0
26	Copying	16	3	0, 5	4, 5	3	3	0	1	0	1	0	0
27	Cheap Disposable	5	1	0	3	0	1	0	0	0	0	0	0
28	Another Sense	6	2	0	1	1	2	0	0	0	0	0	0
29	Fluidity	6	0	0	0	1	4, 5	0, 5	0	0	0	0	0
30	Thin and Flexible	5	0	0	1	1	2, 5	0	0, 5	0	0	0	0
31	Holes	8	3	0	0, 5	0	3	0	0, 5	0	0	1	0
32	Colour Changes	11	1	0	1	1, 5	7	0	0	0	0, 5	0	0
33	Homogeneity	8	2	0	0	1, 5	4, 5	0	0	0	0	0	0
34	Discarding and Recovering	6	0	0	1	0, 5	2	0	1, 5	0	1	0	0
35	Parameter Changes	16	4, 5	0	4	3, 5	2, 5	0	1, 5	0	0	0	0
36	Paradigm Shift	5	0, 5	0	0	0, 5	3	0	1	0	0	0	0
37	Relative Change	9	2	0	0	2, 5	2, 5	0	1	0	0	1	0
38	Enriched Atmosphere	19	2, 5	0	0, 5	2, 5	7, 5	0, 5	3, 5	0	0	2	0
39	Calm Atmosphere	12	0	0	0	0	6, 5	1, 5	2	0	0	2	0
40	Composite Structures	8	0	0	0	3	3	0	2	0	0	0	0
	Totals	472	94, 5	3	69	58	171, 5	8, 5	30, 5	0	15	21	1
	% of Total	100	20, 0	0, 6	14, 6	12, 3	36, 3	1, 8	6, 5	0, 0	3, 2	4, 4	0, 2

The total amount of examples was 472, with 21 that were worded unclearly and one that was questionable. If the remainder were equally distributed across all the business process areas one would expect 45-55 examples for each area, if they were with a ±10% variance. If each Inventive Principle was assumed to be applicable to each business process area it would have at least one example for each area.

§3.3.3.3. Contradiction Matrix for Systematic Innovation in Business and Management

The concept of the contradiction matrix is the same as that of TRIZ.

Table 3.11.: Contradiction Matrix

Worsening parameter						
P_2	$\cdots$	P_m	$\cdots$	P_{31}		
					P_1	Parameter to Improve
					$\vdots$	
		$S_{n,m}$			P_n	
					$\vdots$	
					P_{30}	

The rows and columns consist of the Conflict Parameters discussed above in §3.3.3.1.

This means that if one wants to improve P_n and in the process P_m is worsening, at the intersection one would find a set of Inventive Principals $S_{n,m}$ that one could try to resolve the contradiction/conflict that arises.

The provided matrix is symmetric, which means that at the intersection of P_m with P_n the proposed set of Inventive Principals would be the same as the other way round, $S_{m,n} = S_{n,m}$.

Discussion

The symmetry of the matrix gives the impression that the environment of business and management is fully elastic. In the case of small variations it may be true, but as humans are involved it cannot to be assumed to true to a large extent. People remember and relationships could change unrecoverably as a result of the changes made by suppliers.

In the physical world many actions could be reversed as long as the changes are within the elastic limits of the materials or the materials could be replaced.

§3.3.4. Discussion of the model for Systematic Innovation for Business and Management

The model is a derivative of the TRIZ model for innovation in the physical world. **Altšhuller** (1998) indicated that he built the TRIZ model based on the analysis of patents. Business and management processes cannot be patented.

Mann (2015) indicated that his model was based on experience and derived from internal research by his team of researchers. The process and detail are not available. The reason for it being 40 Inventive Principles and 31 Contradiction Parameters could therefore not be determined.

Altšhuller (1998) is against the use of brainstorming as a method to solve problems as the result is forced to converge according to a predetermined framework. **Mann** (2007a) uses it as a tool in the process, where the 40 Inventive Principles are used as points of departure (Forced associations) to determine potential areas of innovation It could be criticised as being a fixed framework.

According to **Mann** (2007a) the goal of innovation is to achieve Ideality, i.e. when the perceived

benefits are greater than the perceived harmful items that includes costs. This very similar to Benefit Cost Analysis, only it is measured in monetary values and estimated over a time (**Lawrence**, **Nguyen**, **Skolnick**, **Symoun**, **Hunt** and **Alfelor** 2015:27-30; **Chadderton** 2015:51-59).

The Inventive Principles and the Contradiction Parameters were discussed in the preceding parts of this section. The reason for the detailed analysis being that in many instances **Mann** (2007a) indicated that these are the basis for a process or the final step to use in one or another form. The examples of the Inventive Principles overlap in several instances and it is justified by **Mann** (2007a) as the principles also display overlap.

§3.4. Application to the NDP

§3.4.1. Background

A comprehensive development plan (*National development plan.* (NDP)) was compiled for the Republic of South Africa (RSA) and published in 2011. It indicated that development to uplift the country to near first world-class by 2030 would be required in the following areas:

1. Economy and employment
2. Economic infrastructure
3. Transitioning to a low carbon economy
4. Inclusive rural economy
5. Positioning South Africa in the world
6. Human settlements
7. Improving education, innovation and training
8. Promoting health
9. Social protection
10. Building safer communities
11. Building a capable state
12. Promoting accountability and fighting corruption
13. Transforming society and uniting the country

According to **SANPC** (2011:27) the plan was based on: a) extensive research; b) consultation; and c) engagement. *(It was not revised since it was issued and is still frequently referred to by public officials.)*

For the purpose of this research focus would be on one aspect of Economic Infrastructure.

§3.4.2. Economic Infrastructure

SANPC (2011) state the goals for this area as:

1. Increase the access to electricity and the national electrical energy capacity with a large amount obtained from renewable sources
2. Provide clean potable water to all people, ensure that there is sufficient water for agriculture and industry and reduce the utilisation in urban areas
3. Ensure public transport is user-friendly, with minimal environmental impact, costs less and integrated
4. Increase the port capacity of the Durban harbour
5. Ensure affordable widely available broadband data access with the lowest speed at 2 Mbit/s.

The general requirements are (**SANPC** 2011:15):

1. Increase the ability of the economy to absorb more people productively.

2. The generation of energy and the conservation of water needs to change as well as the utilisation these, but this presents a major challenge and can be disruptive to society. Competency and innovation, amongst other, are required to enact the changes in a manner that reduces costs with the main focus on the poor.

The Key drivers of change were stated as:

1. Innovations and inventions may not be well-received, as in the case of GMO foods (**SANPC** 2011:72).
2. In the initial stages of development of innovations they could be very expensive, which will make their benefit inaccessible to everyone. Many medical innovations are good examples of these, as they are initially only in the reach of wealthy people and in effect inaccessible to the majority of people in the average and below average neighbourhoods (**SANPC** 2011:72).
3. Resource-intensive technologies that is aimed at high consumption demand are generally damaging to the environment and increase Carbon Dioxide (CO_2) emissions(**SANPC** 2011:72).
4. The availability of knowledge flows and stocks impact the development of technologies. Utilisation of appropriate technologies will ensure increased productivity. If the stocks and flows of knowledge are low, the development is low and the resulting further innovation is also low. This also causes the most capable people to leave the country as soon as they have the means, which further diminishes innovation and the potential growth (**SANPC** 2011:72).

The specific part of Economic Infrastructure to be investigated is the general provision of access to the Internet.

§3.4.3. General access to the Internet

According to **SANPC** (2011) have this have an effect on the need to absorb more people productively into the economy. It will have an impact on the key driver regarding the flows of knowledge and could improve development and retain more of the most capable people with the effect of more local innovation and higher potential growth.

§3.4.3.1. Contradictions, Conflicts and Trade-offs

SANPC (2011:171) sees the future primary role of the government in the ICT sector to be: 1) facilitation of competition; 2) aid private investment; and 3) regulate if failures in the market come forth. Government's direct involvement will only be to ensure universal access through actions like: a) provision of smart subsidies; and b) developing of the capacity of marginalised groups to effectively utilise ICT..

The ICT industry trade-offs (**SANPC** 2011:175-176):

1. Sufficient large-scale investment is required to extend ICT infrastructure to achieve the objectives of sustainability and increased involvement in the economy and society, from both private and public sources. The challenge is to ensure services are accessible by marginalised groups and in areas that are under-serviced.
   The government is constrained in terms of capital and has several other priorities deemed urgent, therefore capable and willing investors from the private sector are needed to achieve this. Collaboration to reach the goals may also be an option as long as it provides for social responsibilities.
2. Decreased profound regulation will lower the barriers to entry and make the markets more competitive causing lower prices, improved choices and higher quality to consumers. The result, however, could decrease the viability of current participants and state owned enterprises.
3. Available surpluses for services might be constrained and new investments inhibited through

increased competition that would decrease the prices to consumers.
4. Decreased employment may result if cost-reducing efficiencies are ensured through the regulation of prices, on the other hand could it also increase demand and create jobs elsewhere in this or other sectors.
5. A single shared carrier provider that provides fair and open access to competitive service providers without competing against them must be considered versus allowing network competition to increase infrastructure and services that will most probably result in duplication of the infrastructure and resources, while the resources are already limited.
6. Promoting production of local content by enforcing local quotas could increase the cost of information and services resulting a burden that would give unregulated services a competitive advantage over the regulated ones.
7. Losses could be incurred if critical spectrum is not made available to operators to implement new technologies, whilst waiting for the results of a comprehensive audit and then reallocating or auctioning it off.

The acceptance of mobile phones and the accompanying growth in the ICT sector did not bring universal and affordable access to a complete set of services. Several interventions have taken place, but the prices of equipment and services still remain a hindrance to expanded use of ICT. The Independent Communications Authority of South Africa experienced several obstacles in its aim to enable a more open market. The policy was not reviewed since 1996. Effective and positive policy outcomes can only be achieved if sufficient capacity and competence exist with the regulator. The government participates as policy-maker and as competitor through its ownership of Telkom (**SANPC** 2011:174-175).

§3.4.3.2. Systematic Innovation investigation

In this section an attempt will be made to investigate if there is evidence of the application of systematic innovation on the requirement to provide high speed internet access to all people in the country. The original data on which the plan was based is not available. Many of the sources used are not academic sources, because the information was not used in other research. In many cases the statistics on the use of the Internet are from marketing companies that publish it openly. Another aspect is that the information is current information and not from the same time frame as when **SANPC** (2011) compiled and published the plan.

Current background information

ANN (2017) indicated that a project was to be started during 2017 where the World Economic Forum (WEF) would have improved universal internet access in terms of infrastructure, affordability, skills and awareness. The other aim was develop platforms where people can obtain government services by means of the internet and to support Small and Medium Sized Enterprises.

According to **ANN** (2017) the chairperson of the Telkom Group believe that the project "'creates fertile ground for sustainable, accelerated, inclusive economic growth".

Mkhonza (2017) reported Project Isizwe has the aim to lobby that every South African has WiFi access within walking distance. The CEO of the project believes that "Internet access is a tool to empower those in low socio-economic ranks". The means to achieve the result is seen as government subsidised internet access. The project of the WEF would support this project.

Writer (2015) reported on the income distribution of households in SA with internet access that was obtained from Effective Measure (now Narratiive [sic.]) who does research for the Interactive Advertising Buro of SA. **Writer** (2015) stated that 23% of the households were unemployed, but this differs from the data in their table that was used to compile Figure 3.2. The number of

households with income below R3 000/month nearly doubled from 8,76 % in the previous year.

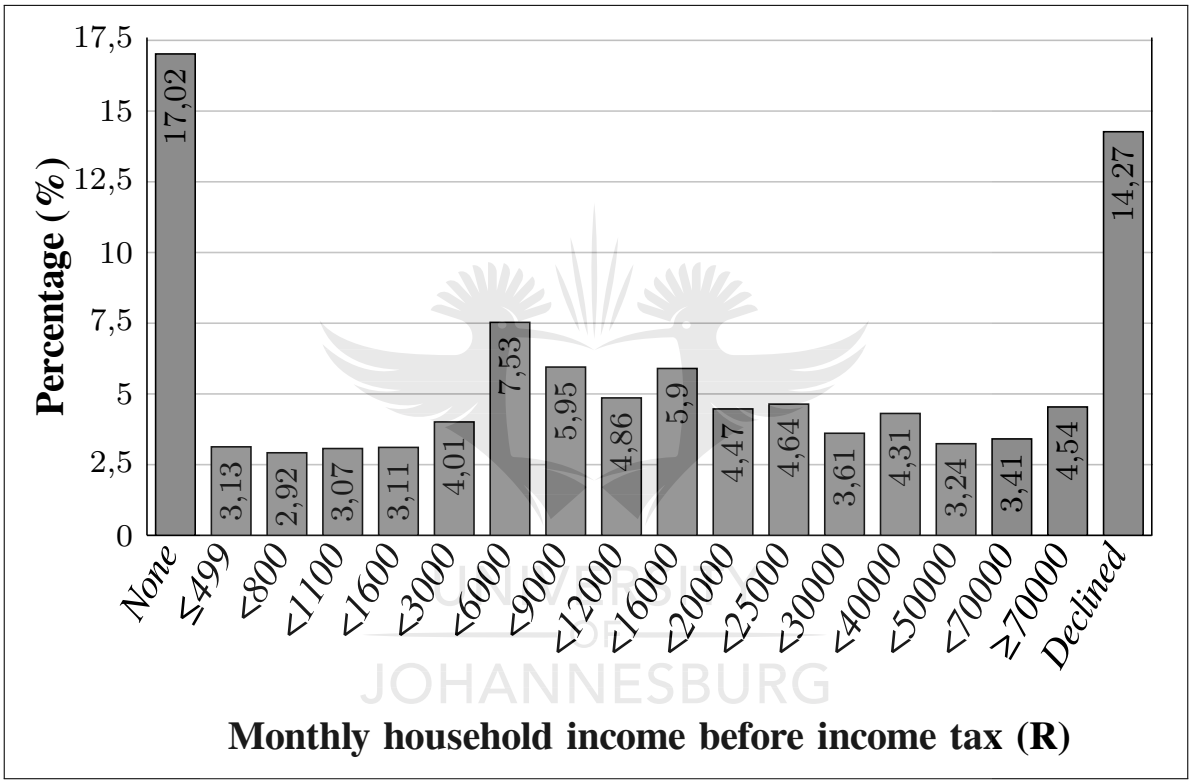

Figure 3.2.: Internet use vs. monthly household income (2015) [drawn from **Writer** (2015)]

In order to see if this had the desired impact the Gross Domestic Product of SA is compared from 2014 to 2017 as obtained from **StatsSA** (2018b).

Table 3.12.: Gross Domestic Product % increase of SA 2014-2017 (**StatsSA** 2018b)

	Year			
Industry/Source	2014	2015	2016	2017
Agriculture, forestry and fishing	6.80	-6.36	-10.24	17.72
Mining and quarrying	-1.73	3.07	-4.16	4.59
Manufacturing	0.35	-0.35	0.91	-0.15
Electricity, gas and water	-0.98	-1.69	-2.35	0.15
Construction	3.49	1.84	1.07	-0.31
Wholesale, retail & motor trade; catering & accommodation	1.43	1.85	1.69	-0.63
Transport, storage and communication	3.51	1.39	0.80	1.47
Finance, real estate and business services	2.71	2.57	2.34	1.87
General government services	3.18	0.98	1.40	0.33
Personal services	1.78	1.03	1.47	1.20
Total value added at basic prices	1.95	1.25	0.66	1.33
Taxes less subsidies on products	0.87	1.60	-0.41	1.27
GDP at market prices	1.85	1.28	0.57	1.32
Total value added at basic prices excluding agriculture	1.81	1.46	0.95	0.94

The information in Table 3.12 shows the percentage increase in GDP was 1,46 % in 2015. The increase in the subsequent years was below 1 %. Whilst there is at least an annual increase in GDP, the number of low income or no income households also increased. The biggest increase in 2014 was in the agricultural sector, in 2015 it was mining, in 2016 it was finance and real estate with agriculture four times bigger than any sector in 2017.

The data provided by **MMG** (2016) shows that total use increased in 2014, 2015 and 2016 respectively by 6,07 % and 3,84 % and 3,78 % with an increase as percentage of population from 49,00 % to 52,00 %. This is shown in Table 3.13. This also is not in the same range as the change in the GDP, it is larger.

Table 3.13.: Internet users in SA

Year	Users	Population	% of Total	% Use increase
2013	$24{,}84 \times 10^6$	$52{,}98 \times 10^6$	46,90 %	
2014	$26{,}44 \times 10^6$	$54{,}00 \times 10^6$	49,00 %	6,07 %
2015	$27{,}50 \times 10^6$	$54{,}78 \times 10^6$	50,20 %	3,84 %
2016	$28{,}58 \times 10^6$	$54{,}98 \times 10^6$	52,00 %	3,78 %

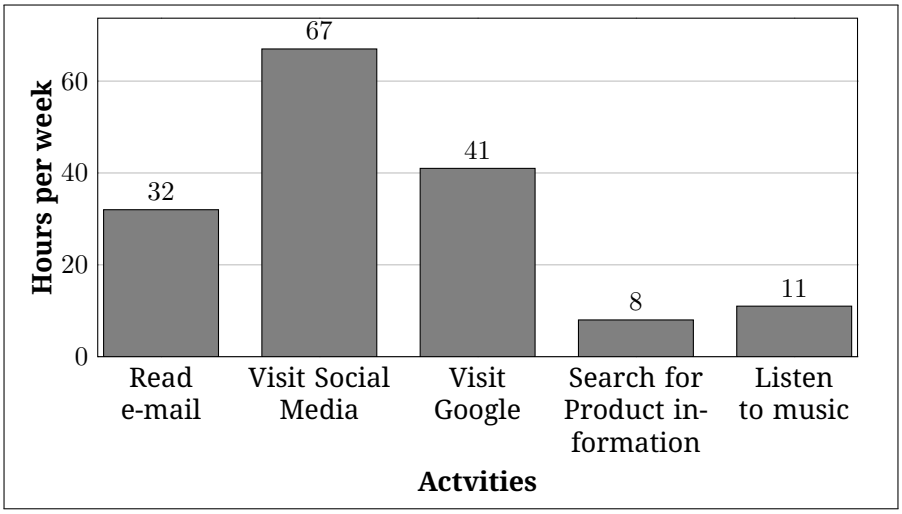

Figure 3.3.: Weekly Internet Activity [adapted from **Olfsen** (2017:9)]

Olfsen (2017:9) indicated that the weekly use of the Internet by people in South Africa is as indicated in Figure 3.3 and the daily use of media is as indicated in Figure 3.4.

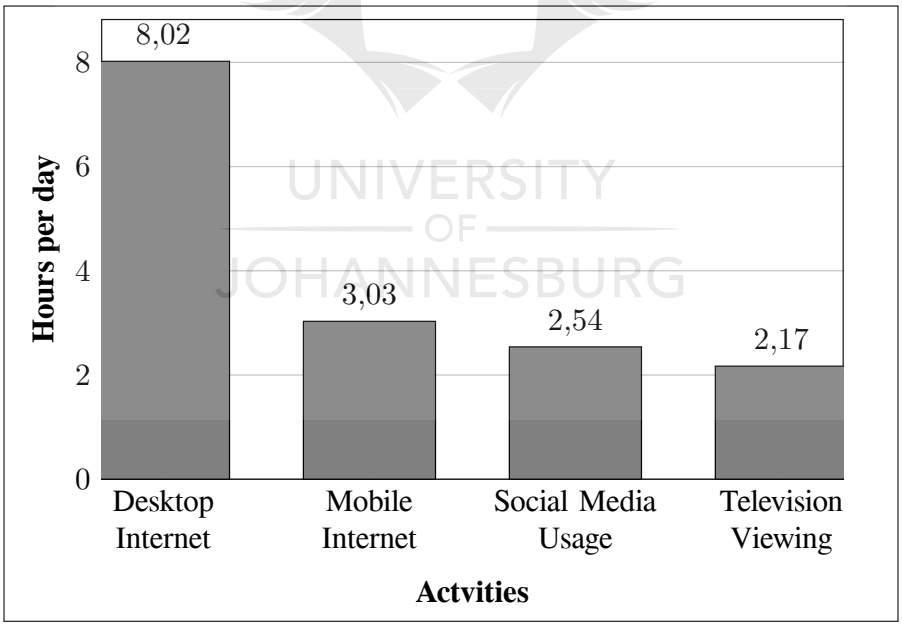

Figure 3.4.: Daily use of Media in SA 2016/17 [adapted from **Olfsen** (2017:8)]

Olfsen (2017:17) indicated that an estimated 17.1 million people in South Africa used e-commerce during the period 2016-2017 and each spent on average R1 800.

Olfsen (2017:18) provided the monthly percentage of e-commerce activities and the means by which they were conducted as shown in Figure 3.5.

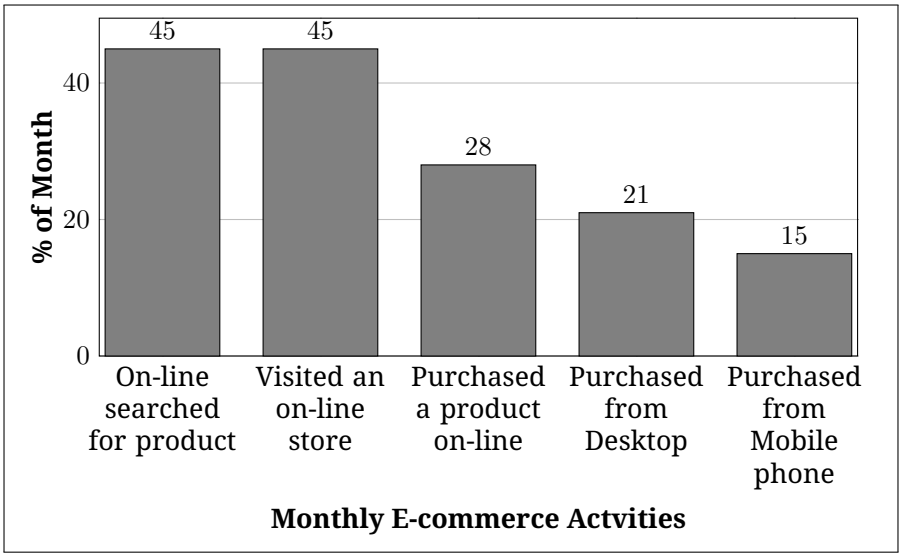

Figure 3.5.: E-commerce activities over 30 days (2016-17) [adapted from **Olfsen** (2017:18)]

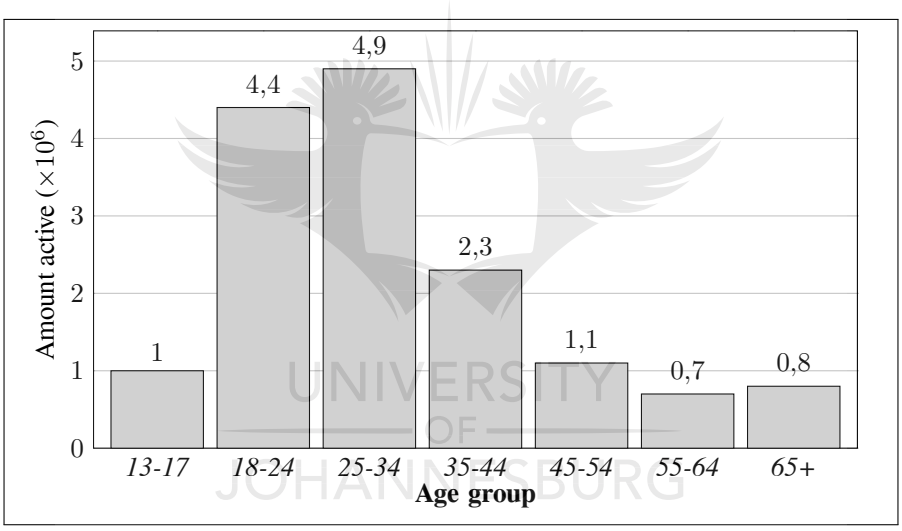

Figure 3.6.: Internet use by age group

For more than 25 years the Human Development Research Office of the United Nations calculated and published a "Human Development Index" for each country. This is an indication of the richness of "life" as opposed to the GDP that is considered the richness of the economy. It has three core perspectives: a) people; b) opportunities; and c) choices (**HDRO** 2016). It is considered to have the following dimensions:

1. Directly enhancing human abilities
   1.1. Life and health expectancy
   1.2. Knowledge
   1.3. Decency of the standard of living
2. Creation of conditions for human development
   2.1. Political and community participation
   2.2. Environmental sustainability
   2.3. Human secrecy and right
   2.4. Gender equality

Table 3.14.: South Africa - Human Development Index [extracted from **UNDP** (2017)]

Year	HDI	Ranking
2015	0,666	119
2014	0,665	116
2013	0,660	118

The HDI for SA improved marginally since 2013 from 0, 660 to 0, 666. The position went up, but then dropped again to 119th. This also indicates that the improvement in internet access did not contribute much to the "richness of life" in SA.

Conclusion

From the above can be deducted that internet use has grown since 2014, but the GDP did not grow at the same rate. The number of households that use the internet with a low income or no income also grew. The other data indicates that the highest use per week is to visit social media. It indicates that the internet has grown as a marketing platform to reach consumers. Users that use the internet for e-commerce mostly use it to obtain information about a product. The improvement in internet access does not reflect in terms a significant change in the Human Development Index.

Van Eck (2017) stated that technology is a very useful enabler but not the end in itself. According to **Moore** (2017) technology is an enabler that allows business to quickly take advantage on opportunities.

Using the currently available information on internet access and macro-economic data it seems that systematic innovation was not used to determine this aspect of the NDP. ICT is an enabler to business. The current information indicates that it reaches the people as a marketing platform and to search for product information. The information indicates that using it for e-commerces is not generally accepted. To make the internet create more opportunities for the people of SA attention must be given to other factors.

§3.5. Summary

The first conclusion reached was that EM contains all aspects of business and management with additional aspects in relation to technical management that are not generally contained in general management.

The analysis of the contradiction and innovative parameters provided by **Mann** (2007a) showed:

1. They do not cover all business processes equally or completely;
2. They seem to have been projected from the TRIZ framework which is suitable for the physical world, but does not fit in a socio-economic frame of reference.

With regard to *NDP* the development goal: *"Ensure affordable widely available broadband data access with the lowest speed at* 2 Mbit/s*."* was investigated. Its purpose is derived from: *"Increase the ability of the economy to engage more people productively."* and it should have an impact on the key driver regarding the flows of knowledge and could improve the development and retain more of the most capable people with the effect of more local innovation and higher potential growth **SANPC** 2011.

This was analysed to determine if there are indications that it has had the impact as based on the

actual internet availability, economic indicators and the HDMI index as calculated by the United nations. It was found that although the availability of the internet increased to above 50 % of the population, the indicators showed a minimal improvement if at all.

Chapter 4

Proposed Approach to Systematic Innovation for Business and Management

§4.1. Introduction

In this chapter an approach is proposed to Systematic Innovation for Business and Management. The aim is to ensure that all the required steps of systematic innovation are covered in a complete high-level approach.

§4.2. Proposed Approach

The proposed approach consists of the following phases:

1. Identification
2. Analysis and Definition
3. Select Approach
4. Create Potential Solutions
5. Verify and Validate Solutions
6. Implement the best Verified and Validated Solution

In the subsequent sections each of the phases will be discussed. The flow of the phases and interactions are depicted in Figure 4.1.

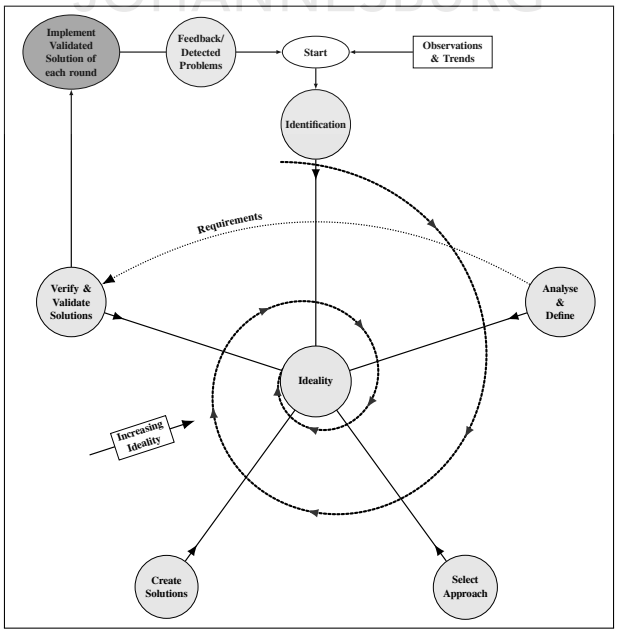

Figure 4.1.: Spiral Systematic Innovation Model

§4.3. Identification

In section §2.3 it was indicated that the aim of innovation is solve problems or close gaps by introducing something new. The gap need not exist it could as **VanGundy** (1988:2-3) stated a perceived one.

It could be a difference between the current situation and a desired state (§2.3.2):

1. Anticipated opportunities exist when a change in goals would be required because a static situation exist, but the desired status is changing;
2. A threat to the goal would exist if the status changes, while the desired state remains constant; and
3. Opportunistic development such as totally new ideas might be possible if both states are changing.

VanGundy (1988) also gave requirements for the existence of a problem (§2.3.2):

1. Realisation of the existence of a gap;
2. A perceived requirement to solve the problem;
3. The extent of the gap must be quantifiable; and
4. To solve the problem would require skills and resources that must be at least available.

Problems that lead to innovation must be characterised as (§2.3.3): a) Semi-formed; or or b) Ill-formed. If they are well-formed they can be solved with routine methods.

In the Algorithm of Inventive Problems Solving (ARIZ) approach to problem solving it is suggested that one analyse the system to detect problem. The TRIZ approach for physical problem solving starts with a known problem as well as in the SIT approach of **Horowitz** (1999) and the USIT approach of **Sickafus** (2006). **Altšhuller** (1985) proposed studying of the S-curve's slopes of an object or system to identify opportunities for innovation. (All of these methods are mostly focussed on physical problems.) *Starting with an existing problem may lead to innovation, but it would probably disregard gaps (actual or percieved) that would lead to other opportunities for innovation.*

Mann (2007a) stated that a need for innovation in business and management could arise from (§2.8.2):

1. Improve or increase outputs,
2. Identify new opportunities and directions,
3. Identify risks and their expected realisation,
4. Reduce costs and wastage, and
5. Maintaining morale and change momentum .

Mann (2007a) also indicated that although problems and opportunities both could lead to innovation the result is typically different. The difference is depicted in Figure 4.2.

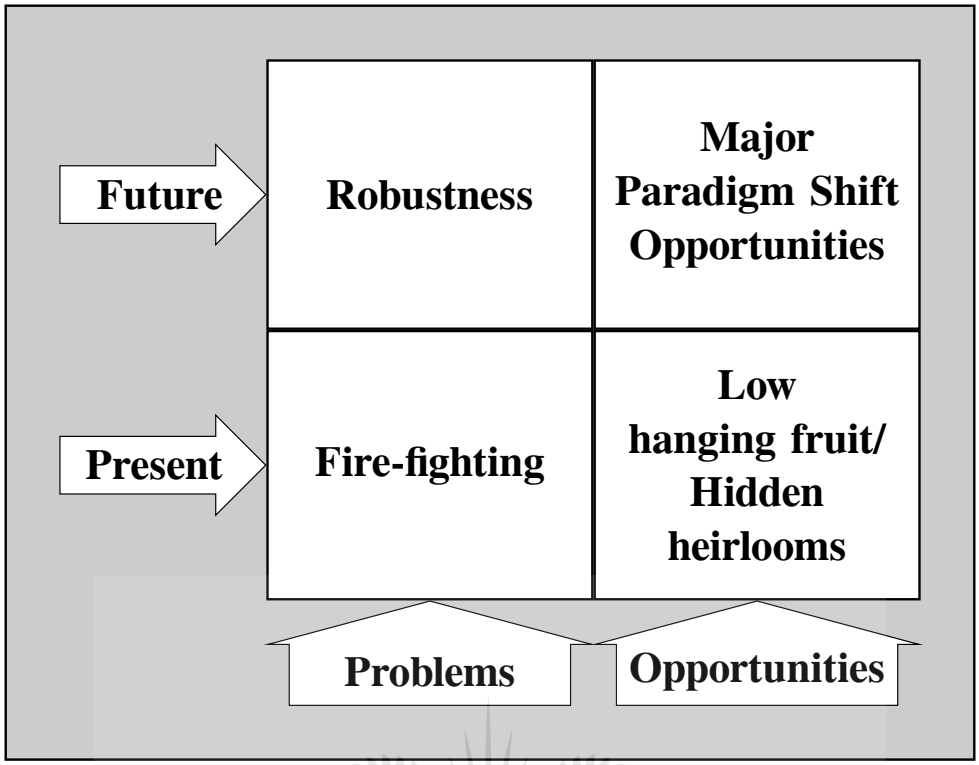

Figure 4.2.: Problems vs. Opportunities

Mann (2007a) (§2.8.2.6) suggested the following methods to identify opportunities:

1. Identification of Trends through use of Evolutionary Potential Maps (2.8.2.6)
2. Other faster methods:
   (a) Resolving conflicts. In this process he suggested use of forced association Brainstorming by means of the 40 Inventive Principles for Business and Management.
   (b) Detection of underutilised resources.

These techniques both are useful. The 40 Inventive Principles provided by **Mann** (2007a), however, lack in addressing all business areas equally and the descriptive definitions of each should be expanded to clearly address all business process areas.

Altšhuller (1998), **Gadd** (2011), & **Mann** (2007a) warned that during the identification of opportunities psychological inertia may be a barrier to success. In the simplest explanation it would be where all participants only view internal perspectives to the information a hand.

To overcome psychological inertia **Mann** (2007a) (§2.8.3) suggested the use of:

1. Generalisation of the situation to find a general problem;
2. The lateral think process through the use of the Six Hats™ approach of De Bono;
3. Structuring of information; and
4. Group Dynamics by subdividing the group to focuss on one of the specific hats of De Bono or to involve more creative people in the group.

VanGundy (1988) gave the characterics of lateral thinking as:

1. Search for new perspectives of items; with change and movement as the primary concern.
2. Refrain from searching for "right" or "wrong". Attempt to determine what is different.
3. Examines concepts to lead to new ones.
4. Preserves continuity by following the steps logically.
5. Is selective in consideration of information to create concepts; rejects contents that is con-

sidered irrelevant.
6. Progresses utilising conventional patterns; regards the obvious.
7. Promises at least marginal success in obtaining a solution.

Mann (2007a) also suggested 9-Windows process to (System Time Operator) as a method to analyse a system in the systems hierarchy and over time.

§4.3.1. Summary

A problem may exist and be identified through its manifestation. If it's well-formed routine methods could be used to solve it and it would probably not lead to innovation. If it's not or an actual or perceived gap has been identified, an opportunity for innovation would exist.

Investigation of trends could also indicate and help identify innovation opportunities. Specific business needs as stated by **Mann** (2007a) and indicated above are also methods to identify them.

Psychological Inertia (PI) could block the identification, but the suggested techniques could limit or overcome it.

Forced Association by means of Brainstorming or -writing could be useful to overcome PI and to identify opportunities. The triggers that **Mann** (2007a) provided need to be expanded and clarified. **VanGundy** (1988) did not provide specific triggers, but warned that it could limit the view of the participants.

§4.4. Analysis and Definition

To use an opportunity for innovation it's required to analyse and define the opportunity.

VanGundy (1988) (cf. §2.5.4) provided guidelines to the assist with the analysis of opportunities (Table 2.2):

1. Determine the available information about it;
2. Quantify it in real terms;
3. Determine if it needs to be solved;
4. Determine what resources are available; and
5. Determine if your sphere of influence covers the problem.

The last one on these could be a barrier that require effort to overcome. It could also be a special opportunity.

The generic steps to analyse and define a problem is is according to **VanGundy** (1988) (cf. 2.3)

1. Collect and analyse the information about the problem;
2. Determine if it is an ill-formed situation;
3. For not ill-formed problems search for and evaluate existing solutions;
4. In the case of an ill-formed problem, determine whether a group or individual ap-proach should be followed to define and analyse it;
5. Pick one or more of the analytical and re-definitional methods;
6. Create alternative definitions of the problem;
7. Choose a tentative definition of the problem; and
8. State the selected definition.

Steps 2-4 are required, but could be redundant if the opportunity identification phase identified the type of the opportunity.

VanGundy (1988) (cf. §2.5.1) described the following methods to analyse and re-define an

opportunity:

1. Boundary examinations;
2. Goal orientation;
3. Five W's and H questions;
4. Progressive abstractions; and
5. Why method.

Techniques that can be used to analyse an opportunity (**VanGundy** 1988) (cf. §2.5.1) are:

1. Decomposable matrices;
2. Dimensional Analysis;
3. Input-Output (moderator) Analysis;
4. Organised Random Search; and
5. Relevance Systems.

Mann (2007a) provided the following methods to analyse a business and management innovation opportunity (cf. §2.8.5.1):

1. Problem/Opportunity Explorer
2. Function/Attribute Analysis
3. S-Curve Analysis
4. Perception Mapping
5. Ideal Final Result

The problem/opportunity explorer is according to **Mann** (2007a) an essential part of the definition of an opportunity. It involves (cf 2.8.2.1):

1. Determination of the current status;
2. Goal of achieving the opportunity;
3. Validation of the solution;
4. Available resources; and
5. The applicable constraints.

The Function/Attribute involves the analysis of the relationships between system elements in terms of existing: a) useful ones; and b) harmful or undesired ones and before, during and after the problem occurs.

The S-Curve analysis is done on different perspectives of system or object growth and maturity. It can provide useful insight if the data is available to determine the S-Curve. It is would be complex to conduct this analysis in all the business process areas.

Perception Mapping (cf. 2.8.5.5) involves the analysis of the different perceptions people have about a problem. The aim is to solve the contradictions or conflicts in the perceptions.

In the Ideal Final Result the best solution ever to problem is determined as the ideal situation to strive for.

Mann (2007a) indicated two important benefits or reasons to innovate:

Going beyond: The situation or system is close to or at its fundamental. The aim would then to set a target above the capacity as the competition will soon find a way to break the barrier if one don't aim right now.

Totally new: No current situation or system exists. Through innovation a new desired one can be accomplished.

§4.4.1. Summary

The basic steps to define and analyse an innovation opportunity would be:

1. Collect and analyse information about the problem or opportunity. By determining:
   (a) How well is it defined?
   (b) The relationship to other situations or aspects in the near and extended environment
   (c) The current boundaries/restrictions or limit of capacity
   (d) The time and systems hierarchy
2. Determine and classify the purpose of the solution
3. Determine the available resources

Mann (2007a) define robustness as immunity to changing conditions and indicated it as a separate method to obtain a solution. It is recommended that robustness should be included in the requirements of all problem definitions. A single innovative solution can probably not make the total organisation robust, but if it's aimed for in every solution it would contribute to the total robustness. Another useful characteristic would to aim for solutions that are autopoietic or help make the business autopoietic.

§4.5. Select Approach

At this stage the problem or opportunity has been identified, analysed and defined.

Mann (2007a) (cf. §2.8.6) provided 18 characteristics to determine the best approach to solve a problem and also see prioritisation as a reason. Based on the characteristic one would then select the applicable solution from the list of 11 possible categories as indicated in Table 2.15.

The first two of the methods directly involve conflicts, trade-offs or contradictions. These methods are then at their core based on the Inventive Principles and Parameters that **Mann** (2007a) derived from the same concepts found in the TRIZ approach for the physical world. The problem is that their coverage of all business processes as indicated in Chapter 3 require more broadening and research.

VanGundy (1988) did not make provision for a method to select a problem solving approach. The only criterion is whether it will be conducted by an individual or by a group. One could use the Advantages and Disadvantages of each method as in indicated in §2.5.3 to decide whether a method is more suitable for the situation at hand.

§4.6. Create Potential Solutions

During this stage the selected approach is applied to solve the problem. If it does not provide a solution, one should either return to the analysis and definition stage or select a different approach to finding a solution as indicated by **Mann** (2007a) (cf. Table 2.15).

If multiple solutions or solutions to different aspects are created an attempt should be to integrate and combine them. It could also indicate that the definition was not at he right level or hierarchy.

§4.7. Verify and Validate Solutions

According to **Mann** (2007a) (cf. §2.8.1.2) the success of an innovation does not point at profitability, but rather at the following:

1. Decisive Components
   Systematic Innovation arises from the following:
   1.1. Idea/concept with clear Intellectual Property Rights,
   1.2. Means to render,
   1.3. Manifestation of the innovation,
   1.4. Customer or end-user, and
   1.5. Management or coordination between the other components.
2. Function
   End-users require functionality from a product or service.
3. Ideality
   Successful innovations have increased ideality in at least one customer segment.
4. Resources
   The innovation uses a previously unused resource or even changed a former negative effect into a useful one.
5. Elimination or reduction of contradictions
   Elimination or reduction of conflicts, trade-offs and contradictions towards higher ideality indicate success.
6. Trend Jumps At least one discontinuous advance on one of the trends is probably a productive innovation.

The one or more solutions from the previous stage must be verified and validated against the problem definition obtained earlier. As indicated in the previous section, during this it could show that none of the solutions completely solve the problem or meet the requirements. One approach is to decided on the best solution and implement it. Another would be to attempt to combine some of them. This would also indicate that the process needs to continue as indicated in Figure 4.1 to move closer to ideality.

§4.8. Implement the Best Verified and Validated Solution

If a solution is found during the verification and validation stage that best meets the requirements it should be implemented. From the implementation feedback will be obtained that would be used as input to the next round of innovation.

§4.9. Summary

A spiral model for systematic innovation was proposed. It consists of five consecutive stages:

1. Identification
2. Analysis and Definition
3. Select Approach
4. Create Solutions
5. Verify and validate solutions

The implementation is not part of the innovation model, but provides feedback for subsequent stages of the process.

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Chapter 5

Conclusion

§5.1. Introduction

In this chapter an overview will be presented of the field covered and the results obtained. A more comprehensive Systematic Innovation Process model for business and management was proposed in the previous chapter. This needs further development and expansion that will also be shown in this chapter.

§5.2. Field Covered and Results Obtained

The research showed that several approaches exist to systematic innovation. Each has shortcomings.

The Creative Problem Solving (CPS) set of processes of **VanGundy** (1988) is largely based on Brainstorming or -writing. It has been criticised for being convergent in the last phase. The solution selection process is characterised by selecting an optimised solution, which will stay within the limitations of the current system. It is also a generic set of processes, which could be useful but is not directly focussed on specific areas.

TRIZ was developed by **Altšhuller** (1998) based on investigation of patents. It means it is aimed at the physical world. In business and management it could be useful when innovation for tangible items is being done. From it two other models were derived: SIT by **Horowitz** (1999) and USIT by **Sickafus** (1996). SIT refers to a closed physical world, which is not useful for business and management. USIT is a simplification and reduction of TRIZ. It is possible to use it in the business world, but it does not directly and clearly relate to business processes and that would place it in the same area as CPS.

Mann (2007a) developed a systematic innovation model for business and management. It uses many of the concepts of TRIZ. Investigation showed that it seems like business information was projected onto the process of **Altšhuller** (1998). Assumptions were made that the parameters and principles applicable to the physical world were the same as for the framework of business and management. This process could be useful if the parameters and principles were re-aligned and new ones determined for business and management that would cover all the areas of the Value Chain or all the core business processes.

§5.3. Contributions

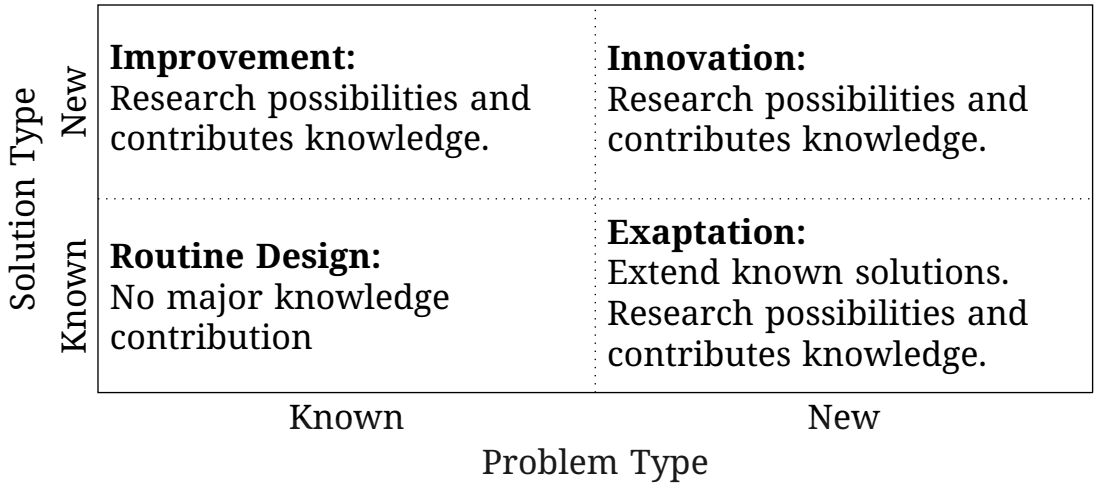

Figure 5.1.: Design Science Research Knowledge Contribution adapted form **Gregor** and **Hevner** (2013:345).

This research improved on previous models and extended current models through the construct provided in Chapter 4. This is aligned with the Improvement and Exaptation elements of Figure 5.1.

§5.3.1. Detected shortcomings

First of all it was discovered that the core elements of the Systematic Innovation approach as provided by **Mann** (2007a) do not cover all core business processes to the same extent. Innovation for business and management should not be limited to some areas of business.

Further analysis showed that a clear relationship exists between the Contradiction and Innovative Parameters provided for business and management and the ones of the physical world as developed by **Altšhuller** (1998) for his TRIZ inventive framework. It gives the impression that the parameters of TRIZ were merely projected to the socio-economic framework of business and management.

§5.3.2. Proposed model

A spiral model for systematic innovation in business and management is proposed in Chapter 4. It attempts to integrate all the other processes.

§5.4. Recommendations

The proposed spiral model does not give all the detail as it refers to components of the other processes. More extensive research is required to provide more explicit detail to each of the steps along the proposed framework. The key concepts are contradictions or conflicts in business and management that are in general resolved through optimisation. Optimisation is considered a barrier to further growth and can only be overcome by innovation. The supporting tools include

Innovative Principles. The research showed that the ones provided by **Mann** (2007a) are not really different from the ones developed by **Altšhuller** (1998) for TRIZ, which was based on the analysis of patents and are therefore well suited to the physical world.

Innovative parameters and principles for business need to be developed. Where the parameters show contradictions, which would mean improvement of the one would result in the deterioration of the other, suitable innovative principles will have to be derived. This has to be conducted in all core business area to ensure that the process does not exclude any area of business. The subsequent research has to published to ensure that a complete and scientific method has been followed. This will enable further improvement on this area of knowledge.

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Appendix A

TRIZ Tools

All of these are repeated from the sources for the purpose of comparison as used in Chapter 3.

§A.1. Altšhuller's 40 Inventive principles

The list is an edited and shortened version of the list published by **Tate** and **Domb** (1997).

1. Segmentation
   A. Divide an object into independent parts.
   B. Make an object easy to disassemble.
   C. Increase the degree of fragmentation or segmentation.
2. Taking out
   A. Separate an interfering part or property from an object, or
   B. Single out the only necessary part (or property) of an object.
3. Local quality
   A. Change an object's structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.
   B. Make each part of an object function in conditions most suitable for its operation.
   C. Make each part of an object fulfil a different and useful function.
4. Asymmetry
   A. Change the shape of an object from symmetrical to asymmetrical.
   B. If an object is asymmetrical, increase its degree of asymmetry.
5. Merging
   A. Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.
   B. Make operations contiguous or parallel; bring them together in time.
6. Universality
   A. Make a part or object perform multiple functions; eliminate the need for other parts.
7. "Nested doll"
   A. Place one object inside another; place each object, in turn, inside the other.
   B. Make one part pass through a cavity in the other.
8. Anti-weight
   A. To compensate for the weight of an object, merge it with other objects that provide lift.
   B. To compensate for the weight of an object, make it interact with the environment (e.g. use aerodynamic, hydrodynamic, buoyancy and other forces).
9. Preliminary anti-action
   A. If it will be necessary to do an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects.
   B. Create beforehand stresses in an object that will oppose known undesirable working stresses later on.
10. Preliminary action
    A. Perform, before it is needed, the required change of an object (either fully or partially).
    B. Pre-arrange objects such that they can come into action from the most convenient place

and without losing time for their delivery.

11. Beforehand cushioning
    A. Prepare emergency means beforehand to compensate for the relatively low reliability of an object.
12. Equipotentiality
    A. In a potential field, limit position changes (e.g. change operating conditions to eliminate the need to raise or lower objects in a gravity field).
13. 'The other way round'
    A. Invert the action(s) used to solve the problem (e.g. instead of cooling an object, heat it).
    B. Make movable parts (or the external environment) fixed, and fixed parts movable).
    C. Turn the object (or process) 'upside down'.
14. Spheroidality - Curvature
    A. Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones; move from flat surfaces to spherical ones; from parts shaped as a cube (parallelepiped) to ball-shaped structures.
    B. Use rollers, balls, spirals, domes.
    C. Go from linear to rotary motion, use centrifugal forces.
15. Dynamics
    A. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.
    B. Divide an object into parts capable of movement relative to each other.
    C. If an object (or process) is rigid or inflexible, make it movable or adaptive.
16. Partial or excessive actions
    A. If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.
17. Another dimension
    A. To move an object in two- or three-dimensional space.
    B. Use a multi-story arrangement of objects instead of a single-story arrangement.
    C. Tilt or re-orient the object, lay it on its side.
    D. Use 'another side' of a given area.
18. Mechanical vibration
    A. Cause an object to oscillate or vibrate.
    B. Increase its frequency (even up to the ultrasonic).
    C. Use an object's resonant frequency.
    D. Use piezoelectric vibrators instead of mechanical ones.
    E. Use combined ultrasonic and electromagnetic field oscillations.
19. Periodic action
    A. Instead of continuous action, use periodic or pulsating actions.
    B. If an action is already periodic, change the periodic magnitude or frequency.
    C. Use pauses between impulses to perform a different action.
20. Continuity of useful action
    A. Carry on work continuously; make all parts of an object work at full load, all the time.
    B. Eliminate all idle or intermittent actions or work.
21. Skipping
    A. Conduct a process , or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.
22. "Blessing in disguise" or "Turn Lemons into Lemonade"
    A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.
    B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.

   C. Amplify a harmful factor to such a degree that it is no longer harmful.
23. Feedback
   A. Introduce feedback (referring back, cross-checking) to improve a process or action.
   B. If feedback is already used, change its magnitude or influence.
24. 'Intermediary'
   A. Use an intermediary carrier article or intermediary process.
   B. Merge one object temporarily with another (which can be easily removed).
25. Self-service
   A. Make an object serve itself by performing auxiliary helpful functions
   B. Use waste resources, energy, or substances.
26. Copying
   A. Instead of an unavailable, expensive, fragile object, use simpler and inexpensive copies.
   B. Replace an object, or process with optical copies.
   C. If visible optical copies are already used, move to infra-red or ultraviolet copies.
27. Cheap short-living objects
   A. Replace an inexpensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance).
28. Mechanics substitution
   A. Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
   B. Use electric, magnetic and electromagnetic fields to interact with the object.
   C. Change from static to movable fields, from unstructured fields to those having structure.
   D. Use fields in conjunction with field-activated (e.g. ferromagnetic) particles.
29. Pneumatics and hydraulics
   A. Use gas and liquid parts of an object instead of solid parts (e.g. inflatable, filled with liquids, air cushion, hydrostatic, hydro-reactive).
30. Flexible shells and thin films
   A. Use flexible shells and thin films instead of three dimensional structures
   B. Isolate the object from the external environment using flexible shells and thin films.
31. Porous materials
   A. Make an object porous or add porous elements (inserts, coatings, etc.).
   B. If an object is already porous, use the pores to introduce a useful substance or function.
32. Colour changes
   A. Change the colour of an object or its external environment.
   B. Change the transparency of an object or its external environment.
33. Homogeneity
   A. Make objects interacting with a given object of the same material (or material with identical properties).
34. Discarding and recovering
   A. Make portions of an object that have fulfilled their functions go away (discard by dissolving, evaporating, etc.) or modify these directly during operation.
   B. Conversely, restore consumable parts of an object directly in operation.
35. Parameter changes
   A. Change an object's physical state (e.g. to a gas, liquid, or solid.
   B. Change the concentration or consistency.
   C. Change the degree of flexibility.
   D. Change the temperature.
36. Phase transitions
   A. Use phenomena occurring during phase transitions (e.g. volume changes, loss or absorption of heat, etc.).
37. Thermal expansion
   A. Use thermal expansion (or contraction) of materials.
   B. If thermal expansion is being used, use multiple materials with different coefficients of

thermal expansion.

38. Strong oxidants
    A. Replace common air with oxygen-enriched air.
    B. Replace enriched air with pure oxygen.
    C. Expose air or oxygen to ionizing radiation.
    D. Use ionized oxygen.
    E. Replace ozonized (or ionized) oxygen with ozone.
39. Inert atmosphere
    A. Replace a normal environment with an inert one.
    B. Add neutral parts, or inert additives to an object.
40. Composite materials
    A. Change from uniform to composite (multiple) materials.

§A.2. Contradiction Matrix

Attached to the archives of the TRIZ Journal, July 1997 (**TRIZ-Journ.** 1997).

Table A.1.: Contradiction Matrix (**TRIZ-Journ.** 1997)

IP↓ / WP→	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
1		-	15 8 29 34	-	29 17 38 34	-	29 2 40 28	-	2 8 15 38	8 10 18 37	10 36 37 40	10 14 35 40	1 35 19 39	28 27 18 40	5 34 31 35	-	6 29 4 38	19 1 32	35 12 34 31	-	12 36 18 31	6 2 34 19	5 35 3 31	10 24 35	10 35 20 28	3 26 18 31	1 3 11 27	28 27 35 26	28 35 26 18	22 21 18 27	22 35 31 39	27 28 1 36	35 3 2 24	2 27 28 11	29 5 15 8	26 30 36 34	28 29 26 32	26 35 18 19	35 3 24 37
2	-		-	10 1 29 35	-	35 30 13 2	-	5 35 14 2	-	8 10 19 35	13 29 10 18	13 10 29 14	26 39 1 40	28 2 10 27	-	2 27 19 6	28 19 32 22	19 32 35	-	18 19 28 1	15 19 18 22	18 19 28 15	5 8 13 30	10 15 35	10 20 35 26	19 6 18 26	10 28 8 3	18 26 28	10 1 35 17	2 19 22 37	35 22 1 39	28 1 9	6 13 1 32	2 27 28 11	19 15 29	1 10 26 39	25 28 17 15	2 26 35	1 28 15 35
3	8 15 29 34	-		-	15 17 4	-	7 17 4 35	-	13 4 8	17 10 4	1 8 35	1 8 10 29	1 8 15 34	8 35 29 34	19	-	10 15 19	32	8 35 24	-	1 35	7 2 35 39	4 29 23 10	1 24	15 2 29	29 35	10 14 29 40	28 32 4	10 28 29 37	1 15 17 24	17 15	1 29 17	15 29 35 4	1 28 10	14 15 1 16	1 19 26 24	35 1 26 24	17 24 26 16	14 4 28 29
4		35 28 40 29	-		-	17 7 10 40	-	35 8 2 14	-	28 10	1 14 35	13 14 15 7	39 37 35	15 14 28 26	-	1 10 35	3 35 38 18	3 25	-		12 8	6 28	10 28 24 35	24 26	30 29 14		15 29 28	32 28 3	2 32 10	1 18		15 17 27	2 25	3	1 35	1 26	26		30 14 7 26
5	2 17 29 4	-	14 15 18 4	-		-	7 14 17 4		29 30 4 34	19 30 35 2	10 15 36 28	5 34 29 4	11 2 13 39	3 15 40 14	6 3	-	2 15 16	15 32 19 13	19 32	-	19 10 32 18	15 17 30 26	10 35 2 39	30 26	26 4	29 30 6 13	29 9	26 28 32 3	2 32	22 33 28 1	17 2 18 39	13 1 26 24	15 17 13 16	15 13 10 1	15 30	14 1 13	2 36 26 18	14 30 28 23	10 26 34 2
6	-	30 2 14 18	-	26 7 9 39	-		-		-	1 18 35 36	10 15 36 37		2 38	40	-	2 10 19 30	35 39 38		-		17 32	17 7 30	10 14 18 39	30 16	10 35 4 18	2 18 40 4	32 35 40 4	26 28 32 3	2 29 18 36	27 2 39 35	22 1 40	40 16	16 4	16	15 16	1 18 36	2 35 30 18	23	10 15 17 7
7	2 26 29 40	-	1 7 4 35	-	1 7 4 17	-		-	29 4 38 34	15 35 36 37	6 35 36 37	1 15 29 4	28 10 1 39	9 14 15 7	6 35 4	-	34 39 10 18	2 13 10	35	-	35 6 13 18	7 15 13 16	36 39 34 10	2 22	2 6 34 10	29 30 7	14 1 40 11	25 26 28	25 28 2 16	22 21 27 35	17 2 40 1	29 1 40	15 13 30 12	10	15 29	26 1	29 26 4	35 34 16 24	10 6 2 34
8	-	35 10 19 14	19 14	35 8 2 14	-		-		-	2 18 37	24 35	7 2 35	34 28 35 40	9 14 17 15	-	35 34 38	35 6 4		-	30 6		10 39 35 34		35 16 32 18	35 3	2 35 16		35 10 25	34 39 19 27	30 18 35 4	35		1		1 31	2 17 26		35 37 10 2
9	2 28 13 38	-	13 14 8	-	29 30 34	-	7 29 34	-		13 28 15 19	6 18 38 40	35 15 18 34	28 33 1 18	8 3 26 14	3 19 35 5	-	28 30 36 2	10 13 19	8 15 35 38	-	19 35 38 2	14 20 19 35	10 13 28 38	13 26		10 19 29 38	11 35 27 28	28 32 1 24	10 28 32 25	1 28 35 23	2 24 35 21	35 13 8 1	32 28 13 12	34 2 28 27	15 10 26	10 28 4 34	3 34 27 16	10 18	
10	8 1 37 18	18 13 1 28	17 19 9 36	28 10	19 10 15	1 18 36 37	15 9 12 37	2 36 18 37	13 28 15 12		18 21 11	10 35 40 34	35 10 21	35 10 14 27	19 2		35 10 21	-	19 17 10	1 16 36 37	19 35 18 37	14 15	8 35 40 5		10 37 36	14 29 18 36	3 35 13 21	35 10 23 24	28 29 37 36	1 35 40 18	13 3 36 24	15 37 18 1	1 28 3 25	15 1 11	15 17 18 20	26 35 10 18	36 37 10 19	2 35	3 28 35 37

Key: IP = Improving; Parameter WP = Worsening Parameter Continued on next page ...

Table A.1 – continued from previous page

IP↓ \ WP→	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
11	10 36 37 40	13 29 10 18	35 10 36	35 1 14 16	10 15 36 28	10 15 36 37	6 35 10	35 24	6 35 36	36 35 21		35 4 15 10	35 33 2 40	9 18 3 40	19 3 27		35 39 19 2	-	14 24 10 37		10 35 14	2 36 25	10 36 3 37		37 36 4	10 14 36	10 13 19 35	6 28 25	3 35	22 2 37	2 33 27 18	1 35 16	11	2	35	19 1 35	2 36 37	35 24	10 14 35 37
12	8 10 29 40	15 10 26 3	29 34 5 4	13 14 10 7	5 34 4 10		14 4 15 22	7 2 35	35 15 34 18	35 10 37 40	34 15 10 14		33 1 18 4	30 14 10 40	14 26 9 25		22 14 19 32	13 15 32	2 6 34 14		4 6 2	14	35 29 3 5		14 10 34 17	36 22	10 40 16	28 32 1	32 30 40	22 1 2 35	35 1	1 32 17 28	32 15 26	2 13 1	1 15 29	16 29 1 28	15 13 39	15 1 32	17 26 34 10
13	21 35 2 39	26 39 1 40	13 15 1 28	37	2 11 13	39	28 10 19 39	34 28 35 40	33 15 28 18	10 35 21 16	2 35 40	22 1 18 4		17 9 15	13 27 10 35	39 3 35 23	35 1 32	32 3 27 16	13 19	27 4 29 18	32 35 27 31	14 2 39 6	2 14 30 40		35 27	15 32 35		13	18	35 24 30 18	35 40 27 39	35 19	32 35 30	2 35 10 16	35 30 34 2	2 35 22 26	35 22 39 23	1 8 35	23 35 40 3
14	1 8 40 15	40 26 27 1	1 15 8 35	15 14 28 26	3 34 40 29	9 40 28	10 15 14 7	9 14 17 15	8 13 26 14	10 18 3 14	10 3 18 40	10 30 35 40	13 17 35		27 3 26		30 10 40	35 19	19 35 10	35	10 26 35 28	35	35 28 31 40		29 3 28 10	29 10 27	11 3	3 27 16	3 27	18 35 37 1	15 35 22 2	11 3 10 32	32 40 25 2	27 11 3	15 3 32	2 13 25 28	27 3 15 40	15	29 35 10 14
15	19 5 34 31	-	2 19 9	-	3 17 19	-	10 2 19 30	-	3 35 5	19 2 16	19 3 27	14 26 28 25	13 3 35	27 3 10		-	19 35 39	2 19 4 35	28 6 35 18		19 10 35 38		28 27 3 18	10	20 10 28 18	3 35 10 40	11 2 13	3	3 27 16 40	22 15 33 28	21 39 16 22	27 1 4	12 27	29 10 27	1 35 13	10 4 29 15	19 29 39 35	6 10	35 17 14 19
16	-	6 27 19 16	-	1 40 35	-		-	35 34 38	-				39 3 35 23		-		19 18 36 40		-		16		27 16 18 38	10	28 20 10 16	3 35 31	34 27 6 40	10 26 24		17 1 40 33	22	35 10	1	1	2		25 34 6 35	1	20 10 16 38
17	36 22 6 38	22 35 32	15 19 9	15 19 9	3 35 39 18	35 38	34 39 40 18	35 6 4	2 28 36 30	35 10 3 21	35 39 19 2	14 22 19 32	1 35 32	10 30 22 40	19 13 39	19 18 36 40		32 30 21 16	19 15 3 17		2 14 17 25	21 17 35 38	21 36 29 31		35 28 21 18	3 17 30 39	19 35 3 10	32 19 24	24	22 33 35 2	22 35 2 24	26 27	26 27	4 10 16	2 18 27	2 17 16	3 27 35 31	26 2 19 16	15 28 35
18	19 1 32	2 35 32	19 32 16		19 32 26		2 13 10		10 13 19	26 19 6		32 30	32 3 27	35 19	2 19 6		32 35 19		32 1 19	32 35 1 15	32	13 16 1 6	13 1	1 6	19 1 26 17	1 19		11 15 32	3 32	15 19	35 19 32 39	19 35 28 26	28 26 19	15 17 13 16	15 1 19	6 32 13	32 15	2 26 10	2 25 16
19	12 18 28 31	-	12 28	-	15 19 25	-	35 13 18	-	8 35 35	16 26 21 2	23 14 25	12 2 29	19 13 17 24	5 19 9 35	28 35 6 18	-	19 24 3 14	2 15 19		-	6 19 37 18	12 22 15 24	35 24 18 5		35 38 19 18	34 23 16 18	19 21 11 27	3 1 32		1 35 6 27	2 35 6	28 26 30	19 35	1 15 17 28	15 17 13 16	2 29 27 28	35 38	32 2	12 28 35
20	-	19 9 6 27	-		-		-		-	36 37			27 4 29 18	35				19 2 35 32	-				28 27 18 31			3 35 31	10 36 23			10 2 22 37	19 22 18	1 4					19 35 16 25		1 6

Key: IP = Improving; Parameter WP = Worsening Parameter

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Table A.1 – continued from previous page

WP→

IP↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
21	8 36 38 31	19 26 17 27	1 10 35 37		19 38	17 32 13 38	35 6 38	30 6 25	15 35 2	26 2 36 35	22 10 35	29 14 2 40	35 32 15 31	26 10 28	19 35 10 38	16	2 14 17 25	16 6 19	16 6 19 37			10 35 38	28 27 18 38	10 19	35 20 10 6	4 34 19	19 24 26 31	32 15 2	32 2	19 22 31 2	2 35 18	26 10 34	26 35 10	35 2 10 34	19 17 34	20 19 30 34	19 35 16	28 2 17	28 35 34
22	15 6 19 28	19 6 18 9	7 2 6 13	6 38 7	15 26 17 30	17 7 30 18	7 18 23	7	16 35 38	36 38			14 2 39 6	26			19 38 7	1 13 32 15			3 38		35 27 2 37	19 10	10 18 32 7	7 18 25	11 10 35	32		21 22 35 2	21 35 2 22		35 32 1	2 19		7 23	35 3 15 23	2	28 10 29 35
23	35 6 23 40	35 6 22 32	14 29 10 39	10 28 24	35 2 10 31	10 18 39 31	1 29 30 36	3 39 18 31	10 13 28 38	14 15 18 40	3 36 37 10	29 35 3 5	2 14 30 40	35 28 31 40	28 27 3 18	27 16 18 38	21 36 39 31	1 6 13	35 18 24 5	28 27 12 31	28 27 18 38	35 27 2 31			15 18 35 10	6 3 10 24	10 29 39 35	16 34 31 28	35 10 24 31	33 22 30 40	10 1 34 29	15 34 33	32 28 2 24	2 35 34 27	15 10 2	35 10 28 24	35 18 10 13	35 10 18	28 35 10 23
24	10 24 35	10 35 5	1 26	26	30 26	30 16		2 22	26 32						10	10		19			10 19	19 10			24 26 28 32	24 28 35	10 28 23			22 10 1	10 21 22	32	27 22				35 33	35	13 23 15
25	10 20 37 35	10 20 26 5	15 2 29	30 24 14 5	26 4 5 16	10 35 17 4	2 5 34 10	35 16 32 18		10 37 36 5	37 36 4	4 10 34 17	35 3 22 5	29 3 28 18	20 10 28 18	28 20 10 16	35 29 21 18	1 19 26 17	35 38 19 18	1	35 20 10 6	10 5 18 32	35 18 10 39	24 26 28 32		35 38 18 16	10 30 4	24 34 28 32	24 26 28 18	35 18 34	35 22 18 39	35 28 34 4	4 28 10 34	32 1 10	35 28	6 29	18 28 32 10	24 28 35 30	
26	35 6 18 31	27 26 18 35	29 14 35 18		15 14 29	2 18 40 4	15 20 29		35 29 34 28	35 14 3	10 36 14 3	35 14	15 2 17 40	14 35 34 10	3 35 10 40	3 35 31	3 17 39		34 29 16 18	3 35 31	35	7 18 25	6 3 10 24	24 28 35	35 38 18 16		18 3 28 40	13 2 28	33 30	35 33 29 31	3 35 40 39	29 1 35 27	35 29 25 10	2 32 10 25	15 3 29	3 13 27 10	3 27 29 18	8 35	13 29 3 27
27	3 8 10 40	3 10 8 28	15 9 14 4	15 29 28 11	17 10 14 16	32 35 40 4	3 10 14 24	2 35 24	21 35 11 28	8 28 10 3	10 24 35 19	35 1 16 11		11 28	2 35 3 25	34 27 6 40	3 35 10	11 32 13	21 11 27 19	36 23	21 11 26 31	10 11 35	10 35 29 39	10 28	10 30 4	21 28 40 3		32 3 11 23	11 32 1	27 35 2 40	35 2 40 26		27 17 40	1 11	13 35 8 24	13 35 1	27 40 28	11 13 27	1 35 29 38
28	32 35 26 28	28 35 25 26	28 26 5 16	32 28 3 16	26 28 32 3	26 28 32 3	32 13 6		28 13 32 24	32 2	6 28 32	6 28 32	32 35 13	28 6 32	28 6 32	10 26 24	6 19 28 24	6 1 32	3 6 32		3 6 32	26 32 27	10 16 31 28		24 34 28 32	2 6 32	5 11 1 23			28 24 22 26	3 33 39 10	6 35 25 18	1 13 17 34	1 32 13 11	13 35 2	27 35 10 34	26 24 32 28	28 2 10 34	10 34 28 32
29	28 32 13 18	28 35 27 9	10 28 29 37	2 32 10	28 33 29 32	2 29 18 36	32 23 2	25 10 35	10 28 32	28 19 34 36	3 35	32 30 40	30 18	3 27	3 27 40		19 26	3 32	32 2		32 2	13 32 2	35 31 10 24		32 26 28 18	32 30	11 32 1			26 28 10 36	4 17 34 26		1 32 35 23	25 10		26 2 18		26 28 18 23	10 18 32 39
30	22 21 27 39	2 22 13 24	17 1 39 4	1 18	22 1 33 28	27 2 39 35	22 23 37 35	34 39 19 27	21 22 35 28	13 35 39 18	22 2 37	22 1 3 35	35 24 30 18	18 35 37 1	22 15 33 28	17 1 40 33	22 33 35 2	1 19 32 13	1 24 6 27	10 2 22 37	19 22 31 2	21 22 35 2	33 22 19 40	22 10 2	35 18 34	35 33 29 31	27 24 2 40	28 33 23 26	26 28 10 18			24 35 2	2 25 28 39	35 10 2	35 11 22 31	22 19 29 40	22 19 29 40	33 3 34	22 35 13 24

Key: IP = Improving; Parameter WP = Worsening Parameter

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Table A.1 – continued from previous page

IP↓ / WP→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
31	19 22 15 39	35 22 1 39	17 15 16 22		17 2 18 39	22 1 40	17 2 40	30 18 35 4	35 28 3 23	35 28 1 40	2 33 27 18	35 1	35 40 27 39	15 35 22 2	15 22 33 31	21 39 16 22	22 35 2 24	19 24 39 32	2 35 6	19 22 18	2 35 18	21 35 2 22	10 1 34	10 21 29	1 22	3 24 39 1	24 2 40 39	3 33 26	4 17 34 26						19 1 31	2 21 27 1	2	22 35 18 39
32	28 29 15 16	1 27 36 13	1 29 13 17	15 17 27	13 1 26 12	16 40	13 29 1 40	35	35 13 8 1	35 12	35 19 1 37	1 28 13 27	11 13 1	1 3 10 32	27 1 4	35 16	27 26 18	28 24 27 1	28 26 27 1	1 4	27 1 12 24	19 35	15 34 33	32 24 18 16	35 28 34 4	35 23 1 24		1 35 12 18		24 2			2 5 13 16	35 1 11 9	2 13 15	27 26 1	6 28 11 1	8 28 1	35 1 10 28
33	25 2 13 15	6 13 1 25	1 17 13 12		1 17 13 16	18 16 15 39	1 16 35 15	4 18 39 31	18 13 34	28 13 35	2 32 12	15 34 29 28	32 35 30	32 40 3 28	29 3 8 25	1 16 25	26 27 13	13 17 1 24	1 13 24		35 34 2 10	2 19 13	28 32 2 24	4 10 27 22	4 28 10 34	12 35	17 27 8 40	25 13 2 34	1 32 35 23	2 25 28 39		2 5 12		12 26 1 32	15 34 1 16	32 26 12 17		1 34 12 3	15 1 28
34	2 27 35 11	2 27 35 11	1 28 10 25	3 18 31	15 13 32	16 25	25 2 35 11	1	34 9	1 11 10	13	1 13 2 4	2 35	11 1 2 9	11 29 28 27	1	4 10	15 1 13	15 1 28 16		15 10 32 2	15 1 32 19	2 35 34 27		32 1 10 25	2 28 10 25	11 10 1 16	10 2 13	25 10	35 10 2 16		1 35 11 10	1 12 26 15		7 1 4 16	35 1 13 11		34 35 7 13	1 32 10
35	1 6 15 8	19 15 29 16	35 1 29 2	1 35 16	35 30 29 7	15 16	15 35 29		35 10 14	15 17 20	35 16	15 37 1 8	35 30 14	35 3 32 6	13 1 35	2 16	27 2 3 35	6 22 26 1	19 35 29 13		19 1 29	18 15 1	15 10 2 13		35 28	3 35 15	35 13 8 24	35 5 1 10		35 11 32 31		1 13 31	15 34 1 16	1 16 7 4		15 29 37 28	1	27 34 35	35 28 6 37
36	26 30 34 36	2 26 35 39	1 19 26 24	26	14 1 13 16	6 36	34 26 6	1 16	34 10 28	26 16	19 1 35	29 13 28 15	2 22 17 19	2 13 28	10 4 28 15		2 17 13	24 17 13	27 2 29 28		20 19 30 34	10 35 13 2	35 10 28 29		6 29	13 3 27 10	13 35 1	2 26 10 34	26 24 32	22 19 29 40	19 1	27 26 1 13	27 9 26 24	1 13	29 15 28 37		15 10 37 28	15 1 24	12 17 28
37	27 26 28 13	6 13 28 1	16 17 26 24	26	2 13 18 17	2 39 30 16	29 1 4 16	2 18 26 31	3 4 16 35	30 28 40 19	35 36 37 32	27 13 1 39	11 22 39 30	27 3 15 28	19 29 39 25	25 34 6 35	3 27 35 16	2 24 26	35 38	19 35 16	18 1 16 10	35 3 15 19	1 18 10 24	35 33 27 22	18 28 32 9	3 27 29 18	27 40 28 8	26 24 32 28		22 19 29 28	2 21	5 28 11 29	2 5	12 26	1 15	15 10 37 28		34 21	35 18
38	28 26 18 35	28 26 35 10	14 13 17 28	23	17 14 13		35 13 16		28 10	2 35	13 35	15 32 1 13	18 1	25 13	6 9		26 2 19	8 32 19	2 32 13		28 2 27	23 28	35 10 18 5	35 33	24 28 35 30	35 13	11 27 32	28 26 10 34	28 26 18 23	2 33	2	1 26 13	1 12 34 3	1 35 13	27 4 1 35	15 24 10	34 27 25		5 12 35 26
39	35 26 24 37	28 27 15 3	18 4 28 38	30 7 14 26	10 26 34 31	10 35 17 7	2 6 34 10	35 37 10 2		28 15 10 36	10 37 14	14 10 34 40	35 3 22 39	29 28 10 18	35 10 2 18	20 10 16 38	35 21 28 10	26 17 19 1	35 10 38 19	1	35 20 10	28 10 29 35	28 10 35 23	13 15 23		35 38	1 35 10 38	1 10 34 28	18 10 32 1	22 35 13 24	35 22 18 39	35 28 2 24	1 28 7 10	1 32 10 25	1 35 28 37	12 17 28 24	35 18 27 2	5 12 35 26	

Key: IP = Improving Parameter; WP = Worsening Parameter

Usage:

The parameters corresponding to the numbers at the left and top are shown in Table A.2.

	Worsening parameter= 8
Improving parameter= 34	Inventive principle = 1

If the intention is to improve parameter 34 (Ease of repair) and in the process parameter 8 (Volume of stationary object) is worsening, inventive principle 1 (A,B or C) (Segmentation) could be applied to circumvent the worsening of nr 8 (Volume of stationary object).

Table A.2.: Parameter Numbers

No	Parameter
1	**Weight of moving object**
2	**Weight of stationary object**
3	**Length of moving object**
4	**Length of stationary object**
5	**Area of moving object**
6	**Area of stationary object**
7	**Volume of moving object**
8	**Volume of stationary object**
9	**Speed**
10	**Force (Intensity)**
11	**Stress or pressure**
12	**Shape**
13	**Stability of the object's composition**
14	**Strength**
15	**Duration of action of moving object**
16	**Duration of action by stationary object**
17	**Temperature**
18	**Illumination intensity**
19	**Use of energy by moving object**
20	**Use of energy by stationary object**
21	**Power**
22	**Loss of Energy**
23	**Loss of substance**
24	**Loss of Information**
25	**Loss of Time**
26	**Quantity of substance/the matter**
27	**Reliability**
28	**Measurement accuracy**
29	**Manufacturing precision**
30	**Object-affected harmful factors**
31	**Object-generated harmful factors**
32	**Ease of manufacture**
33	**Ease of operation**
34	**Ease of repair**
35	**Adaptability or versatility**

Continued on next page

Table A.2 – continued from previous page	
No	**Parameter**
36	**Device complexity**
37	**Difficulty of detecting and measuring**
38	**Extent of automation**
39	**Productivity**

§A.3. Separation principles

The 11 separation principles (**Anon** 1985):

1. Separation of conflicting properties in space
2. Separation of conflicting properties in time
3. System transition 1a: Combination of homogeneous or heterogeneous systems in a super-system
4. System transition 1b: Transition to a system to an anti-system or combination of system with anti-system
5. System transition 1c: The entire system has a property X while its parts have a property opposite to X (anti-X)
6. System transition 2: Transition to system that works on the micro level
7. Phase transition 1: Substitution of the phase state of a system's part or external environment
8. Phase transition 2: Dual phase state of a system part (using substances capable of converting from one to another according to operating conditions
9. Phase transition 3: Using of phenomena associated with phase transitions
10. Phase transition 4: Substitution of a mono-phase substance with a dual phase state
11. Physical-chemical transition: Substance appearance-disappearance as a result of decomposition-combination, ionisation-recombination

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Appendix B

Systematic Innovation for Business and Management

§B.1. Contradiction Matrix for Business & Management

Mann (2007a) provided it as an insert.

Table B.1.: Contradiction Matrix for Business & Management [adapted from **Mann** (2007a)]

←WP																													↓IP
2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
2 4 15 38	21 38 35 23	3 9 24 23	3 13 24 33	23 29 35 4	37 35 10 3	35 6 10 2	3 5 10 2	5 7 37 1	6 2 35 25	15 6 1 5	2 3 12 26	11 39 30 31	11 26 2 5	36 11 2 35	15 35 28 25	5 2 6 27	15 27 40 12	11 2 5 9	14 13 22 7	37 13 25 10	6 25 31 29	11 25 2 26	25 29 2 37	15 35 25 16	30 25 29 1	17 25 1 19	25 15 19 35	3 2 25 35	25 2 15 36	1
	26 34 1 10	27 9 34 16	13 26 35 10	5 2 27 1	26 35 1 7	10 2 6 15	6 7 23 26	15 35 10 25	23 6 11 28	10 5 35	10 19 35 22	11 13 2 16	10 38 13	27 6 1 10	6 1 10 25	6 1 25 10	10 25 22 2	6 10 1 7	7 25 30 21	37 25 28 2	6 18 37 13	35 27 3 28	28 26 2 22	25 2 6 5	35 28 19 1	5 2 35 1	25 19 2 37	1 19 35 27	11 25 27 15	2
		1 29 10 40	15 25 35 1	5 6 20 35	5 29 35 2	7 26 10 15	6 15 7 37	25 23 35 29	11 6 23 19	5 13 23 25	10 25 7 2	23 7 29 2	11 7 40 38	6 10 3 35	7 15 40 26	7 40 1 26	23 24 2 37	6 10 26 24	7 19 21 29	7 2 37 20	6 26 18 19	26 2 35 24	26 2 15 19	1 2 15 19	15 1 35 14	5 6 25 10	25 28 15 2	2 39 24 10	10 3 35 22	3
			6 29 15 14	24 35 10 3	5 35 40 23	5 40 20 15	11 23 39 7	7 3 17 23	5 35 13 26	1 11 2 34	1 2 11 38	13 7 9 37	13 22 25 9	6 1 26 37	11 7 28 35	1 2 32 28	40 36 6 10	6 10 7 26	36 13 25 22	1 3 10 26	30 6 31 4	35 2 15 26	2 3 35 15	26 3 11 24	2 40 31 28	28 30 35 1	25 1 3 37	1 23 2 25	9 14 1 12	4
				5 6 17 40	15 23 29 5	15 40 23 3	7 5 3 37	28 40 6 29	6 35 15 13	2 33 3 15	5 2 35 10	5 35 13 40	28 40 6 15	6 1 3 35	6 7 40 38	6 38 20 10	5 35 40 13	28 40 6 7	4 7 25 40	1 6 3 40	2 6 35 3	3 26 35 28	3 26 35 37	16 13 25 28	29 37 40 1	25 28 1 3	6 28 1 3	35 3 37 32	15 17 25 3	5
					15 25 3 10	1 35 21 15	6 27 35 22	3 25 17 35	7 13 22 6	15 35 13 22	35 5 13 22	15 16 3 2	10 25 3 33	35 23 1 24	13 10 17 2	5 6 10 12	6 10 2 27	6 40 10 2	5 15 35 25	13 32 15 23	6 2 13 25	22 24 35 13	35 22 18 39	2 15 1 5	1 15 17 2	12 17 27 26	28 1 13 16	35 1 3 10	35 1 23 3	6
						1 24 19 10	26 10 1 3	26 1 37 25	5 2 30 35	5 35 31 2	2 35 24 10	2 13 10 26	12 3 35 5	1 35 10 29	3 2 35 10	27 3 10 25	10 25 27 3	10 35 7 24	7 13 1 24	26 27 25 34	6 35 37 18	22 35 3 13	1 35 27 10	1 25 2 27	1 30 10 38	35 5 1 2	6 3 25 10	1 35 2 25	10 1 35 27	7
							10 27 15 6	10 15 38 20	5 17 16 3	5 2 35 13	3 10 23 40	13 2 35 10	23 12 3 24	1 35 10 38	3 13 25 5	35 25 5 4	35 29 13 25	13 9 26 23	13 1 37 17	13 15 23 25	2 37 18 19	34 22 35 13	35 22 18 10	19 2 35 26	10 15 30 7	25 28 2 35	25 37 3 13	2 20 12 25	10 15 29 2	8

Key: IP = Improving Parameter; WP = Worsening Parameter Continued on next page...

Table B.1 – continued from previous page

←WP

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	↓IP
								5 6 23 20	5 25 3 35	5 35 23 25	13 22 25 1	5 26 35 2	5 10 40 2	13 35 2 15	3 35 19 24	24 14 13 35	7 5 3 10	5 35 33 7	13 22 7 13	5 25 3 37	25 38 3 26	35 2 26 34	25 10 39 24	3 26 6 11	2 40 38 30	25 2 26 5	30 12 25 40	25 9 24 39	9 1 37 3	9
									6 2 37 40	5 30 10 15	5 35 6 13	23 33 5 26	33 5 2 26	23 11 40 2	23 10 3 13	23 13 10 1	10 14 2 25	40 33 6 10	7 5 10 40	2 37 4 13	2 28 3 37	3 26 35 28	3 26 35 29	5 19 28 32	29 1 17 40	10 18 28 2	10 28 19 15	3 40 19 1	11 25 1 3	10
										7 35 19 1	35 1 13 2	7 8 11 10	6 30 15 40	11 23 35 1	23 11 2 6	23 11 26 2	11 23 24 2	23 11 2 25	10 3 25 5	13 4 28 37	5 25 23 10	13 17 29 2	10 1 34 35	35 3 13 2	13 17 7 15	29 30 35 17	6 5 28 37	2 23 5 30	15 5 25 10	11
											3 24 38 10	27 3 19 24	1 28 6 38	35 24 5 13	27 5 35 25	10 27 30 35	10 12 2 27	10 24 25 1	2 35 13 25	28 35 2 37	35 6 1 27	11 35 2 3	10 35 2 12	30 2 15 3	1 17 40 3	35 19 1 25	22 2 37 4	10 3 25 7	19 3 35 10	12
												10 29 15 13	5 19 3 15	25 10 29 19	25 27 10 2	27 2 13 35	10 25 35 6	24 5 35 25	35 13 25 1	28 2 37 32	6 31 25 35	35 3 29 2	25 10 29 13	24 35 28 1	15 1 10 27	38 24 16 15	28 32 25 2	1 10 15 25	35 3 5 27	13
													5 10 25 37	1 35 6 24	19 10 5 27	2 27 10 5	24 25 10 7	5 35 2 13	25 22 2 35	5 37 15 6	6 16 13 35	2 13 35 31	2 15 19 23	5 16 10 13	15 17 40 3	2 4 15 28	2 28 15 24	1 19 13 10	9 13 1 25	14
														10 31 24 35	5 10 26 1	29 30 2 25	5 25 10 9	5 6 38 40	13 25 39 24	3 6 37 28	2 3 13 4	3 35 13 14	2 30 40 22	5 25 3 40	29 28 30 3	28 5 3 25	25 8 22 28	5 3 17 29	33 15 23 17	15
															2 25 10 35	22 25 15 3	13 22 10 35	28 25 5 7	28 25 7 22	10 28 3 25	10 28 37 3	27 35 34 2	2 35 40 24	27 17 40 3	35 13 8 24	13 35 1 2	11 13 2 35	11 35 24 19	25 26 1 10	16

Key: IP = Improving Parameter; WP = Worsening Parameter

Continued on next page...

Table B.1 – continued from previous page																														
																													←WP	
2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	↓IP
																5 4 25 10	27 35 25 14	26 25 37 3	24 25 37 3	28 3 17 37	25 1 28 32	1 35 22 25	2 24 35 22	25 12 26	17 35 15 1	35 1 25 2	15 25 19 28	35 24 10 2	1 35 2 29	17
																	15 29 9 19	15 29 10 1	7 20 24 35	1 2 15 35	6 31 2 35	35 15 1 3	35 15 29 3	5 25 13 2	3 30 40 29	28 15 17 32	28 25 37 15	2 24 10 40	10 15 2 30	18
																		5 6 40 33	20 7 4 13	25 3 28 35	29 31 6 2	25 35 11 15	25 3 4 35	2 3 25 10	1 30 40 17	13 35 4 2	10 15 1 34	10 11 39 1	10 35 7 9	19
																			16 17 40 13	1 3 37 2	2 3 15 18	11 24 35 5	25 13 22 10	7 5 6 20	29 30 17 14	28 17 29 37	25 15 10 30	10 8 2 24	11 1 40 13	20
																				2 29 3 35	29 31 30 7	39 3 5 17	38 10 6 5	28 27 35 40	40 17 16 14	25 1 2 19	25 2 7 37	2 10 12 24	10 40 29 30	21
																					2 33 3 4	22 10 1 2	10 21 22 29	27 25 4 10	15 10 2 13	10 25 13 40	2 7 25 19	2 28 35 10	11 13 25 2	22
																						6 30 15 28	1 28 4 35	25 19 29	25 6 37 40	1 25 4 37	25 1 19 37	3 4 6 7	37 1 39 40	23
																							35 3 24 4	2 25 28 39	35 11 22 32	22 19 29 40	3 15 2 22	11 25 30 2	35 24 30 18	24
Key: IP = Improving Parameter; WP = Worsening Parameter																													Continued on next page...	

Table B.1 – continued from previous page

←WP

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	↓IP
																								1 15 13 34	3 1 29 15	19 1 31 3	25 3 15 22	11 25 12 8	35 40 27 39	25
																									15 34 1 16	26 27 32 9	25 5 10 12	10 5 14 12	32 35 30 25	26
																										15 29 28 5	25 15 1 28	17 40 30 3	35 30 14 34	27
																											25 19 1 28	1 10 2 24	2 22 35 17	28
																												11 24 35 2	11 28 32 37	29
																													29 35 11 24	30

Key: IP = Improving Parameter; WP = Worsening Parameter [End of Table]

Key:

The parameters corresponding to the numbers at the left and top are shown in Table B.2.

	Worsening parameter= 8
Improving parameter= 21	Inventive principle = 1

If the intention is to improve parameter 21 (Customer Feedback) and in the process parameter 8 (Production Time) is worsening, inventive principle 1 (Segmentation as in Table B.1) could be applied to circumvent the worsening of no. 8 (Production Time).

Table B.2.: Parameter Numbers for Business & management[from **Mann** (2007a)]

No.	Parameter
1	R&D Capability
2	R&D Cost
3	R&D Time
4	R&D Risk
5	R&D Interfaces
6	Productivity Manufacturability
7	Production Cost
8	Production Time
9	Production Risk
10	Production Interfaces
11	Supply Means
12	Supply Cost
13	Supply Time
14	Supply Risk
15	Supply Interface
16	Product Reliability
17	Support Cost
18	Support Time
19	Support Risk
20	Support Interfaces
21	Customer Feedback
22	Amount of Information
23	Communication Flow
24	System Affected Harmful Effects
25	System Generated Harmful Effects
26	Convenience
27	Adaptability/Versatility
28	System Complexity
29	Control Complexity

No.	Parameter
30	Tension/Stress
31	Stability

§B.2. Inventive Principles for Business & Management

Mann (2007a:271-289) provided these inventive principles. Each principle has one or more descriptive definition (A,B,…).

Principle 1. Segmentation
- A. Divide a system or object into independent parts.
- B. Make a system or object easy to disassemble.
- C. Increase the degree of fragmentation or segmentation.

Principle 2. Taking Out/Separation
- A. Separate an interfering part or property from a system or object, or single out the only necessary part (or property).

Principle 3. Local Quality
- A. Change the structure of an object or system from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.
- B. Make each part of an object or system function in conditions most suitable for its operation.
- C. Make each part of an object or system fulfil a different and useful function.

Principle 4. Asymmetry
- A. Change the form of a system or object from symmetrical to asymmetrical.
- B. If a system or object is asymmetrical, change its degree of asymmetry.

Principle 5. Merging
- A. Bring closer together (or merge) identical or similar systems or objects, assemble identical or similar parts to perform parallel operations.
- B. Make operations contiguous or parallel; bring them together in time.

Principle 6. Universality
- A. Make an object or structure perform multiple functions; eliminate the need for other parts.

Principle 7. "Nested Doll"
- A. Place one system or object inside another; place each, in turn, inside the other.
- B. Make one thing pass through another.

Principle 8. Counter-Balance
- A. To compensate for the tendency of a system or object to deviate from a desired path merge it with others that provide a re-stabilising effect.
- B. To compensate for the deviation tendency of a system or object, make it interact with global/macro-scale phenomena.

Principle 9. Prior Counter-Action
- A. If it will be necessary to perform an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects in advance.
- B. Create beforehand stresses in a system or object that will oppose known undesirable working stresses later on.

Principle 10. Prior Action
- A. Perform the required change of a system or object (either fully or partially) before it is needed.
- B. Pre-arrange elements such that they can come into action from the most convenient place and without losing time for their delivery.

Principle 11. Prior Cushioning
- A. Prepare emergency means beforehand to compensate for the possible problems that might

occur later.

Principle 12. Remove Tension
- A. Where harmful tensions may exist, create conditions to compensate, reduce or eliminate them

Principle 13. The Other Way Around
- A. Invert the action(s) used to solve a problem.
- B. Make movable parts (or the external environment) fixed, and fixed parts movable.
- C. Turn the system, object or process 'upside down'.

Principle 14. Curvature
- A. Turn flat or straight things into curved ones.
- B. Go from linear to rotary motion.

Principle 15. Dynamization
- A. Allow (or design) the characteristics of a system, object, external environment, or process to change to be optimal or to find an optimal operating condition.
- B. Divide a system or object into parts capable of movement relative to each other.
- C. If a system, object or process is rigid or inflexible, make it movable or adaptive.

Principle 16. Slightly Less/Slightly More
- A. If 100 percent of an objective is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

Principle 17. Another Dimension
- A. If a system or object uses only one or two dimensions; make use of the unused dimensions.
- B. Use a multi-storey arrangement instead of a single-storey arrangement.
- C. Tilt or re-orient the system or object, lay it on its side.
- D. Use 'another side' of a given system or object.

Principle 18. Resonance
- B. Find and use the 'resonant frequency' of a system or object.

Principle 19. Periodic Action
- A. Instead of continuous action, use periodic or changing actions.
- B. If an action is already periodic, change the periodic magnitude or frequency.
- C. Use pauses between actions to perform a different action.

Principle 20. Continuity of Useful Action
- A. Make parts of a system or object work at optimal conditions continuously.
- B. Eliminate all idle or intermittent actions or work.

Principle 21. Hurrying
- A. Conduct a process, or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.

Principle 22. "Blessing in Disguise"
- A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.
- B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.
- C. Amplify a harmful factor to such a degree that it is no longer harmful.

Principle 23. Feedback
- A. Introduce feedback (referring back, cross-checking) to improve a process or action.
- B. If feedback is already used, change its magnitude or influence.

Principle 24. Intermediary
- A. Use an intermediary carrier article or intermediary process.
- B. Merge one system or object temporarily with another (which can be easily removed).

Principle 25. Self-Service
- A. Make a system or object serve itself by performing auxiliary helpful functions
- B. Use waste (or lost) resources, energy, or substances.

Principle 26. Copying
- A. Instead of an unavailable, expensive, or vulnerable object, use simpler and inexpensive copies.
- B. Replace a system, object, or process with optical or virtual copies.
- C. If copies are already used, move to an out of the ordinary illumination and viewing perspective.

Principle 27. Cheap Disposable
- A. Replace an expensive system or object with a multiple of inexpensive alternatives, comprising certain less-important qualities (such as service life, for instance).

Principle 28. Another Sense
- A. Replace or supplement one sensory means with another (visible, touch, acoustic. taste or smell)

Principle 29. Fluidity
- A. Make solid things into 'fluid' things.

Principle 30. Thin and Flexible
- A. Use thin and flexible structures instead of large, three dimensional ones
- B. Isolate a system or object from a potentially harmful environment using thin and flexible structures.

Principle 31. Holes
- A. Add 'holes' to a system or object.
- B. If a system or object already has holes, use them to introduce a useful substance or function.

Principle 32. Colour Changes
- A. Change the colour of an object or its external environment.
- B. Change the transparency of a system, object or an external environment.

Principle 33. Homogeneity
- A. Make systems or objects interact with others of a similar form or with similar properties.

Principle 34. Discarding and Recovering
- A. Make portions of a system or object that have fulfilled their functions go away or modify them directly during an operation.
- B. Conversely, restore consumable parts of a system or object directly in operation.

Principle 35. Parameter Changes
- A. Change an object's physical state (e.g. from physical to virtual).
- B. Change the concentration or consistency.
- C. Change the degree of flexibility.
- D. Change emotional and other parameters.

Principle 36. Paradigm Shift
- A. Use phenomena occurring during disruptive shifts in an economy. (Awareness of macro-scale business phenomena)

Principle 37. Relative Change
- A. Use the relative differences that exist in an object or system to do something useful
- B. Make different parts of a system act differently in response to changes

Principle 38. Enriched Atmosphere
- A. Replace a normal atmosphere with an enriched one.
- B. Expose a highly enriched atmosphere with one containing potentially 'unstable' elements.

Principle 39. Calm Atmosphere
- A. Replace a normal environment with an inert one.
- B. Add neutral parts or elements to a system or object.

Principle 40. Composite Structures
- A. Change from uniform to composite (multiple) structures, be aware of and utilise combinations of different skills and capabilities.)

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Appendix C

Classification of Inventive Principles for Business & Management

The Inventive Principles for Business & Management were evaluated to determined how much they relate to business processes. The principles each have one or more Descriptive Definition, which are numbered alphabetically. Principle 18 was not provided with a definition A. **Mann** (2007a:271-289) provided examples of how each of the definitions relate to business and management and they are indicated with • in Table C.1. The summary per principle is provided in Chapter 3.

In Chapter 3 the following core business processes were identified:

1. Marketing & Sales (M&S)
2. Supply (Su)
3. Rendering of Products and/or Services (RPS)
4. Development of Products and/or Services (DPS)
5. Management Responsibility & General management (MR)
6. Financial Administration & Records (Fin)
7. Employee Administration, Development & Satisfaction (EADS)
8. Technology Administration (TA)
9. Quality (Q)

For the evaluation 1 was assigned to an example if it clearly addresses one and only one of the above categories. If it adresses two categories simultaneously each was assigned 0,5. It was not further subdivided.

For the classification of the Inventive Principles for Business & Management the above was used as two other categories:

Unclear (U): It is unclear to which of the business processes it relates to.
Questionable (X): It is an example that should rather not be used at all as it tends to give the idea of an unethical practice.

Table C.1.: Addressing of Business Areas by Inventive Principles' Descriptive Definition Examples(**Mann** 2007a:271-289)

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
Principle 1. Segmentation											
A. Divide a system or object into independent parts.											
• Divide an organisation into different product centres.					1						
• Autonomous profit centres.					1						
• Use a work breakdown structure for a large project.				1							
• Franchise outlets.	0,5		0,5								

Table C.1 is continued on the next page

Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Red team/Blue team proposal preparation structures					1						
• Kano Diagram - Excitement, Performance, and Threshold product attribute parameters.				1							
• Marketing segmentation by demographics, socio-graphics, psycho-graphies, lifestyles, etc. (creation of 'micro-niches')	1										
• Triage prioritisation of problems					1						
• Supermarkets have 'cash-only' or 'basket-only' tills to make it quicker for shoppers who are purchasing just a few items	1										
• Strength/Weakness/Opportunity/Threat (SWOT) analysis.					1						
• Recognise difference between 'special' and 'common' cause failures									1		
B. Make a system or object easy to disassemble.											
• Flexible pensions										1	
• Use of temporary workers on short-term projects			0,5			0,5					
• Flexible Manufacturing Systems			1								
• Modular accounts allowing customers to 'mix and match'	1										
• Modular offices/'hot-desking'					1						
• Container shipment			1								
C. Increase the degree of fragmentation or segmentation.											
• 'Segment of one' advertising - mass customization	1										
• Virtual office/remote working					1						
• Special Economic Zones	1										
• 'Creative Segmentation' - 'high performance small car', 'easy to use SLR', 'cordless power tool'				1							
Principle 2. Taking Out/Separation											
A. Separate an interfering part or property from a system or object, or single out the only necessary part (or property).											
• Breakdown barriers between departments (Point 9 of Deming's Fourteen Points).					1						
• Eliminate exhortations (Point 10 of Deming's Fourteen Points)					1						
• Eliminate targets (Point 11 of Deming's Fourteen Points).					1						
• Drive Out Fear (Point 8 of Deming's Fourteen Points)					1						
• 'Separate the PEOPLE from the PROBLEM' ('Getting To Yes').					1						
• ATM banking			1								

Table C.1 is continued on the next page

Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• USP advertising	1										
• Just-In-Time inventory management					1						
• Separate development and production activities- skunkworks, tiger-teams, etc.					1						
• Smart software learns user preferences and filters out non-useful information.				1							
• Semantic processors used to extract 'knowledge' from text				1							
• Anonymous questionnaires of customers and employees	0,5						0,5				
• Disintermediation	1										
Principle 3. Local Quality											
A. Change the structure of an object or system from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.											
• Moves away from rigid salary structures/job grading.							1				
• Skill/personality matching in project teams					1						
• Flexible working hours.							1				
• Franchise fast food outlets have local dishes in addition to normal product range.	0,5		0,5								
• Casual ('dress-down') days.							1				
• Regional advertising campaigns/coupon programmes	1										
• Red team/Blue team proposal preparation structures					1						
• 'Quiet' work areas/meeting areas/etc.					0,5		0,5				
B. Make each part of an object or system function in conditions most suitable for its operation.											
• 'Empowerment' of individuals					1						
• Have each employee's workplace customized to individual ergonomic and psychological needs.					0,5		0,5				
• Working hours phased to accommodate people working on international, shifted time-zone projects					0,5		0,5				
• Using coffee-breaks for informal (non-uniform) communication					1						
• 'Early adopter' focused products and services				1							
• Customisable software				1							
C. Make each part of an object or system fulfil/ a different and useful function.											
• Organisational division by function rather than product.					1						
• Staff specialists in centres of excellence					0,5		0,5				
• Hire local people to acquire cultural knowledge of local customers	0,5				0,5						

Table C.1 is continued on the next page

Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• 'Kids areas' in restaurants, etc	1										
Principle 4. Asymmetry											
A. Change the form of a system or object from symmetrical to asymmetrical.											
• 'Buy-now, pay-later'	1										
• (Proportionately) more 'Plan' or more 'Study ' in the Deming PDSA cycle				1							
• Skewed normal distributions.									0,5	0,5	
• Budget for different departments individually rather than using a constant percentage increase or reduction for all departments					1						
• More 'customer' in the customer-supplier relationship	1										
• Take account of seasonal variations in sales forecasting	1										
B. If a system or object is asymmetrical, change its degree of asymmetry.											
• 360° appraisals					0,5		0,5				
• More equitable 2-way dialogue between management and workers					1						
• Shift away from calendar-influenced sales bias (e.g. shift from annual to bi-annual car registration dates (to reduce August sales peak), greetings card companies, etc.)			1								
• Honda's 4M- 'man maximum, machine minimum' product design philosophy.				1							
• Bigger customer focus groups/Internet focus groups	1										
• On-line, web-cam shopping - 'one store serves the world'	1										
• Collaboration with 'complementary' organisations when competing for business with other directly competitive companies					1						
Principle 5. Merging											
A. Bring closer together (or merge) identical or similar systems or objects, assemble identical or similar parts to perform parallel operations.											
• Cell-based Manufacture			1								
• Toyota JIT/'Lean manufacture'		0,5	0,5								
• Common-interest groups					1						
• Multi-screen cinemas			1								
• Shopping malls	0,5		0,5								
• Banks, etc offer customers a full range of financial service packages - current, savings, mortgage, pension, etc.			1								
• Debt-consolidation loan			1								
• Collaboration with 'complementary' organisations when competing for business with other directly competitive companies					1						

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Partner with non-competing companies in other countries					1						
•"Young engineers have ideas, old engineers have bad experiences" (Japanese saying)				1							
B. Make operations contiguous or parallel; bring them together in time.											
• Eli Goldratt's Theory of Constraints			1								
• Enlisting customer and supplier help in designing the product (Boeing 777 'Working Together Teams')				1							
• Multi-media presentations	1										
• Groupware – mail/email/intranet/video-conference/etc.					1						
• Movie/book/soundtrack/Internet/merchandise tie-ins	1										
• Package holidays	1										
• Call centres			1								
Principle 6. Universality											
A. Make an object or structure perform multiple functions; eliminate the need for other parts.											
• Multi-skilling of work-force			0,5				0,5				
•'One-stop shopping' - supermarkets sell insurance, phone, fuel, newspapers, etc.	1										
• Rapid Reaction Forces in the military- cross-trained, equipment versatility, etc			1								
• Semco - managerial staff set their own salaries, shopfloor workers set their own productivity targets. part of change agent's job is to eliminate need for his/her job					1						
• Internet/Intranet allows improved communication across companies, project teams - everybody has access to all relevant information.					1						
• Industry standards- e.g. communication protocols- HTML/Internet/TCP-IP			0,5	0,5							
• IS09000 and related universal standards			0,5	0,5							
• Market-based cost standards	1										
• Templates					1						
Principle 7. "Nested Doll"											
A. Place one system or object inside another; place each, in turn, inside the other.											
• Store-in-store	1										
• Profit centres inside an organisation					1						
• Cash machines work for multiple banks			1								
• Hierarchical organisation structures					1						

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Four levels of knowledge- 1) Basic Skills, 2) Know How, 3) Process Management, 4) Strategic Vision- contained in effective company training schemes.					1						
B. Make one thing pass through another.											
• Expose traditionally inward facing job-holders to external events/customers(e.g. engineers shadow marketing people during customer visits)	0,5						0,5				
• Door sensors count customers into and out of a store/office, etc. (use data for market profiling, etc.)	1										
• Internet 'Navigator' companies			0,5							0,5	
Principle 8. Counter-Balance											
A. To compensate for the tendency of a system or object to deviate from a desired path merge it with others that provide a re-stabilising effect.											
• In a merger of two companies, one 'lifts' the other with whatever its stronger features are (distribution system, marketing, methods, capital, etc.)					1						
• Companies increase flagging sales by connecting with other rising products (e.g. movie tie-ins)	1										
• Attaching the word 'new' is the most powerful way of enhancing the sales of fast moving consumer goods	1										
• Recruit 'champions' to assist during change initiatives					1						
B. To compensate for the deviation tendency of a system or object, make it interact with global/macro-scale phenomena.											
• A small company is 'lifted' by use of an external transportation network lo the level of the larger companies			1								
• Political parties boost poll ratings by attaching themselves to popular causes	1										
• Attach product/service marketing to customer and business driving forces (Mega-trends- ageing population, desire for flexibility, simplicity, etc.)	1										
Principle 9. Prior Counter-Action											
A. If it will be necessary to perform an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects in advance.											
• When making a public announcement, include all the information, not just the harmful parts (e.g. Perrier's handling of their water quality problem)	0,5				0,5						
• Use formal risk assessment methods to quantify risk and identify mitigation actions before and during a project- subversion analysis ('how could we destroy this system")				1							
• Customer trials/segmented launch of (high risk) new products (e.g. film companies' film several endings to a movie and trial with different audiences before finalising selection)				1							
• Asking to be 'paid to play' during a competitive bid when you are the new player and the customer is looking to get the incumbent to reduce price											1
• Use of voluntary redundancy/pay-cuts/short-time working/job-sharing as alternatives to down-sizing					0,5		0,5				
• Telling someone that they can't have something is often a very effective way of making them want it	1										

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Introduce deliberate mistakes then 'wow' the customer with the efficient way in which things are fixed	1										
B. Create beforehand stresses in a system or object that will oppose known undesirable working stresses later on.											
• Epson product development engineers spend time as sales and then service staff before they are allowed to work on product development activities				0,5			0,5				
• Team-building tasks are done before the real project starts. (for example the team spends one week on a special seminar, so that they can learn to work together)					0,5		0,5				
• Negotiate upfront stage payments in a long term contract						1					
Principle 10. Prior Action											
A. Perform the required change of a system or object (either fully or partially) before it is needed.											
• Pre-pay/post-pay financing arrangements						1					
• Project pre-planning				0,5	0,5						
• Visit Gemba - go see how the customer actually uses products/services	1										
• Perform non-critical path tasks early (where circumstances permit)				1							
• Dialogue with employees before embarking on re-organization structure					0,5		0,5				
• 'Of the-shell'/'ready-made'/'pre-packaged' solutions				1							
• Rent, lease or partial-purchase property instead of outright purchase					0,5	0,5					
• Phone-in food order before arriving at restaurant	0,5		0,5								
• Create buzz about a new product by 'leaking' news ahead of formal launch	1										
B. Pre-arrange elements such that they can come into action from the most convenient place and without losing time for their delivery.											
• Kanban arrangements in a Just-In-Time factory		0,5	0,5								
• Cell-based manufacture		1									
• Publish an agenda before meetings					1						
• 'Hub-and-spoke' network delivery concept (e.g. FedEx)			1								
• If I had 8 hours to chop down a tree, I'd spend 6 hours sharpening my axe' Abraham Lincoln.					1						
• Benetton 'retarded differentiation' - clothing is knitted before it is dyed; colour only applied when the season's popular colours emerge.			1								
• Car-servicing overnight (when most customers are not using their vehicles)	0,5		0,5								
• Dealer- fit car accessories- CD player, alloy wheels, air-con, etc.			1								
• Distributed systems- local depots, etc.			1								

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
Principle 11. Prior Cushioning											
A. Prepare emergency means beforehand to compensate for the possible problems that might occur later.											
• Contingency planning and definition of 'fall-back solutions'					1						
• Establish a worst-case, fall-back position prior to negotiation- 'Best Alternative to a Negotiated Agreement'					1						
• Back up computer data	1										
• Anti-virus software					1						
• Encourage short, effective meetings by removing the chairs					1						
• Put clauses in contracts requiring arbitration/mediation to avoid litigation					1						
• Begin with 'S' in the PDSA cycle				1							
• Second-sourcing critical sub-systems			1								
• '80% of a successful production is in the casting' Lindsay Anderson					1						
Principle 12. Remove Tension											
A. Where harmful tensions may exist, create conditions to compensate, reduce or eliminate them											
• Make 'horizontal' career changes to broaden skills							1				
• Team members distribute their own merit award money (rather than often divisive distribution methods employed by management)							1				
• Force-Field Analysis- group discussion of the phrase 'forces push in various directions'- team-building/problem-solving technique.				0,5			0,5				
• Empathy - manager tunes presentation to best suit audience of, for example, workers and directors					1						
• Beware of the Peter Principle- 'Every employee tends to rise to his/her level of incompetence					1						
• Single-union agreements					0,5		0,5				
• 'No-fault' termination clauses written into contracts			0,5		0,5						
• 'Communication is and should be hellfire and sparks, as well as sweetness and light' Aman Vivian Rakoff					1						
Principle 13. The Other Way Around'											
A. Invert the action(s) used to solve a problem.											
• Bring the mountain to Mohammed, instead of bringing Mohammed to the mountain.										1	
• Expansion instead of contraction during recession.	0,5				0,5						
• Benchmark against the worst instead of (or at least as well as) the best					0,5				0,5		
• Blame the process not the person					0,5				0,5		

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Transform the Maintenance department into the 'Robustness' department and get them to eliminate maintenance			1								
• 'I used to think that anyone doing anything weird was weird. I suddenly realised that anyone doing anything weird wasn't weird at all, and it was the people saying they were weird that were weird' Paul McCartney.	0,5			0,5							
B. Make movable parts (or the external environment) fixed, and fixed parts movable.											
• Home-shopping	1										
• Home banking	1										
• Park-and-ride schemes in busy cities				1							
• Mobile car service - mechanic comes to you rather than you going to garage			1								
• Mobile library			1								
• Don't make changes just because they are fashionable management fads					1						
C. Turn the system, object or process 'upside down'.											
• Cash-till assistant is the most important part of a retail organisation	1										
• Computer help lines were often originally set up with relatively no-technical staff at the front-end, directing calls to progressively more technically able staff the more complicated the problem is. Latest logic suggests reversing this trend - i.e. place the most qualified staff as first point ot contact (e.g. IBM)			1								
• Pull rather than push-based organisation structures			1								
• 'Ready, Fire, Aim' Tom Peters					0,5					0,5	
• Mercedes Benz vision changed from 'the best or nothing' to 'the best for our customers'- i.e. shift from internal to externally focused vision statement.	1										
• The Peter Pyramid			0,5		0,5						
• Corporate 'unlearning'- acquiring the ability to forget about the past where appropriate					1						
• 'Ours is the age that is proud of machines that think and suspicious of men who try to' H Mumford-Jones										1	
• Russian government pays inventors for patent applications/West makes the inventor pay to apply.				1							
• Chairman of company spends time in the complaints department answering customer complaints	0,5				0,5						
• 'Nothing fails like 'success'	0,5			0,5							
• 'We don't stop playing because we grow old, we grow old because we stop playing'										1	
• 'When you reach the top, that's when the climb begins' Michael Caine										1	

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Table C.1 – continued from the previous page											
Description	**M&S**	**Su**	**RPS**	**DPS**	**MR**	**Fin**	**EADS**	**TA**	**Q**	**U**	**X**
Principle 14. Curvature											
A. Turn flat or straight things into curved ones.											
• Take the shortest path to the customer -around the organisation rather than point-to-point through the bureaucracy	1										
• Levi Strauss' IS Department's organizational chart resembles a solar system, with the names of 20 managers appearing once on a large circle-and in many cases also on one of four smaller circles intersecting the large one. The small circles represent action groups focusing on specific tasks, including customer service and business systems.			1								
• Set up 'virtuous circles' – self re-enforcing activities					1						
• 'Form the wagons into a circle' John Wayne										1	
B. Go from linear to rotary motion.											
• Rotate leadership of a team					1						
• Revolving credit agreements						1					
• Circular work cells			1								
• Recognise that the Deming PDSA cycle is circular and that the 'Act' stage feeds into the next 'Plan' stage (e.g. project teams are often disbanded before any 'lessons learned' are recorded)									1		
Principle 15. Dynamization											
A. Allow (or design) the characteristics of a system, object, external environment, or process to change to be optimal or to find an optimal operating condition.											
• Empowerment					1						
• 'Customer Response Teams'/Rapid Reaction Force	1										
• Continuous Process Improvement									1		
• Seasonal pricing/advertising	1										
• Regional pricing/advertising	1										
• Flexible shift patterns										1	
• 'Drum, Buffer, Rope' process operation scheduling					1						
• Swatch design proliferation- design for specific market niches	0,5			0,5							
• Adjust meeting frequency according to rate of change during a project					1						
• 'In today's turbulent business environment, there are no hard fast conclusionsonly transitions'					1						
• 'Change is the only constant'					1						
B. Divide a system or object into parts capable of movement relative to each other.											
• Work teams oriented to achieve same goal, but work at different rates on different objectives			1								
• Geographically or functionally independent business units			1								

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Conglomerate structures					1						
C. If a system, object or process is rigid or inflexible, make it movable or adaptive.											
• On-line shopping webcam - customer is able to control and move cameras to point to different products in different parts of the store from home computer	1										
• Changing the supervisor's role; avoid 'whack-a-mole' fire fighting					1						
• Usage-based warranties (instead of fixed time period)			1								
• Virgin 'One' bank account- continuously optimises funds to earn maximum interest without the customer having to do anything			1								
• Flexible organisation structure (chaocracy)					1						
Principle 16. Slightly Less/Slightly More											
A. If 100 percent of an objective is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.											
• 'If it ain't broke, improve it anyway'- Japanese process management philosophy.									1		
• Use Pareto analysis to enable work to concentrate on the high return elements.					1						
• Set stretch targets in the knowledge that achievement of less than the full amount is still well worth having					1						
• Saturation advertising	1										
• Aim to ' delight' rather than 'satisfy' customers	1										
• Design deliberate over lap between the roles of managers in order lo improve communications (commonly used Japanese strategy)					1						
• 'The most important numbers are tile ones you'll never know' - W. E. Deming (i.e is it possible to ever know what '100%' means)					1						
Principle 17. Another Dimension											
A. If a system or object uses only one or two dimensions; make use of the unused dimensions.											
• 360^{o} appraisals.					1						
• Continuous appraisals (i.e. use of the time dimension)					1						
• Portfolio investment strategies- with deliberate selection of different but complementary stocks					1						
• Buy in one location and sell in another	0,5	0,5									
• Multi-dimensional organisation hierarchy charts - 3D (e.g. to show 'hard' and 'soft relationships), or 4D - to include an element of time ('Buckyball Management')					1						
• Distributed responsibility and authority- e.g. Quality department advises on technical details and conducts audits, but everyone is responsible for quality. Ditto Safety Office.					0,5				0,5		
B. Use a multi-storey arrangement instead of a single-storey arrangement.											
• Organisational hierarchy					1						

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Multi-stack storage systems use the height of a building, and save floor space			1								
• 'Standing on the shoulders of giants…'				1							
• 'When two people meet, there are really six people present. There is each man he sees himself, each man as he wants to be seen, and each man as he really is Michael De Saintamo										1	
C. Tilt or re-orient the system or object, lay it on its side.											
• Horizontal (peer) communication					1						
• Switch between Horizontally and vertically integrated operations					1						
• Switch from vertical to horizontal (lateral) thinking - and vice-versa										1	
• Shift from 'line' to 'project' management dominance in matrix organisation (and vice-versa- depending on prevailing market conditions)					1						
• Shift from portrait to landscape report format					1						
D. Use 'another side' of a given system or object.											
• View your organisation from the outside - either directly or using consultants,'mystery shoppers', etc.	0,5				0,5						
• New ways of looking at the selling process - instead of selling carpets to its commercial and industrial customers, Interface offers what it calls the "Evergreen Lease." Its customers no longer buy carpets or pay an installation fee - they just pay a monthly service fee that guarantees they will always have clean, attractive carpets	0,5		0,5								
• 'A good manager doesn't try to eliminate conflict; he tries to keep it from wasting the energies of his people. If you're the boss.and your people fight you openly when they think that you are wrong – that's healthy' Robert Townsend'					1						
• The things we fear most in organisations - fluctuations, disturbances, imbalance are the primary sources of creativity' Margaret J Wheatley.				0,5	0,5						
Principle 18. Resonance											
B. Find and use the 'resonant frequency ' of a system or object.											
• Use the process of hoshin planning to get the whole organisation 'vibrating'					1						
• 'I don't think that you should ever manage anything that you don't care passionately about' D Coleman, VP & CFO Apple					1						
• 'He inspired in us the belief that we were working in a medium that was powerful enough to influence the world' Lillian Gish on D. W. Griffiths					1						
• Use strategic planning (policy deployment, hoshin Kanri) to select the right frequency and get the organisation resonating at that frequency to accomplish a breakthrough strategy					1						
• 'In a start-up company, you basically throw out all assumptions every three weeks.' Scott McNealy					1						
• 'Kansei'- Japanese term for resonance/one-ness between product and user	0,5			0,5							
Principle 19. Periodic Action											
A. Instead of continuous action, use periodic or changing actions.											
• Batch manufacture.			1								
• Tidal traffic flow schemes ease transport into and out of busy areas											

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
			1								
• Change team leadership periodically (e.g. the EU leadership is rotated on an annual basis between different countries)					1						
• Introduce 'time-out' periods in difficult negotiations					1						
• Introduce 'breathing spaces' into contracts					1						
• Introduce sabbaticals to refresh people's points of view					0,5		0,5				
B. If an action is already periodic, change the periodic magnitude or frequency.											
• Audit at irregular intervals									1		
• Use monthly or weekly feedback instead of annual reviews					1						
• Flexible savings schemes which pay higher interest rates the fewer the number of withdrawals made			1								
• Ritz-Carlton hotels have 10 minutes staff training per day instead of less frequent longer. sessions.					1						
C. Use pauses between actions to perform a different action.											
• Use travelling time to catch up on reading										1	
• Perform maintenance work during holiday			1								
• Introduce stimulating activities (external speakers, etc) during times of the week when work output is low- e.g. Friday afternoons.					1						
• 24-hour car service operation- evening pick-up, return of serviced car by breakfast the following morning (customer perspective).	0,5		0,5								
• 'Hot-till'ing in supermarkets- staff do other tasks during quiet periods and move to tills when they see queues developing	1										
Principle 20. Continuity of Useful Action											
A. Make parts of a system or object work at optimal conditions continuously.											
• Run the bottleneck operations in a factory continuously, to reach the optimum overall pace. (from Theory of Constraints)			1								
• Institute Constant Improvement (Point 5 of Deming's Fourteen Points)									1		
• Continuous on-line monitoring of elevators by Otis who take on total maintenance responsibility			1								
• Continuous compounding of interest						0,5				0,5	
• Perpetuities										1	
• 24 hour car service operation- evening pick-up, return of serviced car by breakfast the following morning (garage perspective)	0,5		0,5								
• 'Life-long learning'							1				
• 'The power of a waterfall is nothing but a lot of drips working together'										1	
• 'The more I practice, the luckier I get' Gary Player											

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
							1				
B. Eliminate all idle or intermittent actions or work. ,											
• Multi-skilling to enable working in bottleneck functions to improve workflow			1								
• 24hour shift patterns					1						
• Conduct training during pauses in work					0,5		0,5				
Principle 21. Hurrying											
A. Conduct a process, or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.											
• 'Incrementalism is innovation's worst enemy' Nicholas Negreponte, MIT Media Lab				1							
• 'Don't be afraid to take a big step if one is indicated. You can't cross a chasm in two small jumps' David Lloyd George				1							
• 'Fail Fast; Learn Fast'				1							
• 'Fast Cycle - Full Participation'- method of involving the whole organisation simultaneously and rapidly in a major change, such as a re-organisation					1						
• Get through painful processes quickly (e.g. firing someone)					1						
• Rapid prototyping				1							
• 'If you want to succeed, double your failure rate' JR Watson, IBM founder				1							
Principle 22. "Blessing in Disguise" or "Turn Lemons into Lemonade"											
A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.											
• Recast an attack on you as an attack on the problem.					1						
• Making a fuss over customers who have experienced a problem with your goods/services/etc, tends to re-enforce their overall positive feel about you -to a level greater than that where no problem had occurred.	1										
• Turn contract negotiations into win-win situations- see a drive to reduce price as an opportunity to negotiate longer term or 'last-look' options					1						
• 'Provocations' method of encouraging new ideas				1							
• The Extra Mile will have no traffic jams.' Unknown	1										
B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.											
• Eliminate fear of change by introducing fear of competition					1						
• Put a 'problem' person on an assignment in another area where he/she can do well and not be a problem to the original group					1						
• Loss-leader strategy for increasing sales	1										
• Keep traffic out of cities by introducing low cost 'park and ride' and expensive downtown parking charges.			1								
• Make potentially polluting industries place flow intakes downstream of flow outlets on a river											

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
										1	
C. Amplify a harmful factor to such a degree that it is no longer harmful.											
• Reduce resourcing levels to such an extent that new ways of doing the job have to be discovered				1							
• Restrict supply of goods to create scarcity value (e.g. some sports car manufacturers seek to maintain a multiple year waiting list on vehicles giving them a certain cachet that they would not otherwise have)	1										
• Borrow ten thousand dollars from the bank and they own you; borrow ten million and you own them!										1	
Principle 23. Feedback											
A. Introduce feedback (referring back, cross-checking) to improve a process or action.											
• Statistical Process Control (SPC) – Measurements are used to decide when to modify a process.									1		
• Enlist customers in the design process.				1							
• 'Extranets'/Electronic bulletin boards					1						
• Customer surveys/customer seminars, etc.	1										
• 'Active Transition Management' as a way of controlling product development process between research, development and production phases.					1						
• (Supermarket) loyalty cards- provide customer shopping profile information	1										
• 'What you measure is what you get' Joe Juran									1		
• Beta testing on-site with customer	0,5			0,5							
• 95% of customers who have a bad experience with your services will not complain, they will simply move to another provider. Introduce easy feedback mechanisms so customers can give (possibly anonymous) feedback	1										
B. If feedback is already used, change its magnitude or influence.											
• Change a management measure from budget variance to customer satisfaction.					1						
• Expose designers as well as marketers to customers	0,5			0,5							
• Allow customers to watch (e.g. via webcam) the manufacture or preparation of their order	1										
• Multi-Criteria Decision Analysis (valid 'apples and oranges' comparisons).					1						
• Toshiba medical systems division split into R&D, Engineering and Manufacture sectors. As a product is being developed, key personnel and leadership physically move from one sector to another to actively manage transitions between product development stages.					1						
• 'Open the kimono' -everything out in the open - communication					1						
• 'Supravision' rather than 'supervision'					1						
• 'Go-evolutionary marketing' - e.g. Amazon.com invites readers to write on-line book reviews; other readers often prefer these views to professional reviewer evaluations, therefore people visit the site more often	1										
• Motorola 'open dissent' policy- employees fill in a minority report to senior management when ideas they consider valuable are unsupported by colleagues and immediate superiors											

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Description	**M&S**	**Su**	**RPS**	**DPS**	**MR**	**Fin**	**EADS**	**TA**	**Q**	**U**	**X**
					1						
• Use of 'half-life' as a measure of improvement (e.g. time taken to half product development time) to encourage large-scale thinking				1							
• Feed-forward - anticipatory feedback	1										
Principle 24. 'Intermediary'											
A. Use an intermediary carrier article or intermediary process.											
• Use of impartial body during difficult negotiation (e.g. ACAS)					1						
• 'Po' (provocative operator)- a place between 'yes' and 'no', construct devised by Edward DeBono to help avoid premature discarding of ideas				0,5	0,5						
• Sub-contract non-core business (e.g. cleaning services, transport)					0,5		0,5				
• Franchisee acts as intermediary between corporate vision and customer	1										
• Travel agent (NB can also mean removal of intermediary - e.g. direct selling).	1										
• Collection Agent - debt						1					
• Brokers, trustees, etc			1								
• Product placement in TV shows or films	1										
• UPS distribution system using core sorting centre.			1								
• KLM 'feeder' airline concept- short flights from Germany, England pull passengers away from national airlines in order that they fly long distances using Holland as a hub	1										
• 'Video Plus' -programme video using simple codes to represent channels, dates and times			1								
• 'Cuckoo Investments'										1	
B. Merge one system or object temporarily with another (which can be easily removed).											
• Introduction of specialist trouble-shooting or fire-fighting teams			0,5		0,5						
• Hire consultant.			1								
• Use bridging loan arrangements to help cashflow					1						
• Subcontract occasional services- grounds maintenance, etc.					1						
Principle 25. Self-Service											
A. Make a system or object serve itself by performing auxiliary helpful functions											
• Quality Circles									1		
• Self-help groups									1		
• Viral marketing campaigns	1										

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Brand image circularity- Harvard Business School produces bright people; these people enhance the School's reputation; hence lots of people apply; hence they only take on very bright people; bright people in equals bright people out; and so the circle re-enforces itself.	1										
• 'Cookies' on the Internet gather data useful for future marketing activities, while performing a useful service for the 'surfer'	1										
• Bar-codes in supermarkets provide instant pricing information, but the system also gathers information to assist future marketing decisions	1										
• Edward De Bono's suggestion to Ford UK that they buy National Car Parks and then only let Ford cars into the parking lots - i.e. motorists buying a Ford are also buying a parking place in every city	1										
B. Use waste (or lost) resources, energy, or substances.											
• Re-hire retired workers for jobs where their experience is needed					1						
• Loan out temporarily under-utilised workers to other organisations (load-capacity balancing across companies- e.g. footballers - win-win situation; the player stays match fit, the loaner saves wages, the loanee fills skill shortage)					0,5		0,5				
• 'Industrial eco-systems'					1						
• 'Brown-field' developments				1							
• Body Shop re-cycles used containers brought back by customers - helps promote corporate green image	1										
• Leveraged buy-out					1						
• Re-cycle all packaging material			1								
Principle 26. Copying											
A. Instead of an unavailable, expensive, or vulnerable object, use simpler and inexpensive copies.											
• Bench-marking.									1		
• Rapid prototyping (e.g. stereo-lithography)				1							
• On-line bookings/transactions/applications replace physical offices	0,5		0,5								
• Problem-based learning/case-based reasoning				1							
• Scan rare, historic books, documents, etc so they are accessible to all and the original remains protected			1								
• Lascaux II - reproduction of Lascaux cave paintings which is open to visitors			1								
B. Replace a system, object, or process with optical or virtual copies.											
• Virtual product service manuals.			1								
• Flight simulator reduces pilot training costs.					0,5		0,5				
• Numerical simulation- operational analysis (virtual war-gaming, virtual business development, strategic planning modelling).				1							
• Video-conferencing instead of physical travel					1						

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Use a central electronic database instead of paper records in cases where multiple users would benefit from simultaneous access to data- e.g. medical records, customer data, engineering drawings, etc			1								
• Keep your personal calendar on a web-site so you (and others?) can access it from any computer, and it can't get lost					1						
• Novell 'iHome' system gives users an Internet accessible version of their computer hard-drive.	1										
C. If copies are already used, move to an out of the ordinary illumination and viewing perspective.											
• Evaluate employee morale using multiple methods such as interviews and questionnaires (2 different 'wavelengths')					0,5		0,5				
• Evaluate customer satisfaction using multiple techniques	1										
• Have your customers benchmark you/have your suppliers benchmark you	0,5	0,5									
Principle 27. Cheap Disposable											
A. Replace an expensive system or object with a multiple of inexpensive alternatives, comprising certain less-important qualities (such as service life, for instance).											
• Use disposable paper objects to avoid the cost of cleaning and storing durable objects. Plastic cups in motels, disposable diapers, many kinds of medical supplies.			1								
• Throw-away cameras/mobile-phones, etc.			1								
• 'Disposable organisation structures' in rapidly changing markets - i.e. little point in massively optimising structures in e-commerce businesses which are still in a state of rapid evolution. *					1						
• Swatch 'renewed impulse' buying'- 'Change clothes? Change Swatch'.	1										
• 'Cardboard police'- 2D policemen or police cars over freeway bridges used as a means of slowing down traffic			1								
Principle 28 Another Sense											
A. Replace or supplement one sensory means with another (visible, touch, acoustic. taste or smell)											
• CEO of budget motel chain; 'our goal is that when you turn out the lights and climb into bed, you think you are at the Hilton'			1								
• Multi-media presentations	1										
• Learning by listening, seeing and doing					1						
• Supermarkets pump bakery odours around the store to help advertise bread products	1										
• 'The seeing of objects involves many sources of information beyond those meeting the-eye when we look at an object. 1t generally involves knowledge of the object derived from previous experience, and this experience is not limited to vision but may include the other senses: touch, taste, smell, hearing, and perhaps also temperature or pain.' R.L.Gregory				1							
• MBWA- Management By Walking Around					1						
Principle 29. Fluidity											
A. Make solid things into 'fluid' things.											
• 'Water logic' versus 'rock logic' -fluid, flowing, gradually building up logic versus permanent, hard-edged, rock-like alternatives				1							

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Flexible (fluid) organisation structure versus old fixed hierarchical structures					1						
• Organisations traditionally viewed as 'competitors' may become collaborators on certain projects - this is happening increasingly in the aerospace industry; which now has a much more fluid approach to who works with whom					1						
• Make use of the informal communication channels (grapevine) that exist inside the organization- e.g. spread important messages by utilising the natural connectors					1						
• Liquidation of assets					0,5	0,5					
• Floating deadlines in contracts					1						
Principle 30. Thin and Flexible											
A. Use thin and flexible structures instead of large, three dimensional ones											
• The thinnest film is a single molecule thick. Likewise, the thinnest organisational structure is one employee thick. Get faster customer service by having the slngle employee customer service agent have all the necessary data easily available, so the customer only deals with the single. flexible 'shell' of the organisation not the whole bulky volume.			1								
• 'De-layering' within an organizational hierarchy					1						
• 'We like to delegate and leave people as free as possible, so we try to push management decisions down the line. We run Rolls-Royce with a very thin corporate structure', Lord Tombs of Brailes. ex-Chairman of Rolls-Royce					1						
B. Isolate a system or object from a potentially harmful environment using thin and flexible structures.											
• Office workers in open areas can use flexible curtains to shut themselves off from the visual chaos of the open area when they need to concentrate rather than communicate					0,5		0,5				
• Use 'trade secret' methods to separate company proprietary knowledge from general knowledge				1							
Principle 31. Holes											
A. Add 'holes' to a system or object.											
• Think of the customer-facing layers of a company as a porous membrane which filters information flow both into and out of the organisation	1										
• Introduce 'breathing spaces' into contracts					1						
• Improve internal communications by creating Intranet accessible by all hierarchical layers; giving workers access to CEO and vice-versa.					0,5		0,5				
• 'Nature abhors a vacuum'- deliberately eliminate certain roles In an organisation as a way of exploring how the system will fill in the missing elements					1						
• Government 'leaks'- used as a way of gauging public reaction to (usually) controversial issues	0,5				0,5						
B. If a system or object already has holes, use them to introduce a useful substance or function.											
• Empower the customer facing layer (information is the thing that fills the poressee 30A).	0,5		0,5								
• Use mind-maps, seif-patterning capabilities, etc. to improve the information/knowledge intake and filtering abilities of the brain										1	
• Media relations department turns spin-doctor and/or marketing feedback gatherer	1										

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
Principle 32. Colour Changes											
A. Change the colour of an object or its external environment.											
• Red/Blue proposal preparation teams					1						
• Use of lighting effects to change mood in a room or office					1						
• Six Thinking Hats				1							
• Creation of 'corporate colours'- creating a strong brand image through use of bespoke colours- 'BP green', 'British Telecom red' phone boxes, 'Ford blue', etc	1										
• Use colours to communicate state of alert (green, black, amber, red, etc.)			1								
• Security alert states- psychologically, people remember colours better than text					1						
• Have software change the colour of presented data when it- for example - goes outside a prescribed range					0,5				0,5		
B. Change the transparency of a system, object or an external environment.											
• 'Transparent' organisations					1						
• Transparent communications					1						
• Importance of creating clear, concise mission statement					1						
• Smoke-screen/misinformation to disguise confidential R&D etc. activities				0,5	0,5						
Principle 33. Homogeneity											
A. Make systems or objects interact with others of a similar form or with similar properties.											
• Go-located project teams					1						
• Internal customers					1						
• Product branding/product families	1										
• Boeing 'Working Together Teams'- bring customers and suppliers into the design loop.	0,5			0,5							
• 'Complementary' organizations - ones that are not competing with yours, but which enable the creation of a win-win benefit- e.g. toothpaste and chewing-gum companies	0,5				0,5						
• 'Singing from the same hymn sheet'					1						
• Common data transfer protocols between different organisations					1						
• 'The best way to make a silk purse from a sow's ear is to begin with a silk sow. The same is true of money' (Augustine's Law #1)				1							
Principle 34. Discarding and Recovering											
A. Make portions of a system or object that have fulfilled their functions go away or modify them directly during an operation.											
• Flexible, variable-sized project teams				0,5	0,5						
• Load/capacity balance using contract labour			0,5				0,5				

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Consultants					1						
• Contract hire of specialised equipment/facilities, etc			0,5		0,5						
B. Conversely, restore consumable parts of a system or object directly in operation.											
• Need to periodically re-energise continuous improvement initiatives ('enthusiasm injections')									1		
• Life-long learning (where individuals are given responsibility for managing their own personal continuing education, ensuring skills remain up to date)							1				
Principle 35. Parameter Changes											
A. Change an object's physical state (e.g. from physical to virtual).											
• Virtual prototyping				1							
• Numerical simulation				1							
• Virtual shopping- e.g. Amazon.com	1										
• e-Commerce/e-Business	0,5		0,5								
• Telephone banking	0,5		0,5								
• Electronic voting in elections			1								
B. Change the concentration or consistency.											
• Stock options							1				
• 'Six Thinking Hats'/'Six Action Shoes'			0,5	0,5							
• Change the team structure (e.g. football teams use substitutes)					1						
• Stores introduce 'special offers' and other promotions	1										
C. Change the degree of flexibility.											
• Introduce intelligence into on-line catalogues (e.g. first generation catalogues were replicas of previous paper versions, latest generation incorporate search engines, expert systems, etc)	0,5		0,5								
• Software with options for 'beginner' through to 'expert' usage				1							
• Moves away from fixed clothing size partitions -e.g. 'Personal Pairs' - a customer at a participating store chooses which fabric he/she wants, then is measured. Those measurements are transmitted instantly to a levi's plant in Tennessee where the data controls a laser cutter. The bar-coded pieces are stitched on the regular assembly line, and mailed directly to the customer.			1								
D. Change emotional and other parameters.											
• Get customers excited about the product by giving them ownership of the change	1										
• Get employees excited about the future of the company by using full involvement strategic planning, or stock options, or... etc.					0,5		0,5				
• 'A fired-up team wins games even if it's not the best team. A fired-up company can achieve the same result'					1						

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
Principle 36. Paradigm Shift											
A. Use phenomena occurring during disruptive shifts in an economy. (Awareness of macro-scale business phenomena)											
• Awareness of the requirements of different stages- conception, birth, development, maturity, retirement - of a project (e.g. shifting manpower requirements, shifting budget requirements) .					1						
• Take account of transition from a 'bull' to a 'bear' market.	0,5				0,5						
• Tendency to relax after receiving a Quality Award, Innovation Award, etc.					0,5		0,5				
• Alvin Toffler's stated need for companies to 'learn, unlearn and re-learn' as economies shift from disruptive wave to the next				0,5	0,5						
• Forming/storming/norming/performing phases of team development- e.g. take advantage of enthusiasm dip during storming-norming					0,5		0,5				
Principle 37. Relative Change											
A. Use the relative differences that exist in an object or system to do something useful											
• Personality matching on work-teams							1				
• Derivatives										1	
• Creative tension- some organisations employ two independent teams to develop a new product or process, and then compete them. This is often done using one team constructed along 'traditional' lines, and the other using a smaller number of 'maverick' types; ones that don't fit well into traditional structures.				1							
• It seems safe to say that significant discovery, really creative thinking, does not occur with regard to problems about which the thinker is lukewarm'. Mary Henle				1							
B. Make different parts of a system act differently in response to changes											
• Expand or contract marketing efforts depending on the product's rate of sales and profitability.	1										
• Combination of high risk and high-stability investment strategies during market turbulence.					1						
• Pincer movement during war-gaming	1										
• 'Good-cop/bad-cop' negotiation/interrogation strategies					1						
• Creation of off-shoot companies to better exploit new product developments				0,5	0,5						
Principle 38. Enriched Atmosphere											
A. Replace a normal atmosphere with an enriched one.											
• Risk and Revenue Sharing Partnerships					1						
• Guest speakers at a seminar					1						
• Use internal subject matter experts					1						
• Use simulations/games instead of lecture-style training							1				
• Injection of new-blood/new challenge into a team'					0,5		0,5				
• Lotteries and other gaming activities										1	

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Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• 'Free gift inside'	1										
• Unsecured loan					0,5	0,5					
• Underwrite insurance for others										1	
• Set stretch targets that cannot be achieved without a significant re-think of the way things are currently done				0,5	0,5						
• A fired-up, empowered, appreciated individual will do the work of three who aren't'					0,5		0,5				
• South West Airlines POS - Positively Outrageous Service	1										
• Consider personal chemistry issues when assembling a project team - find people who will spark-off interesting reactions with each other.				0,5			0,5				
• Deming's 4th stage of learning - unconscious incompetence, conscious incompetence, conscious competence, unconscious competence							1				
• 'Leadership is a potent combination of strategy and character. But if you must be without one, be without strategy.' General H. Norman, Schwartzkopff					1						
B. Expose a highly enriched atmosphere with one containing potentially 'unstabfe' elements.											
• Corporate Jester/'Trickster'/Fool - someone who is paid to provoke the system and ask the difficult questions that often don't get asked				0,5	0,5						
• 'Devil's Advocate'				0,5	0,5						
• Bring your 'worst customer' into design or planning meetings	0,5			0,5							
• 'I like Bartok and Stravinsky. it's a discordant sound and there are discordant sounds inside a company. As president you must orchestrate the discordant sounds into a kind of harmony. But you never want too much harmony. One must cultivate a taste for finding harmony within discord or you will drift away from the forces that keep a company alive' Takeo Fujisawa, Honda co-founder_			0,5		0,5						
Principle 39. Calm Atmosphere											
A. Replace a normal environment with an inert one.											
• Move away from the (normal) disruptive performance appraisal, merit award, and reward environment to an (emotionally neutral) more fair system of working practice.					0,5		0,5				
• Tie finances to stable currencies					0,5	0,5					
• Quarantine zones										1	
• Hare Brain, Tortoise Mind										1	
• Time-out during negotiation					1						
• 'Away-day's! - team-building days					0,5		0,5				
• Secured loans						1					
• Corporate Retreats					0,5		0,5				

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Table C.1 – continued from the previous page

Description	M&S	Su	RPS	DPS	MR	Fin	EADS	TA	Q	U	X
• Operations Room- e.g. for planning organisational change, proposal submissions, contract tendering, etc.					1						
B. Add neutral parts or elements to a system or object.											
• Use of neutral third parties during difficult negotiations (e.g. Senator George Mitchell in Northern Ireland, ACAS, etc.)					1						
• Introduction of 'quiet areas' into the workplace.					0,5		0,5				
• Rest breaks/'pause for reflection' breaks in meetings.					1						
Principle 40. Composite Structures											
A. Change from uniform to composite (multiple) structures, be aware of and utilise combinations of different skills and capabilities.)											
• Multi-disciplinary project teams.				1							
• Do training with a combination of lecture, simulations, on-line learning, video, etc.							1				
• Employ different personality types (e.g. Myers-Briggs) on a team							1				
• Hard person/soft person negotiating team.					1						
• 'Small is beautiful'- appreciation for diverse, interconnected systems				1							
• Mix of thinking skills in a project team				0,5	0,5						
• Positional players in a football team				0,5	0,5						
• Combined high risk/low risk investment strategy					1						
Total	94,5	3	69	58	171,5	8,5	30,5	0	15	21	1
Percentage	21,0%	0,7%	15,3%	12,9%	38,1%	1,9%	6,8%	0,0%	3,3%		

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