UNIVERSITY OF LIVERPOOL

Integrated Approach for Developing Agile Strategies

Thesis submitted in accordance with requirements of the University of Liverpool for the degree of Doctor of Philosophy by Mark Hetherington

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Contents

Abstract

The project looks at Agility and Agile manufacturing in particular, with a focus on the SME type business. The initial focus is on the development of the ASF (Agile Strategic Framework) to make the selection of tools and techniques for manufacturing environments automated and systematised. This is to give consistency of approach, repeatability and to develop the system automation potential. This work will produce a test type model of how the business environment audit tool can be automated to produce results quickly and easily with less human time and intervention.

One part of the ASF which needs particular development is the process of examining a company strategy from an agility type perspective. The project fills this niche by looking at how agility fits with traditional schools of strategy, how it relates to definitions of agility from content analysis and pulls these together. Using grounded theory and qualitative methods to examine the meanings, usage and context of Agility an examination of how this may relate to TRIZ type systems using agility paradigms is undertaken. This particular study relates to agility in a large context including software, construction and business processes as well as manufacturing definitions. A working model with Case Study examples is suggested as a point for further development.

List of Figures and tables

List Abbreviations and Common Terms

5S	Manufacturing technique
AAM	Agililty Assesment Model
ACI	Agile Capability Indicators
API	Agile Performance Indicator
ARM	Agility Road Map
ASF	Agile strategic Framework
ATO	assemble to Order
ATS	Assemble to Stock
BEA	Business Environment Audit
BIZ	Business Izobretatelskikh Zadatch
BOM's	Bills of Manterial
BPP	Best Practice Providers
BPR	Business Process Re-engineering
CTF	Critical Turbulent Factor
DCR	Dynamic Customer Requirements
DSSM	Decisions Support simulation Model
EFQM	European Foundation for quality Managed
ERP	Enterprise Resource Planning
ETO	Engineer to Order
FMEA	Failure Modes and Effects Analysis
GM	General Motors
H&S	Health and Safety
IDEF	Integrated DEFinition Methods
IT	Information Technoogy
JIT	Just In Time
Kaizen	Continuous Improvement Technique
Kanban	Production Materials Replenishment Technique
KPI	Key Performance Indicator
KTP	Knowledge Transfer Partnership
MRP	Materials Requirements Planning
MTO	Manufacture To Order
MTS	Manufacture To Stock
OEE	Overall Equipment Effectiveness

OEM	Original Equipment Manufacturer
Paradigm	A philosophical or theoretical framework
QFD	Quality Function Deployment
ROI	Return on Investment
SME	Small to Medium size Enterprises
SPC	Statistical Process Control
STEEP	Social Technological Envirnmental Ecconomic Political (factors)
Systemisation	Organise into a code or system
TEA	Turblence Effects Analysis
TLR	Turbulence Level Rules
TPM	Total Preventative Maintenance
TPN	Turbulence Priority Number
TQM	Total quality Management
TRIZ	Theory of Inventive Problem solving, Teorig Resheniya Izobretatelskikh Zadatch
VA	Value Adding
VBA	Visual Basic Apllications
WIP	Work In Progress

Agile Capability Indicator Definitions

Product

A1	Degree of Customisation
A2	Component Flexability
A3	Process Similarity
A4	Process Replaceability
A5	Structure Adaptability
A6	Component adaptability

Process

B1	Scaleability
B2	Re Configurability
B3	Useability
B4	Replaceability
B5	Utilisation
B6	Robustness

B7	Effectiveness

People

C1	Employee Skills Flexbility
C2	Employee Skills Replaceability

Operational

D1	Customer Volume
D2	Cusotmer Delivery
D3	Customer Quality

Chapter 1

Introduction and Project IDEF

The background of this project lies in the development of a business assessment tool by the Agility Centre at The University of Liverpool. The tool is reviewed later in the project. In summary this tool looks at the business strengths and weaknesses and how to build on strengths and improve areas of weakness. The tool currently looks at a bottom up approach of manufacturing tools. It is proposed by the author that there is also a need for a top down or strategic approach to develop a more rounded tool which can implement and drive agility in the business. The author proposes that a strategic view is essential to drive agility within a company when combined with providing manufacturing capabilities to match this strategic positioning.

Agile manufacturing is a recent concept aimed at meeting the demands of today's consumer driven global economy. Companies must be responsive to the demands of markets, which always demand lower prices, faster delivery, more customisation and higher productivity.

More and more companies are relying on networks of suppliers and distributors to ensure that their product is first to market, low in cost, and high in customisation, features and innovation. The world of manufacturing is increasingly competing on supply chain performance rather than individual company performance. This means every company in the chain must be continuously looking for ways to improve the way they that perform to both internal and external customers.

Small and Chen (1997) state that 'The basis of competition for manufactured products during the past two decades has shifted from focusing on lower costs to an emphasis on quality, reliability and flexibility.' This shows that cost is becoming more of an order qualifier than order winner. Order winners have become factors based around performance, customisation, responsiveness and quality.

Olugbenga O. Mejabi (2003) in his Framework for Lean Manufacturing Planning System states, 'Many companies now realise that business success in the short, medium and long term is predicted upon outstanding performance in the quality of products and efficiency of manufacturing operations. The application of the principles and strategies of lean with emphasis on waste elimination and streamlining can offer a steady path towards business excellence.'

Lean manufacturing is the basis on which companies build upon to become Agile. After a company has reduced stock, streamlined its operations and processes and attacked waste they can say they are lean. Agile manufacturing aims to make companies more responsive and give better performance. Ultimately it aims to create a pull from the market for the product, generated by the choice available and the product quality perception. It is a strategic approach to manufacturing and considers conditions of the business environment along with internal operations and conditions. Agile companies aim to be able to respond to market as quickly as possible and to predict what might happen in future market trends. This does not mean setting up for a new operation / product but having operations which can change direction efficiently and quickly. 'Agility may be seen as similar to flexibility, but, agility is different from flexibility in that agility is a management philosophy which allows a quick re-configuration of the business, it encompasses organisation, people, and technology into a meaningful unit by developing advanced IT capabilities and business structures to support highly skilled and motivated workforce.' Blackhouse and Burns (1999).

'Agile manufacturing was first introduced with the publication of a report entitled '21st Century Manufacturing Enterprise Strategy', which is a revolution of manufacturing systems beyond traditional ones such as mass production and lean production.' Dove et al (1991). Agility was defined here as 'The ability of an organisation to thrive in a continuously changing, unpredictable business environment.' The paper went on to describe the four principle dimensions of agility, 1) Enriching customers with total solution products, 2) Mastering change and uncertainty, 3) Co-operating to enhance competitiveness, 4) The knowledge driven enterprise.

The above research came from a government sponsored program looking into how manufacturing could be made more responsive, profitable and world beating. Companies in today's markets are offering many of their customers these types of services. If we look at companies who may provide examples of these principles we can see that there are many markets where this is apparent. For example: Total solution products, many computer companies are now looking to provide more than just flash memory to customers, Cisco the network providers will actively encourage customers to develop total solutions rather than plug in components.

Cooperating to enhance competitiveness can be seen in many industries, and one of the first to champion this was the automobile industry. While the automobile industry may show co-operating to enhance competitiveness it is often not the OEM (Original Equipment Manufacturer) who is driving agility. The focus at this level is traditionally on lean and cost / waste reduction to provide a cost effective option to the customer. Further down the supply chain some companies however are utilising Agility in an effort to enhance their business.

One such example is Brembo braking systems. The company started by providing high performance and specialist brakes. Then moving into Formula 1, and high-end sports cars, the company has created a pull from the market where it is seen as desirable to have this equipment fitted on a car. This in turn creates pull from the manufacturers and Brembo have geared up to supply this wide range of products and services to enhance their reputation.

Dove et al's point about knowledge driven enterprise can be seen in all the above. For companies like Brembo, the knowledge they posses about the parts they make and the performance of their products is invaluable in driving pull from the marketplace, both from consumers and the OEM. However the OEMs' product becomes more desirable by having the component in place.

Objectives and Methodology

How is agile manufacturing created; how is it implemented and how can it be sustained in companies today? The project will examine and answer these questions. The project also aims to examine the top down strategic link with agility and propose a framework for strategic implementation of agility. The research methodology section will outline exactly how this will be done and explain each section more fully. The research will build on the Business Environment Audit (BEA) system developed by The Agility Centre at The University of Liverpool. This framework aims to provide a roadmap for agility. The roadmap for agility will comprise of a top down strategic approach to developing agility in a formal framework. This is something that has not been developed before.

The research flow is summarised in the project IDEF (Integrated Definition Methods) diagram on page 17. In short the project will review the previous Agile Framework from The University of Liverpool Agility Centre, and review other frameworks available. From this review the author will propose an approach for recommending manufacturing tools to implement which is repeatable. This will systemise the process allowing then an IT (Information Technology) tool to be developed which automates the selection of manufacturing tools. This is an area that has not been previously researched and will provide repeatable data relating to the existing framework.

There will also be a review on strategy literature and manufacturing strategy to see how Agility is related to traditional schools of strategic thought. This will look at how Agility can be used with multiple business strategies to enable a company to position for agility. The output from this will feed into the top down framework the author will develop. Again this top down framework approach is new in agile research. The framework development also uses the output from content analysis; looking at where agility is used, how it is developed and the context of the current research. This framework will make use of the principles of TRIZ (Theory of Inventive Problem Solving) and develop them to give agile competitive advantage. The author proposes that the development of this framework is necessary to provide a full agile tool kit.

Therefore the main objectives of the project are:

To review the previous work undertaken on the ARM (Agility Road Map) and the BEA system to provide full background information.
To review literature on frameworks available for implementing manufacturing change and compare these to current work.
To review literature on strategy and manufacturing strategy and identify where agility fits with current strategy schools
To develop a tool selection framework for testing and to automate this through the use of IT
To show through content analysis the existence of paradigms of agility, and examine how these are related to strategy
To develop a framework to show how agile paradigms can be used to implement strategies that are agile

These objectives and the research theory behind them are summarised in the following IDEF diagram showing the two distinct phases of the research.

Project IDEF Specification

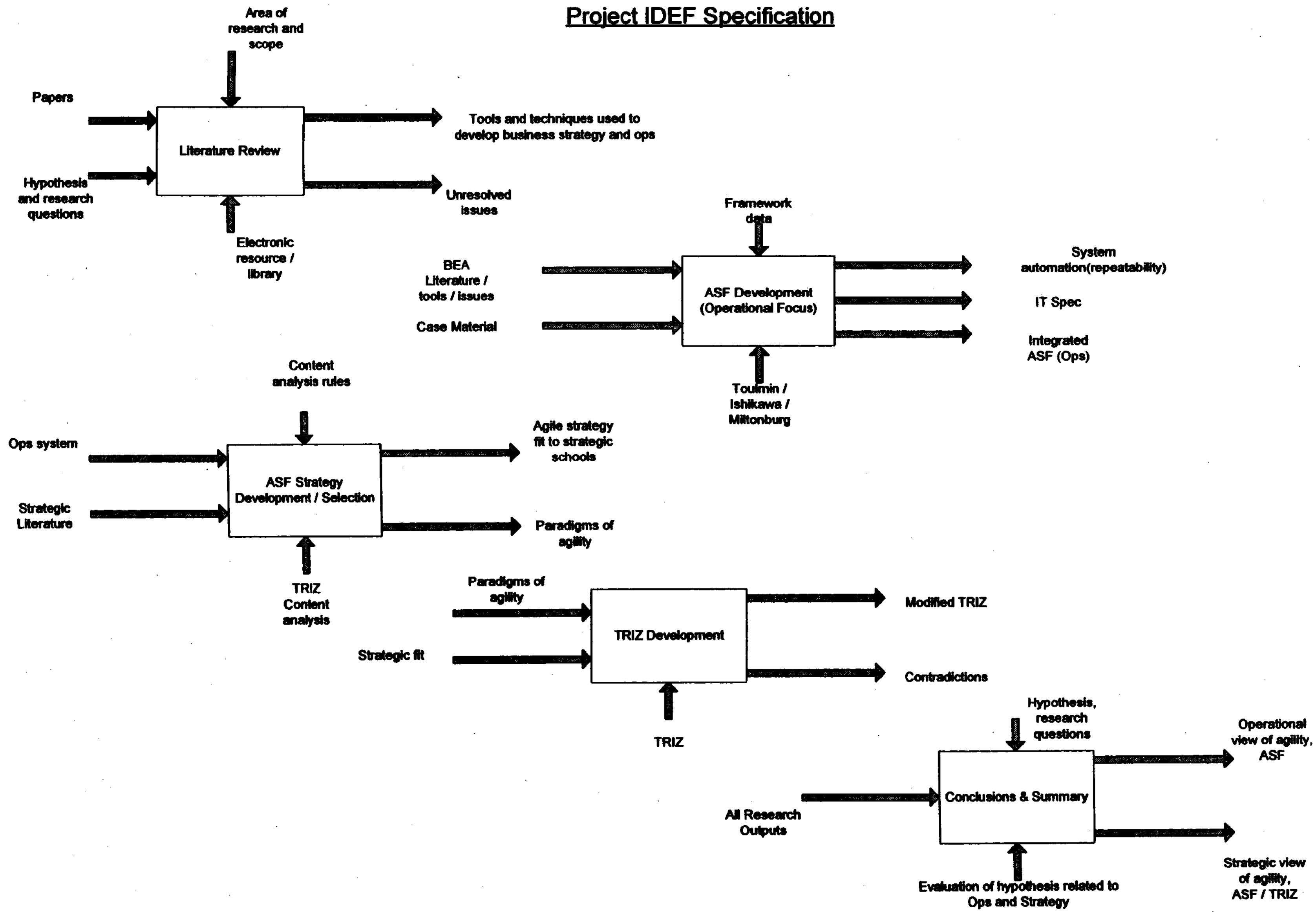


Figure 1: IDEF of proposed project research process (Hetherington)

Chapter 2 Section 1

Agile Strategic Framework Literature Review

The Agility Strategic Framework and How It Works

A Strategic framework for agile implementation is the end goal of several collaborative research projects at The Agility Centre, Liverpool University. There is already a framework available with many sections functioning and tested in real life applications. An overview of this is shown by the ASF (Agility Strategic Framework) Diagram. This first section of literature review looks at work already carried out on the framework and gives background information on how it works and asses various factors needed to be taken into account. It will describe the system, parts available and how they are intended for use. The second part of the literature review will focus on other tools and frameworks available by looking at published papers and books.

The Agility Strategic Framework starts with the Business Environment Audit tool (BEA), it is a tool for the assessment of the level of turbulence in a specific business environment. The BEA encompasses the ETI (environmental Turbulence Indicator) questionnaire, TLA (Turbulence Level Assessment) and identification of CTF (Critical Turbulent Factors). The assessment identifies the impact of the environmental turbulence through a series of questions and measures of change. The result of the analysis is a prioritised list of factors in terms of their impact on the performance and operations of the business.

The BEA is applied in several stages to identify those areas of management concern within the business. This information is sourced through discussions with senior management who have knowledge at the strategic level but whose knowledge also encompasses the operational characteristics of the business. The information is gathered in a structured manner through the ETI questionnaire. Each section of the BEA will be described in more detail later but a brief overview of how it works is provided below.

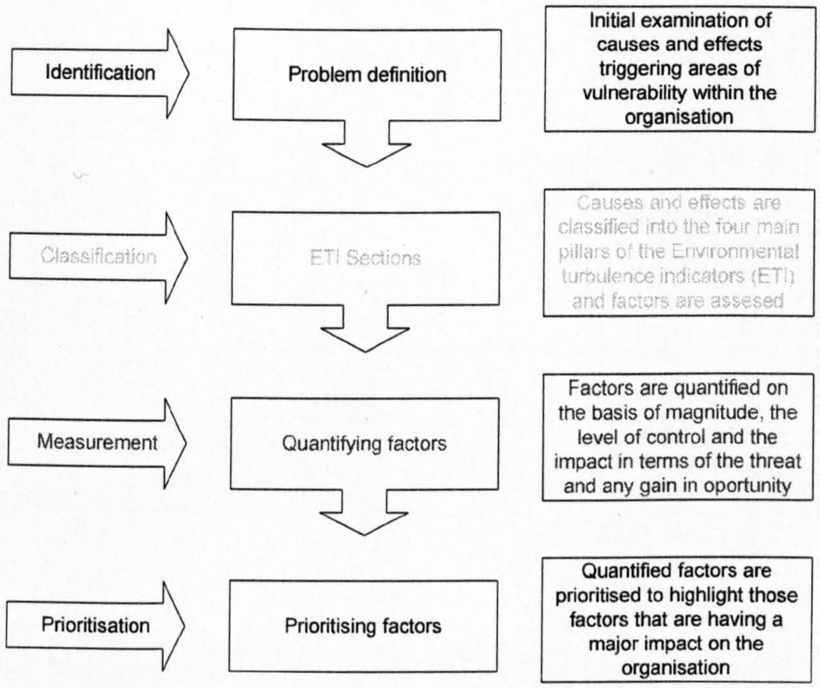


Figure 2: Overview of BEA process (Hetherington)

The BEA audit forms the first part of The Agile Strategic Framework for improvement which aims to give companies a performance enhancing strategy and plan for improvement implementation with the tools and techniques that help you to get there. The Agile Strategic Framework is summed up in diagrammatic form on the next page. This is taken from documentation produced by The Agility Centre, The University of Liverpool.

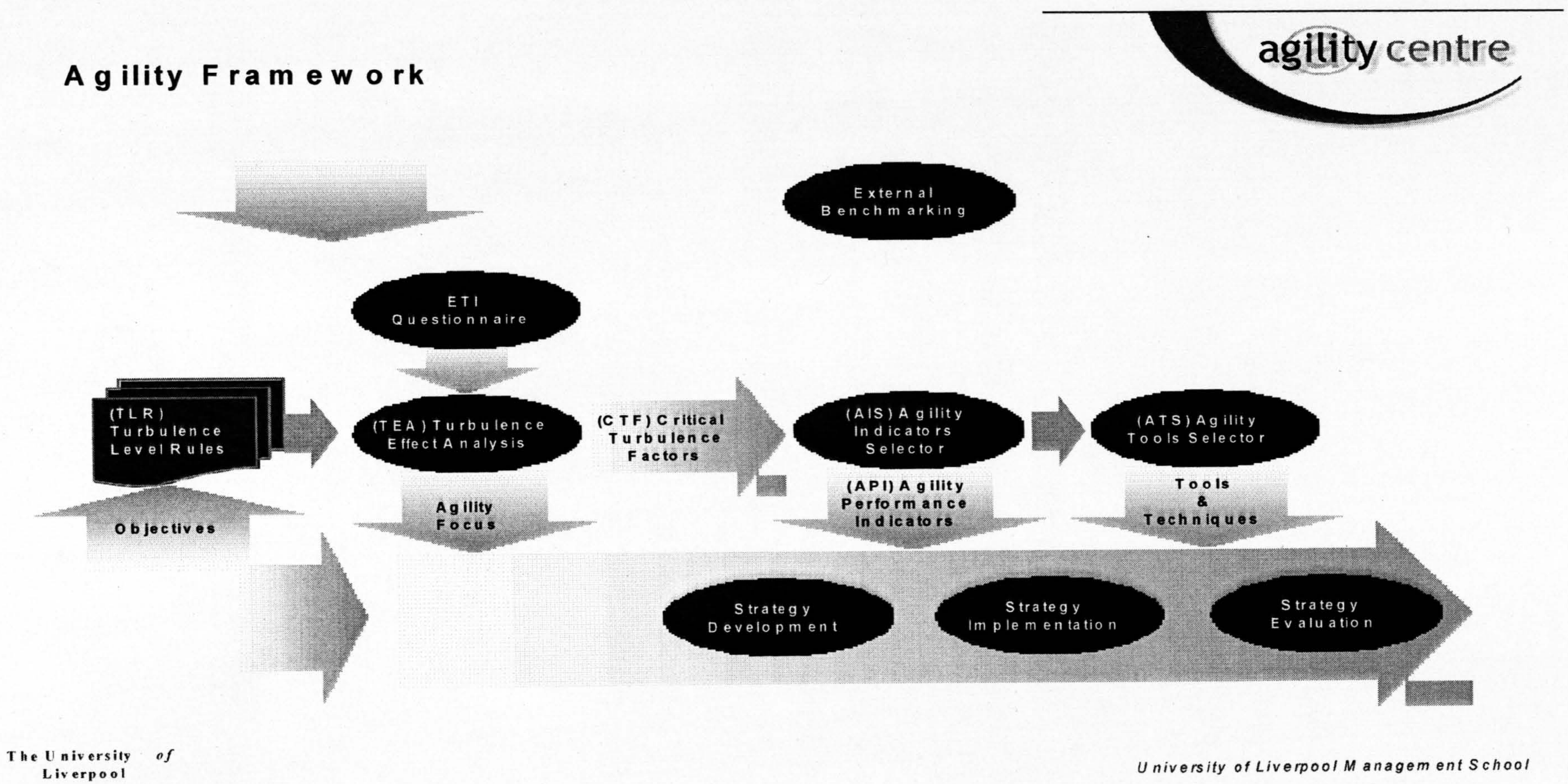


Figure 3: Overview of Agile Strategic Framework (ASF) (Ismail, Hetherington)

The framework aims to utilize the fact that all companies will on a daily basis receive and act upon information about the product, people, process, market, customers and many other factors affecting the way that they do business. The way in which this information is processed effects the agility of the company. There must be the correct structure and setup (strategy) to deal with these changes and challenges to the business. If these are met with the right strategy the business can be agile to the customers' needs and the market situation and demands. The author proposes that by becoming agile the costs of business may drop, however the real advantage come from adopting premium positions in the market though the superior choice service and quality that the company can offer.

The Environmental Turbulence Questionnaire.

This aims to identify changes in the environment, the effects on the company and the behavior of these factors over time. To do this effectively the BEA audit is split into four pillars of Environmental Turbulence Indicators, ETI. These form the main structure of the questionnaire and subdivide further into various categories as described below. The sub divided sections contain specific questions related to particular areas of the business and will form an outline of the important areas for the business once each section has been completed and mapped. The four main categories are as follows:

Intensity Of Competition: Examines changes that have occurred in the direct competitive environment

Dynamic Customer Requirements: Examines how customers' needs and expectations are diversifying and how these demands are placing additional pressure on companies

Supply Chain Turbulence: Examines changes in the network of facilities and options that perform the functions of Procurement, Manufacture and Distribution.

Changes in STEEP (Social Technological Environmental Economic factors): This represents factors in the macro environment and refers to Social, Technological, Environmental, Economic and Political factors and the effects that these have on an organization or within a particular industrial sector.

Each of the above is broken down into a number of sub sections which comprise of a series of questions used to evaluate the company. The sub sections are as follows:

Intensity of Competition: This comprises of Rivalry and Substitute products questionnaires.

Rivalry examines factors relating to organizations operating in the same market who are considered to be direct threats to the target organization., the competitive behavior and performance of these organizations, and the impact of such behavior on the target organization. This factor also addresses issues that can be attributed to the companies' products from a market perspective.

Substitute products examines those new or existing competitors products that are functionally comparable but are not identical in terms of structure, technology and operation to those of the target organization. The substitute products can coexist with the company's products and due to their price, extended / specialized functionality or performance, could constitute a major threat to the company.

Dynamic customer requirements: This has three component areas. They are Product Development Process, Product Performance and Customer Bargaining Power.

Product development process looks at how the customer drives the product development process and the influence on the steps or activities that an organization employs to conceive, design and commercialize a product, indicating whether the market is customer driven.

Product performance looks at change caused by customers that determine the performance of an organizations product(s) within the business environment, thus having an impact on internal business operations in terms of Time, Quality, Cost and Flexibility.

Customer bargaining power is the factor that drives prices down, demands better quality and service levels and sets competitors against each other. Here control is with the customer who can demand the requirements in terms of price, quality and delivery.

Supply Chain Turbulence: This pillar also has three subsections. Changes in Procurement, Changes in Manufacturing, and Changes in Distribution.

Changes in Procurement looks at the sourcing of materials through relationships with suppliers and the interaction of activities through communication, partnership and integration.

Changes in Manufacturing looks at the process of producing saleable products through the activities of the workforce and processes utilized, up to and including packing.

Changes in STEEP: This section is split into the four acronym letters of Social, Technological, Environmental, Economic and Political factors. These are all assessed for changes on separate questionnaires.

Social Changes is looking at factors primarily focusing on the characteristics of people in terms of age, education and movement in and out of the region, and the impact that this may have on an organization.

Technological changes refer to technological innovations that influence or enforce the target organizations to change and maintain market position.

Environmental factors are those issues that affect the environment in terms of pollution, safety and operating requirements for products and processes.

Economic changes are those factors that govern the macro economic environment, which affect the market as a whole and have an impact on organizations.

Political changes looks at the influence of the government on the local economy where an organisation may operate, focusing on changes in policy and new legislative introductions. Also addresses the impact of trade unions and other bodies including issues not addressed in other areas.

The Pillars are summarized in diagrammatic form below:

Intensity of Competition:	**Examines changes that have occurred in the direct competitive environment.**
Dynamic Customer Requirements:	**Examines how customer needs and expectations are diversifying and how those demands are placing additional pressure on Companies.**
Supply Chain Turbulence:	**Examines changes in the network of facilities and options that perform the functions of Procurement, Manufacture and Distribution.**
Changes in STEEP:	**This represents factors in the macro-environment and refers to Social, Technological, Environmental, Economic and Political and the effect these factors have on an organisation or within a particular industrial sector.**

Figure 4: Summary of ETI pillars (Christian 2005)

The questionnaire assesses the turbulent factors on a number of criteria based on the following seven change components:

1) Time base, the period of time for which an assessment is based
2) Pattern of change, cyclical or non cyclical
3) Trend, the direction and rate of change within the time based specified (linear increase, linear decrease, no change, exponential increase or decrease)
4) Distance, the level of change in the duration of this time base (low, medium or high)
5) Frequency, how often the change occurs (low, medium or high)
6) Magnitude, the average deviation from the mean in cyclical patterns of change (low, medium or high)
7) Size, the mean value for the sub factor and its unit of measurement

The above seven change components are each related to a turbulence rule, which gives a numerical output for each of the questionnaires undertaken. The numerical output allows a ranking of the factors in order of priority. However it does not give an indication to the scale of turbulence and allow comparison of levels of turbulence. A table showing the calculations of turbulence can be found after the questionnaire example.

Below is a diagram outlining the questionnaire and how each section is completed.

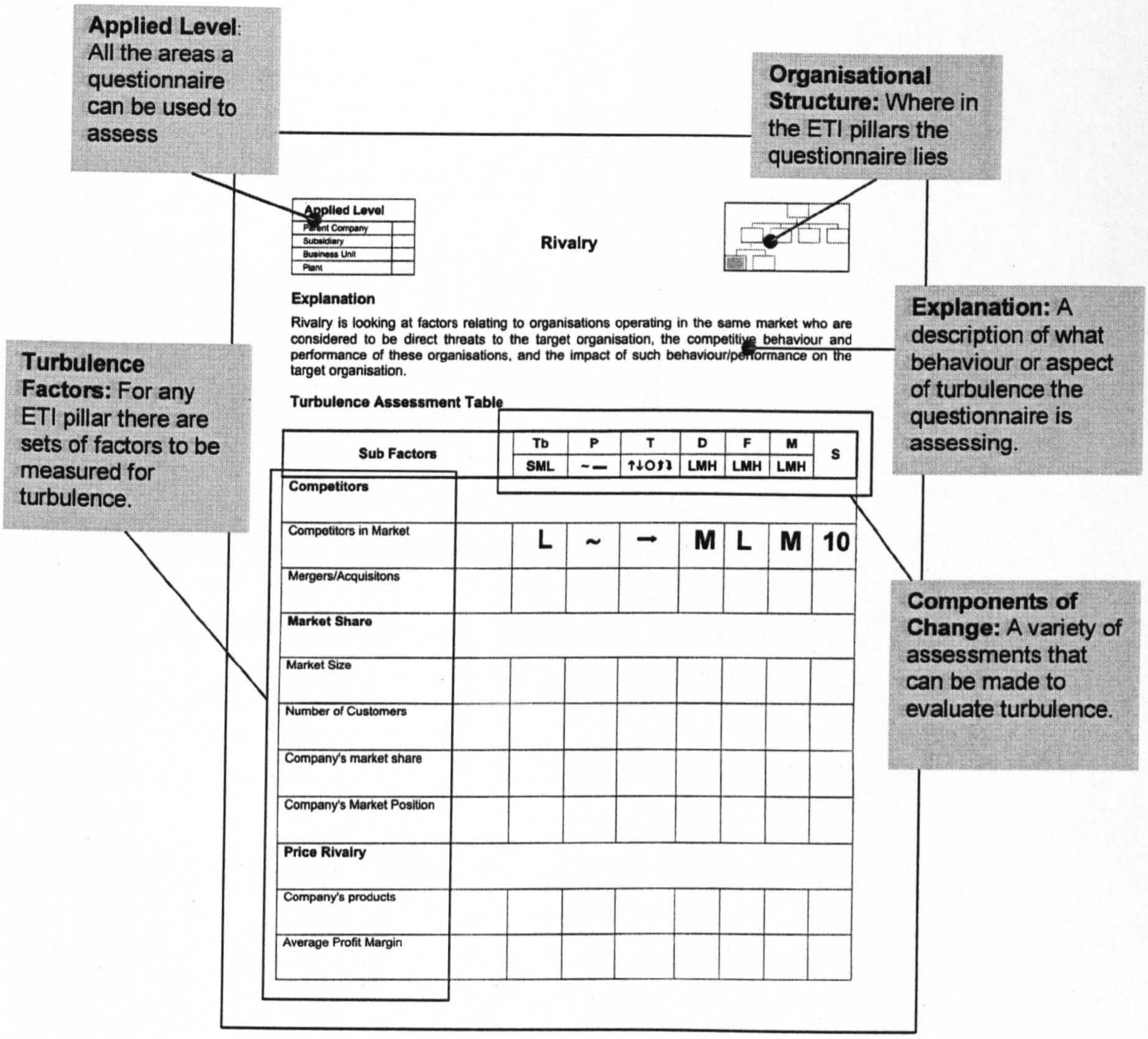
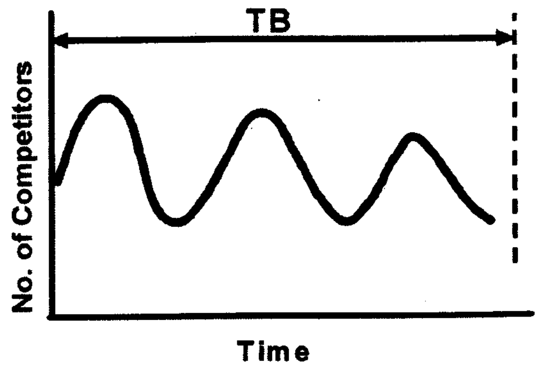


Figure 5: Outline of a questionnaire (Ismail)

1. Time Base (TB)

This is the period of time over which the particular sub factor is assessed

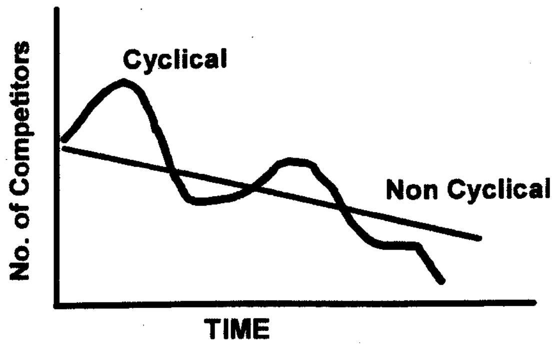
- **Short Term:** (days-weeks). (S)
- **Medium Term:** (months) (M)
- **Long Term:** (months-years) (L)



2. Pattern of Change (P)

This identifies the form of change for each factor. Changes could be:

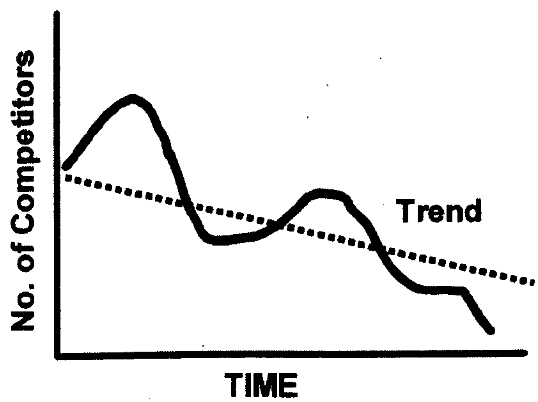
- **Cyclical** (~)
- **Non-cyclical** (—)



3. Trend (T)

For the specific pattern of change, this metric measures the direction the change moves in from the beginning to the end of the time base specified. This can be:

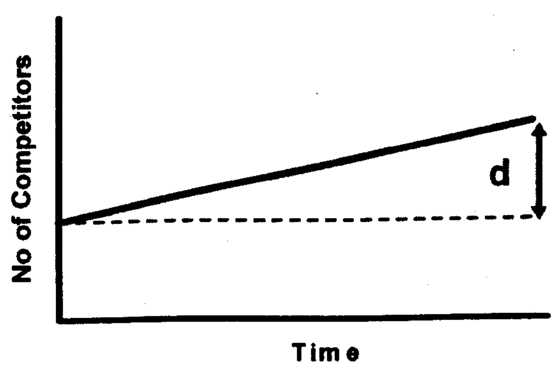
- **Linear increase** (↑)
- **Linear decrease** (↓)
- **Constant** (O)
- **Exponential increase** (⤴)
- **Exponential decrease** (⤵)



4. Distance (d)

The value of the change from the beginning to the end of the time base

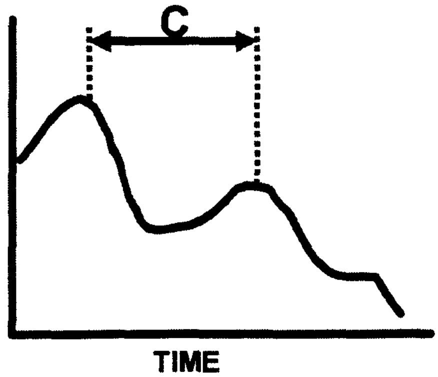
- **Low:** Less than 5% (L)
- **Medium:** 5% to 30% (M)
- **High:** Greater the 30% (H)



5. Frequency

How often the change occurs; this metric is only relevant to cyclical patterns of change.

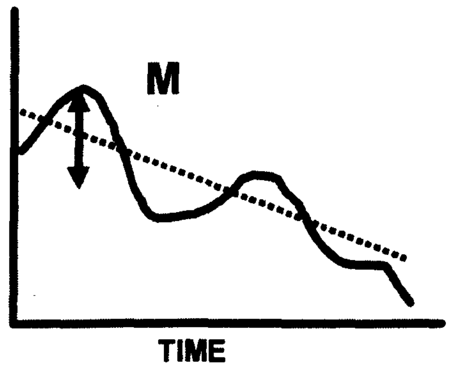
- **Low:** up to 5 cycles over TB (L)
- **Medium:** 5 to 10 cycles over TB (M)
- **High:** more than 10 cycles over TB (H)



6. Magnitude

The average deviation from the mean in cyclical patterns of change.

- **Low:** Less than 5% (L)
- **Medium:** 5% and 30% (M)
- **High:** Greater the 30% (H)



7. Size

This represents the scale of the factor being measured in terms of number size etc.

Figure 6: Components of change measurements (Ismail)

Select Capability Indicators:

Once the turbulent factors have been identified ACI (Agile Capability Indicators) should be selected to aid in the measurement of processes and operations. Each of the agility capability indicators has several measures of performance related to it which will measure how well the company performs in this capability. These have been developed from a combination of recognized best practice performance measures for agile companies and measures that have been specifically adapted or developed to aid the framework and measure certain factors. See Appendix 2 for the ACI and their associated measures. These measures are monitored closely upon implementation of operational improvement tools. This therefore allows improvements to be charted and implementation success to be monitored.

Implement Improvement Tools:

Once ACI have been selected to monitor performance in critical areas some tools and techniques must be implemented to improve the performance relating to the turbulent areas. These tools come from the 'Best Practice' folder and are selected manually by the operator of the frameworks components. The tools are selected to have the most impact on the areas being measured by the ACI.

The procedure for carrying out a BEA is as follows:

Outlined in the procedure for implementing the framework the steps are as follows:

-Form the audit teams

-For each questionnaire fill in the turbulence assessment table

-Utilising the Turbulence Level Rules identify high medium and low areas of turbulence

-From the score identify which areas cause the most turbulence and are going to be addressed. These can be plotted on a radar graph

-Prioritise the turbulence with the TEA (turbulence Effect Analysis) tool and identify which ACI should be used to aid measurement of agility

- Propose tools (Manufacturing Best Practice Tools) to improve upon the companies agility.

The project will look to develop the tool selection into an automated or semi automated system. It is also proposed that the tools selection table will form part of a strategy formulation section similar to a QFD (quality function deployment) diagram. See diagram below:

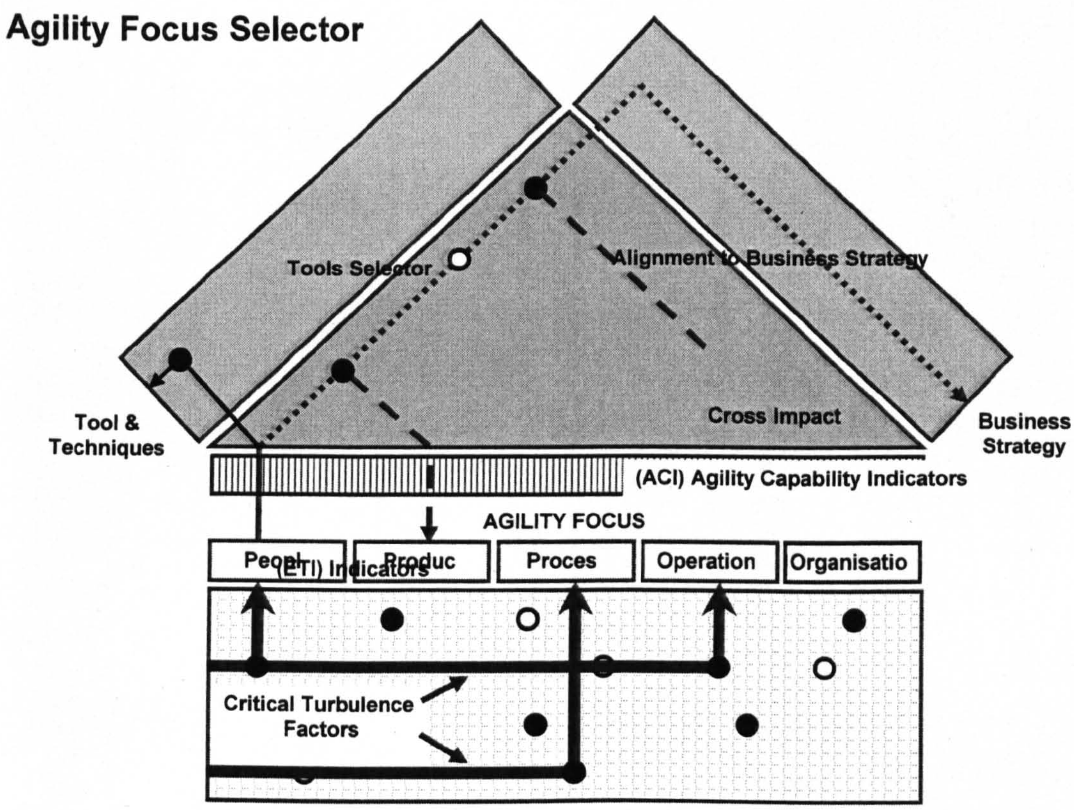


Figure 7: QFD Diagram representing ASF and BEA system (Hetherington 2006)

In the above system once the tools and techniques have been identified along with the strategy, the plan can be implemented and monitored by using the capability performance measures. These should show a clear improvement of the company's agile capabilities through improved metrics. If the company enters new markets with new products and customers, the framework should be applied again, as the demographics of the new market may be different and will therefore require a different set capabilities.

The next chapter will examine literature published on frameworks for implementation of tools in a manufacturing environment and how these relate to the above framework. It will also look at how the strengths and weaknesses of these frameworks compare with each other.

Chapter 2 Section 2

Agility and Strategy Literature Review

In the previous section the ASF and its components of ETI (Environmental Turbulence Indicators) TEA (Turbulence Effect Analysis) ACI (Agile Capability Indicators) and ACS (Agile Capability Selectors) have been outlined. This provides background information on the system, its design, how it works and a brief step by step guide of the system. In this section the need for agility will be examined within the manufacturing and wider business environment. Frameworks used in business for evaluation and implementation of tools and techniques will be assessed, along with the need for such frameworks.

Strategy and manufacturing strategy are reviewed as the author proposes that in order to drive true agility it must be implemented as a strategy. The traditional schools of strategy will be examined and suggestions to where agility fits, has some commonality or differs will be highlighted. This will be used to feed into the work on Agile Strategic frameworks.

The need for agility has been explored in many papers and articles over the 15 year period since the concept was first introduced. The needs for companies to become agile has been defined and explored briefly in the introduction. Some anecdotal evidence is included here. GM's (General Motors) Delphi Energy and Engine Management Systems introduced a Lean then Agile strategy and at one plant, the Saginaw Steering Systems business. Some $600 million dollars worth of savings have been made on cost reductions, and defect reductions approached 60% for the first two years of implementation (Sheridan 1996). Another example at General Motors is the Lordsdown plant which saw huge results from agile manufacturing implementation. The results claimed at this plant were to reduce Lead times by 38%, inventories by 48% and is production floor space by 27% (Kasarda, Rondinelli 1998).

It is not just large companies like GM who need to be able to gain the benefits from such programs. SME's are becoming more and more common on the international marketplace and can offer some advantages over larger companies. They generally have a small flat management structure and therefore implement agile systems quickly. It often means they are used to being responsive to the market place and already have the mind set of being first to service the needs of the customer. SME's realize that if they are servicing large industrial customers they will have large amounts of competition for the business which is often worth a large proportion of turnover every year. For an SME to win this business and then hold onto it they must respond rapidly to the demands of the customer and provide solutions which are timely, cost effective and innovative. Once an SME has a large customer like this, they need to keep hold of them to maintain large portions of turnover and profit. They often therefore devote a large amount of time to ensuring that they are providing the best service to that account as possible. This may not necessarily be in an agile manner but due to the company's dynamics they can make things happen quite quickly. By introducing agile strategies there can be a structured approached to this account servicing and they can meet the customers needs in a more organized, structured, measurable and cost effective manner.

One example of a small company placing a large amount of effort into servicing a larger client is a small healthcare company based in Liverpool. This is an SME specializing in the production of operating table mattresses for OEM equipment manufacturers; the company services most of its business away from its home market of the UK. There are several major manufacturers in the operating table market and the company services the majority of these. Around ten to fifteen years ago the company developed a fully moulded table mattress to service the need in the market for increased infection control. This new product had no seams in which to catch blood residue and harbour infection, it also won them several major accounts and placed them at the forefront of the market place. This product became the biggest single production seller for the company. To meet demand increases in the late nineties and early 2000's they implemented lean and then agile production systems to cope with the unique products and deliver increased quantity and variety products to its growing customers. In late 2002 the market was demanding a different type of product for the operating tables. The company had a small management structure and responsive production facilities and prioritised the development of the next generation of moulded mattresses for its existing customers, this secured market share and won back some USP within the market place. The new product was into production within three months. The nearest competitor in the market place was a large multinational company who had a moulding plant based in mainland Europe, closer to the majority of the customers. By the time the company had developed and placed into full production a new product the competitor had only just sent its first small sample to the customer.

The short development time meant that the company recaptured the business and secured a large part of their turnover. The larger company has not been examined for agile techniques implemented but it can be assumed that the combination of large hierarchy, and non agile production and development techniques, meant that the new product could not be delivered on time (even with the geographical advantages), and they lost the business. This presents a very good case for SME's becoming agile. It shows how these techniques can lead to SME's competing and winning in marketplaces where there are several large companies with much greater resources and equipment reserves. By applying agile techniques and combining them with the inherent benefits of a small company, some if not all of the obstacles of being an SME are removed or overcome. It means that competition is about the skills and strategies of the company not about size and money. This makes a very convincing argument for SME's to look at the way they run their business and start to progress on the route of agile techniques. This is backed up by a presentation given by Steven Goldman at the agility Forum, Lehigh University when he describes what an agile company can do.

'It can for example:

Rapidly bring to market products that are variable combinations of hardware, information, and services.

Design product that are easily reconfigurable and upgradeable.

Produce (goods and services) to individual customer order in arbitrary order quantities.

Create continuing, rather than single instance, sales relationships by continually adding value for current customers.' (Goldman 1996)

Drivers for agile manufacturing techniques are stated in many different forms in literature and by people in industry. For example, 'We invited senior level managers to list the key drivers or common aspirations of all plants. These were then ranked and five common traits emerged:

(1) To become more customer focused in operations – one of the computer plants used the phrase "to become more customer centric", in describing the task for the plants operations.

(2) To become faster in the speed of delivery of products.

(3) To be able to move from manufacturing and assembling standard products to far greater levels of customisation around numerous configurations.

(4) To be able to satisfy the above but, at the same time, to lower costs.

(5) To enable the firm to compete against other competitors who, themselves, are pursuing mass customisation strategies.' (Brown, Bessent 2003)

These statements help to illustrate the need for agile techniques and strategies in modern industry. Agile strategies and capabilities within a company can provide all the above. Many companies are looking at what is going on in the market place and realizing that they must move to compete with other companies offering similar products and services. Markets must be examined for the next way to differentiate the product and service offered, this is shown through market entry requirements becoming higher as more companies take on the challenge of customisation. The consumer expects more and will dictate to the supplier / manufacturer what the terms of sale are. This requires careful examination of market, product and capabilities being offered by other companies in the market place.

The framework developed by the Agility Centre helps to look at the market conditions for a particular company and its products and develops a plan for implementing agile techniques and strategies. It looks at the skills and tools needed and communicates this information to the company in a short report outlining a plan for implementation. There are limitations to the agility centres framework in that it is most suited to application in SME sized organisations. This is due to the large amount of work that would be required in applying the system to large organisations. Therefore some development work may be required to scale up the framework.

This type of system is also called for by larger industries, Donald Runkle at General Motors Corp. called for 'a game plan that makes sense to factory workers – and they can buy into.' (Runkle. D, In an Article by Sheridan. J, H 1996). For the record he made it clear that he was not trying to imply that factory workers are thick headed merely that the people issues in change management have to be taken into account to produce a plan which is relevant to the people who will feel the change first. The ASF goes some way to making this game plan a reality although the results are presented to managers in the form of a report, the implementation suggestions and the way tools and techniques are used always takes into account the skills issues of the factory. The Agile Strategic Framework also considers the change management that is involved in the implementation of any new ideas into a factory environment. The Agility Capability Indicators has a specific section looking at the people agility and as such they are of major concern to the progress of agility in a company using this system.

On top of this call for 'a game plan for agility' there are calls in the paper for 'what else will need to be examined in order to establish a realistic game plan for agility' (Sheridan, J 1996). The papers author quotes Steven Goldman from the Agility Forum at Lehigh University as stating 'There is a fundamental difference between lean and agile at the implementation level. "Lean is a tactic", he says. "It translates into a game plan. But agile is a strategy – you have to think about how it translates into a game plan in your industry sector". A particular company's strategy must take into account its unique competitive environment – including the nature and maturity of its products and what is valued by the marketplace' (Sheridan, J 1996)

The ASF takes into account all of the above by looking at the marketplace companies are operating in. It looks at how the product can be agile, does it need to be, are the processes agile to manufacture these products, are the people agile and trained to deal with agility issues and is the operation and the organization structured and managed in a manner that facilitates the above. The framework therefore meets the criteria for developing a game plan. However, the plan that is generated does focus more on the managerial level, rather than, suggest how to transmit this information to the factory floor. A development of the system may be to have an extra or optional step which provides some sort of training or explanation to the factory floor. This could include basic information around the changes taking place, why they are happening and what is means to them and their role within the organisation. After all without the support and understanding of the factory floor any managerial plan to move to agility will fail through lack of understanding, trust and enthusiasm. However, the management level should not be dismissed as unimportant, most attempts at implementing new techniques and ideas fail due to lack of support and drive from the senior management of a company.

So some companies are experiencing a need for manufacturing agility and claiming the need for a framework which lays out a plan to become agile. They are also experiencing a lack of clear evaluation of the business environment in relation to their product(s) lifecycle(s) and what the customer is demanding. This is obviously a major driver for the development of agility frameworks such as the ASF model. But what other kind of influences are companies feeling to make them want to become agile. What pressures are being exerted on manufacturers and what can a framework do to help?

'In most industries, rapid worldwide political and economic shifts are increasing the number and power of new international competitors. Former socialist countries are entering the capitalist marketplace with vigour. What was previously Third World countries in Southeast Asia and Latin America are producing sophisticated goods and services.' (Kasarda J. and Rondinelli D 1998).

This type of argument seems to be occurring more and more in today's business environment. When trying to reduce the costs of doing business many companies are looking abroad to places such as China and India and quoting labour costs. There are however many things a company can do to remain in the west and still be competitive. Agile techniques are one of them. The feeling that there is still ways of remaining competitive within the home market and retain production and facilities in the home country is summed up in an anonymous' quotation found on the internet:

'why not have production here and move headquarters to China, India, Mexico or wherever, somewhere we can get reasonably priced executives'

While this evidence is anecdotal it does sum up the fact that labour is always seen in terms of a cost and not an asset. Yes labour does cost money and is a large expense to a company but it is also the people who make the products, organize the facilities, and process raw materials into a finished good. If we have the right people trained to do the right job in the right way why should we still remain uncompetitive? Automation is one way to address the rising expense that companies may face due to the increase in wage bill, but care must be taken to ensure that the people who are in the company are working the in most efficient way possible and are able to serve the market in the quickest and cheapest way possible. However forming value in the eyes of the customer is not simply about price, it is about image, perceived quality and functionality and creating a pull from the market place for a product. The author proposes that this is agile competitive advantage. 'International customers are also more sophisticated and demanding. With access to an unparalleled variety of product from all over the world, they can more easily identify value. As a result they have become selective purchasers. They expect quality, reliability and competitive pricing but also want customized products that are delivered quickly.'(Kasarda J, and Rondinelli D, 1998).

It is the author's belief that companies who are experiencing a shift of production to facilities abroad are not making best use of the products and services they provide. There are many options to combat international competition, and becoming an international company is one of the ways of doing this. Many SME's now source and deliver on a global basis and have structures in place to do this. 'Even small and medium sized enterprises increasingly rely on a network of suppliers, distributors and customers to improve their global competitiveness' (Agmon T, Drobnik R, eds 1994). They must also however be geared to provide the market with timely goods which are innovative and high quality. The innovation of the product must be continuous otherwise competitors will copy the product / service and find a method of producing it cheaper and quicker. In other words the company must be agile to respond to changes in the marketplace and continually drive demand.

It is also apparent that in the technological industries no one company can maintain expertise in all areas to form today's complex products. This means partnerships must be formed, and to become successful the partnerships must bring together several areas of expertise and forge them into one product. This can be seen in many areas, one such area is computing, companies will come together and develop new plants to built specific chips and parts which will benefit all involved while spreading risk, increasing knowledge and providing an agile product used in many applications. By many companies utilising one production facility to produce a component, agility can be driven through late customisation to make a component performing many different operations.

A model is shown in the paper Innovative Infrastructure for Agile Manufacturers, (Kasarda J, Rondinelli D, 1998) which gives elements that support agile manufacturing. The author would also argue that these are drivers for companies to become agile and use the benefits that these can offer. The model suggests that, 'Integrated Telecommunications networks, Multimodal transport systems, Commercial and Service Support, and Knowledge centres' all support agile manufacturing. The capabilities of these should drive the manufacturing system forward and allow the company's infrastructure to be response to market demands.

A real life case study of how these new and emerging technologies can be used to help drive agility is from Hewlett Packard. 'Hewlett-Packard's field service division put a significant percentage of its 15000 employees into a virtual office. Thanks to the Internet and communication technology, those employees could work from home, airplanes, cars, hotels or customer offices.' 'the intertwining of real space and cyberspace creates huge opportunities for workplace agility' (Joroff M, et al 2001).

Because companies are facing change every day in the modern consumer environment a system is needed which will embrace that change and help to make the company effective at handling that change. If change is not managed, anticipated and used to best advantage, chaos and disorder can follow. This is where a company becomes unable to deal with marketplace change and incurs cost trying to match the customers changing demands. Eventually this company will be overtaken by all its competitors who are better able to manage the changes in the workplace created by customizing and developing new products to meet the market needs. Agility is defined in one paper as 'the ability to create change proactively (at the micro level) and reactively (at the system level).' (Joroff M, et al 2001).

Agility is not a license for chaos or randomness but a tool to become proactive and foster continuous improvement, the benefits of which are passed on to the customer. This is why the ASF has been developed, to promote organization of the change needed to meet customer demand. It aims to take out the randomness found in many companies trying to meet customer demands and helps to put in place procedures and tools which manage the process of change and uncertainty. It promotes a forward looking environment where uncertainty is met with plans to create certainty and solid outputs. This is also why companies need framework type implementations to bring structure and order to a changeable environment. It enables an approach based on information.

The ASF also aims to show that there is no ideal state for all organizations; this state must fit with the situation of the company, customers, marketplace and the area in which they operate. This is an important feature of a framework for implementation, it must not be a one size fits all, rather should tailor solutions to the situation.

'Workplace making for agility happens when people are willing to challenge assumptions about work, employees, workplaces and the ideal state of organizations' (Joroff M, et al 2001).

This illustrates that there is no lasting ideal for an organization, the ideal must be modified with the customer and market demands. If the changes are managed properly and the opportunities are embraced with agile strategies and practices within the work place then change can be exciting not daunting. It is often the case that companies with a long history and stable customer market suddenly find themselves having to make big changes and restructures to compete in the 'new' marketplace. But is the marketplace so new? Or has the market been changing incrementally over a period of time and not been noticed, predicted, or driven by that particular company. This sort of large change is more difficult and comes of necessity rather than comes of a structured approach to managing the workplace. Implementing agile practices and procedures, however it is done, can sometimes involve major changes in the workplace. These need to be carefully thought out, so as to leave the company in a position of strength, which it can build on and manage its destiny and growth for the future in a more structured manor.

One supporting statement for the argument of the management of change and agility to create workplace stability is quoted as 'This kind of workplace making has no fixed goals but is a continuous process that encourages design, management and maintenance activities directed towards creating stability *and* flexibility' (Joroff M, et al 2001). This is done through involvement of the workforce and stakeholders of the workplace. In the same paper the author suggests four characteristics for 'making' a workplace. The fourth stage is 'participants are collaboratively engaged. The process facilitates the participation of all stakeholders in workplace making, drawing upon them for the expertise they can contribute to that process, and maximizing the benefits that they can achieve from participation' (Joroff M, et al 2001). This creates the difference between change with stability and change disorder; there must be a clear communication of intention to the workforce to allow involvement, participation and correct decisions to be made where it counts.

The author states that agility is never fully 'achieved', companies may perform in an agile manner, but agility by its very nature must be fluid. This view is supported by Joroff M, et al 2001, and runs in contradiction to other published material. Companies may, and often do, rest on their laurels if they have achieved something. This leads to the achievement being quickly enveloped in other inefficiencies, returning back to how it was before or being overtaken by some other idea, technology or product / process. Companies develop agility and maintain a level of agility depending on the management of that agility in deliveries of a good to the marketplace. This means that companies can no longer say, "I am agile, I have completed my journey to agility." They may instead say "I am agile. I have completed my journey to agility capabilities for the market I am in now, and I am now maintaining and managing these capabilities".

From all the discussion above around the topic of agility and its implementation it shows there is a necessity for an aid to agility implementation and acquiring the most effective set of capabilities. The ASF is developed as a tool to help asses, review, measure, implement, monitor and re-measure a company's journey of agility. There are other tools available to help do this to some extent, but the ASF seems to be the most comprehensive, meeting criteria set out in several discussion papers on the topic and providing additional functionality and support. The next section will look at published material for what such a tools provide and why, and see how this is relevant to ASF development. This will also include some information on performance measurement and best practice tools used to measure other areas of performance in businesses.

Models of Implementation and Improvement

There are many sets of criteria set out in literature for what an agility implementation framework should do for a company. These range from very specific to the very broad and have been considered in comparison to the ASF. The issues raised in the literature review are those which have been discovered during research into the subject of agility, the research into the implementation of agility or looking at developing some sort of framework for implementation. This gives a broad view of requirements necessary to build a framework which is useful in many industry sectors. It is agreed by all literature read that a framework for implementation should be general, and create specific plans for a company, not a one fits all output. This is agreed within the development of the ASF which aims to produce a solution individual to a company's need and situation, dependant on product, process, and people among other factors.

Frameworks are examined in the context of developing the paradigms into a framework for implementation. The frameworks therefore serve two purposes, one to compare with the existing bottom up approach for tool implementation and secondly for strategy implementation.

An example of the difference in opinions that arise when looking at the needs of a framework is given below:

Wootton and Horne for example offer a nine point sequence to formulate an improvement strategy. These steps are:

'1. Analysis of the external changes in Technology, Economy, Markets, Politics, Law, Environment and Society and identification of the related problems and opportunities.

2. Internal audit for the declaration of weaknesses in company's attributes, e.g. market reputation, market agility, management, monitoring, manpower, machines, materials etc.

3. Summary of the external appraisal and internal audit.

4. Identification of prospects in the absence of changes.

5. Determination of objectives.

6. Gap analysis.

7. Creation of alternative improvement options.

8. Check of determined alternatives.

9. Formation of the implementation strategy.' (Wooton s, and Horne T, 2001)

Where as Bessent et al (2000) offer a four point model of agile capabilities which a framework or model must consider:

'1. Agile strategy – involving the process for understanding the firms situation within its sector, committing to agile strategy, aligning it to a fast moving market and communicating and deploying it effectively.

2. Agile processes – the provision of actual facilities and processes to allow agile functioning of the organisation.

3. Agile linkages – intensively working with and learning from others outside the company, especially customers and suppliers.

4. Agile people – developing a flexible and multi-skilled workforce, creating a culture that allows initiative, creativity and supportiveness to thrive throughout the organisation.' (Brown S, Bessent J, 2003).

The first example from Wootten and Horne is from a framework which is used to asses companies needs and provides solutions to suggest improvements to the company, i.e. to make it more agile by installing the correct strategies. This framework however has no quantitative or qualitative measurements. It is based entirely on questions which allow the user to get a 'feel' for the company and where it is in relation to the market and its competitors. It could be argued that the ASF has only questions, but, it does quantify this data and place varying degrees of importance on to allowing an analysis of the most important factors to the company through the turbulence effect analysis. The TRIZ framework also does not have quantitative information output, rather relies on the qualitative output from large numbers of case studies and experience.

Bessent et al do not suggest a method for the four points outlined in their paper. There is merely a suggestion at the back of the paper under the title of 'conclusions and future research' that there is a need to develop 'measurement / positioning frameworks to help strategic decision makers to identify the particular configuration necessary for their sector or product / market;' (Brown S, Bessent J, 2003). They also state earlier in the paper reasons for formulating a manufacturing strategy. It is claimed that a manufacturing strategy is necessary for a company to achieve agility. This highlights the need for any framework used to help develop a strategy for the company. The paper also sates however that having a strategy alone is not enough for a company to become agile, this is true and is why the ASF development has also focused on tools and techniques to be implemented at shop floor level to aid companies capabilities in operations. Operational capabilities must be used to drive through strategy into action.

This is a key piece of evidence for the need to develop a strategy tool for agility. The author also agrees that having a strategy alone is not enough to achieve agility. However the author is suggesting a top down (strategy development) and bottom up approach (manufacturing tools) which translates strategy into action thereby satisfying the need for operational capabilities.

'We are not suggesting the presence of a manufacturing strategy is an instant panacea in pursuing mass customisation. What has already begun to emerge with these plants is manufacturing strategy is a necessary, though not sufficient, condition to achieving agility.' (Brown S, Bessent J, 2003). Manufacturing and corporate or business strategies have an important part to play and are covered later in the project. The examination of these is key to the implementation of agility within companies as opposed to the optimisation of capabilities, which is what the BEA tool as developed so far.

Another researcher offers more reasons for frameworks to exist. It is pointed out that companies also need to study the markets and environments in which they operate as this can help generate a strategy and plan of tools for implementation. It also mentions the kind of tools and techniques being used to aid companies. It states that there should be consideration of best practice tools which will enable companies to install systems recognised as working, adaptable and structured.

'A methodology to assist manufacturing companies to enhance agility is needed.' 'Studying and establishing relationships between the concept of agile manufacturing and manufacturing best practices will provide the ground for a practical approach to achieving agile manufacturing.' (Sharifi H, Zhang Z, 2000). The paper goes on to state reasoning for a model developed by the authors 'model is developed to study the circumstances in which a company struggles for success.' (Sharifi H, Zhang Z, 2000)

The ASF is developed as a methodology to assist manufacturing companies and enhance their agility. It therefore fulfils the criteria set out in the beginning of this extract. It also calls on a selection of tools which are used to implement and enhance the capabilities that have been identified as required by the first part of the ASF. This is what has been called for by the previous paper. The tools used have been researched and identified as best practice tools in the modern manufacturing plant. They are then related by a framework of relationship to capabilities of agile manufacturing. These capabilities are generic and represent the 'concept of agile manufacturing'. They are applicable across a wide variety of situations, the framework selects which are most important for the company to posses, depending on its current market situation and the type of product the company manufactures. This means that the practical application of the framework shows the link between the research done during the development of the ASF and the concept of agility and best practice tools to aid agility. The ASF effectively identifies and evaluates the market and situation in which the company operates and the types of product and process within the business. This gives a unique solution to the company's agility implementation plan, rather than a standard procedure made to fit.

The framework does however only implement the above for the current situation that the market faces and does not implement for strategic change or look where to maximise strategic advantage. The other major limitation currently is that the operator of the framework manually selects manufacturing tools to implement in the host company. This introduces an element of error, non repeatability and can rely on human experience to implement the right tools. This is where a process of automation or systemisation can be seen as improving the output reliability of the BEA.

In the paper 'A Decision Framework for Implementing Agile Manufacturing' it is suggested that there are four steps to achieving agile. These four steps are a summary of the above and give a concise definition to what needs to be achieved to implement an agile strategy. The paper states 'Priess et al defined four steps to achieve agility, Understanding the Business Environment, Recognising Enterprise Level Attributes, Obtaining Enabling Infrastructure, and implementing Business Process.'(Preiss K, Goldman SL, Nagel RN 1996).

The paper then goes on to split these into three basic questions. '1) Where they are, 2) Where they are going to, 3) What actions they are taking'.

The four steps suggested by Preiss are well covered by the ASF framework. To understand the business environment the ASF has the Business Environment Audit, utilising the ETI questionnaire. These are divided into four pillars of Intensity of competition which looks at the external factor of competitors. Dynamic customer requirements examining the way in which people re buying the product and what type of performance or features are expected of the product and how the company is dealing with this demand. Supply chain turbulence looks at both ends of the company, raw materials and components coming in and the finished item going out, changes and turbulence in this area are assessed by looking at changes taking place, and future trends and how these will impact on the company. The fourth and final pillar looks at STEEP factors, Social, Technological, Environmental, Economic and Political. Each of the four pillars is gives a numerical output for each section which aids in prioritising areas for examination. This covers the first two sections of Preiss's requirements of a framework. The last two criterion of the Preiss framework are covered by the techniques used in identifying agile capabilities the company should have, this overlaps recognising enterprise attributes, measuring the capabilities in each area and prioritising the capabilities that need to be strengthened or implemented. Manufacturing tool or Technique implementation aids to strengthen the capabilities.

It also answers the three questions outlined above of where the company is, (business environment assessment), where they are going to, (company strategy), what actions they are taking, (implementing selected tools) in an orderly fashion to enable the business to travel to where it wants to be. The ASF at this stage however does not have a well documented strategy section; this is included in the overview but needs development.

This theory is echoed in another paper which sates 'Empirical study through benchmarking (including some form of statistical and empirical analysis) will be a valuable vehicle for the scientific development of agility. Analytical, normative models to evaluate agility may also aid theory building process.' (Sarkis J, 2001). The paper also goes on to state that measuring change and analysing this change will aid in the understanding of where a company is and where is should be going. The paper is on the subject of benchmarking of agility which has many similarities to what the ASF is looking at. The ASF tries to look at where competitors in the market place are, what the market wants and how to get there. The benchmarking tool however does not provide a vehicle or plan of how to get to the standard examined or to beat any other standard that has been marked against.

There are more explicit demands on frameworks for implementation also discussed in various papers. The papers call for similar concepts to the ones discussed, but express the demands more fully. Even though the demands are expressed more fully the research has focussed more on the generic area of framework development and concepts. The more specific areas of demand have been discarded on the whole. By expressing too fully how a framework should be developed there is a certain amount of restriction placed upon a tool that a company or researcher is willing to consider. By keeping the demands to a generic level a flexible framework can be developed. This provides companies with a tool for application in situation specific environments and allows a more tailored solution to the problems being faced by the company in moving forward with agility. It means that the solutions provided in the framework are of value to more businesses in a wider range of applications. It also allows for the possibility of using parts of the framework, or the framework methodology, in developing agility implementation models for completely different markets. Service sectors for example, retail markets, banks, and other non manufacturing related areas. These will require more research but the frameworks that have been proven to be of benefit in manufacturing environments may well prove useful as a basis for providing other frameworks.

Two more explicit framework requirements are quoted below:

'They are looking for methods and tools to help configure their processes in order to respond effectively to unanticipated change.' 'A methodology for configuring agile business processes is needed to assist the enterprise in its pursuit to engineer agility.' 'The four dimensions are: Co-operating to enhance competitiveness, enriching the customer, mastering change and uncertainty, and leveraging the impact of people and information.' (Meade L, Rogers K 1997).

'It is postulated that any agility metric should:

1. Focus on specific divisions of agility types from which overall agility measures will be derived. The observable parameters for each measure should be specified together with the derivation methodology.
2. Allow agility comparisons among different installations.

3. Provide a situation specific measurement by taking into account the particular characteristics of the system / enterprise.
4. Incorporate relevant accumulated human knowledge / expertise.

In view of the above statements, the agility metric will be:

1. Direct: it focuses on the derivable operational characteristics that effect agility (direct measurement) such as changeover time, number of manufacturing routes, product variety, versatility, change in quality...etc. And not on the effects of agility (indirect measurements) such as increased assets or profits, short delivery times etc.
2. Adaptive: it provides context specific measurements but without changing its structural characteristics every time. The measure will adapt to different manufacturing systems /enterprises and allow agility comparisons among them.
3. Knowledge based: it is based on the expert knowledge accumulated from the operation of the system under examination, or on similar systems. The measure is capable of handling both numerical and linguistic data, resulting in precise / crisp (agility = .85) and or qualitative (e.g. high agility) measurements.' (Tsourveloudis N et al, 1999).

The first definition given here has four main points that should be satisfied. These are covered in the ASF in several sections and hence satisfy the demand for a method to configure processes for unpredicted demand. Co-operating to enhance competitiveness is covered in one of the sub sections of the ETI questionnaire. Enriching the customer is covered in the section about product performance where the product is examined for performance in the marketplace. Mastering change and uncertainty and the leveraging of people and information are covered by the tools used to help implement agility. These form part of the basis of becoming agile and tools used fall under the Best Practice category. They help to promote information exchange, aim to train people to high standards in their job, multi-skill to allow continuity and motivate the workforce.

The second long extract quoted, has many comparisons to the ASF, and it is believed that the ASF satisfies the demands that this raises. The statement reads that any agility metric should focus on divisions of agility from which overall agility can be drawn. This is done in two parts in the ASF. Firstly the ETI analysis focuses on four distinct pillars when using the questionnaire and prioritisation techniques. It allows examination of distinct parts of the business where agility can come from or be generated. This aids in focus of analysis and later on tools and measures to implement and check progress. Secondly the agile capability indicators (which all have their own measures) also are split into distinct sections of Product, Process, People, Operational and Organisational. This allows focus of measures where required and also gives several layers of agility which aims at making an agile organisation rather than part of an organisation agile. It also means measures specific to the individual areas have been developed meaning a better focus of progress and ability is gleaned from the information provided. This is numerical data, also which satisfies part three in the second half of the quote, showing the system deals with linguistic data (from questionnaires) and numerical data (from some of the measurements).

The ASF also allows for comparisons amongst different instances from the numerical and verbal data gathered, and the measures that are applied to any capabilities deemed to be important for the company. Measures for the whole company or specific capabilities can be compared directly with each other. The last two parts of the first section are satisfied by the nature of the frameworks development. The framework is designed to analyse the situation the company is facing and the type of product, market etc they choose to operate in. Therefore the solutions offered are directly related to this information which has been gathered and processed accordingly. Relevant human knowledge is incorporated throughout the whole system when the operator of the framework is asked to make choice. There are guide lines for tool implementation but the operator must have experience of these or will be unable to offer a level of expertise the company are looking for. There are also choices to make in the framework developed for tools selection, where a number of tools may be offered up for use but, the most appropriate for the company must be selected from a list of three or four offered. It should be possible to develop a more robust system for tool selection which can automate this process. The author proposes that this should be an area of research for this project.

In the second part of the quotation the authors call for direct and adaptive tools. These are found in the ASF as it looks to find the direct capabilities required by the company, then fit tools and measures tailored to these capabilities. The framework is also generic, meaning it is adaptive to many manufacturing industries; it can be applied to many situations and still produce results that generate agility within an organisation.

Now that the reasons behind an agility implementation tool have been explored some performance measurement techniques will be briefly examined. This will look at how performance is judged and what generic factors affect the way performance is related to measurement. It is important to understand how measurement works and how it is applied to different situations. As the saying goes 'you can not improve what you don't or can not measure'.

From the book The Basics of Performance Measurement, there are several key steps identified to how performance is measured and how it can assist:

'Companies are discovering that performance measures can help any organisation:

Determine where they are – that is establish an initial baseline, "as is" performance level.

Establish goals based in their current performance.

Determine the gap or delta between a set of desired goals and current performance levels.

Track progress in achieving desired performance goals.

Compare and benchmark their competitors' performance levels with their own.

Control performance levels within predetermined boundaries.

Identify problem areas and possible problem causes.

Better plan for the future.' (Harbour J, 1997)

This step by step methodology to measuring performance seems to fit in with many of the papers reviewed on what the requirements for performance measurement should be. It starts with finding out where we are right now. This is echoed in many of the papers previously reviewed; see reference (Brown S, Bessant J, 2003) 'the process for understanding the firms situation within its sector'. This means that the current situation within the market is the base line to work from. It is where the company is right now and represents a start point for the framework. It has already been established that is happens within the ASF when examining requirements for an implementation tool.

Next comes establishing goals. This too happens in the ASF, looking at which capabilities are the weakest, which are non existent and which need implementing. The agile capabilities tool selects capabilities to be improved or implemented to better the company's performance against turbulence. These are measured using the appropriate metrics to show where the capability is now. Goals are set to improve these capabilities and outlined in the final report to the company. The gap analysis section is also completed within the ASF framework when the bar or radar chart of the current situation is plotted. This is an option within the ASF, which can be utilised to graphically display the results of an audit. The desired level of capability can be added on to this chart allowing a very visual display of where the company wants to be. This may be best in class, or better than the certain competition or somewhere in between for strategic reasons. Whatever the target may be a graphical representation is very easy to understand, and can be seen very quickly. Gap analysis is also mentioned in a paper entitled 'Agile manufacturing in Practice – Application of a Methodology' see reference (Zhang Z, Sharifi H, 2001).

Comparing and benchmarking competitors' performance against that of the company is something that is done right at the beginning of the ASF framework. It is looked at on several occasions within the ETI questionnaire and helps to provide a view of where the company is in relation to the market leaders and market average. It is hard to gather information on where competitors are without examining the internal processes of a company so these are based on best available information. However they are of some use because they work from perceptions in the marketplace, these perceptions are mostly generated by performance. Therefore these are not entirely accurate but give a good general view of the state of play. These perceived performances may also be plotted in the same way as the other measure previously talked about onto a radar chart.

Controlling performance is done within the ASF framework during the implementation of tools. Pre defined boundaries will be set along with clear objectives and goals. While the tool is being implemented there will be monitoring of its progress and performance should stay within the defined boundaries. This also helps with the next stage, identifying problems and causes. If a tool is being properly implemented the problems should be identified during measurements. Also common problems are listed with each tool in the best practice folder allowing some pre-emptive measures against the most common down falls. This also does however rely on some operator experience of the tools and therefore some work may be required on the ASF to assist in looking at areas where it is known for tools to have possible negative effects.

Finding a better plan for the future is one of the objectives which runs through all the papers evaluated in this project and is the main aim of the ASF framework. This means devising a plan / strategy to help provide the company with the necessary tools to cope with market demands in the future. The quote below highlights the opinion of the work evaluated in finding a better plan for the future, and implementing it. After all, it is moving forward to meat new challenges and demands head on that keeps businesses in business.
'positioning frameworks are necessary to help strategic decision makers to identify the particular configuration necessary for their sector' (Bessant J 2003).

The ASF will select only key capabilities and variables to target during an improvement project. This may seem strange but the reasons behind this are that only certain capabilities are necessary for a particular market, providing other features may make no difference to the companies position or the service / product it can offer its customers. The book 'The Basics of Performance Measurement' agrees with this viewpoint 'Companies must attempt to optimise a key set of performance variables' (Harbour J, 1997).

Many other frameworks and measuring techniques also use selective improvement, as this section will examine further on.

The final relevant point taken from the above book is that of collecting the information to measure performance, or in this case a capability. 'When designing a performance measurement collection process, always try to "piggyback" an existing system if possible.' (Harbour J, 1997).

This is shown in the ASF system where there are several measures for each capability allowing the use of available data to measure the capability that the company posses in a particular area. It means that a new data collection system does not necessarily have to be set up to monitor progress or establish a base line. However in companies with no collection this is not the case, and there are a large amount of companies, especially SME's who do not collect and store data in an organised and useable fashion. This in itself can be a large piece of work and the ASF needs to provide some guide lines on doing this as companies may need to gather data for a period of time before work is carried out. It will also mean an element of education in why data is gathered and how it can be used.

The next tool to be examined is the balanced scorecard model; this is a widely used tool in industry and has been applied to a varied cross section of industries. It is a universal tool and can be used from many different perspectives, e.g. financial, customer, internal business processes, learning and growth, and structure and strategy. This gives the tools its balance, and it has been widely called for in industry to have a balanced measurement technique. But this is nothing new. The way in which the balanced scorecard differentiates itself is by retaining traditional financial measurements that companies have used for a long period of time and combines them with the measures of future performance drivers. It does this because 'Financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology, and innovation.' (Kaplan R, Norton D, 1996).

In this the balanced scorecard differs from the paper, On the measurement of Agility In Manufacturing Systems, where it is stated that measures will 'focus on the observable characteristics that effect agility' 'not on the effects of agility such as increased assets or profit' (Tsourveloudis N et al, 1999). Admittedly the balanced scorecard technique does not measure agility directly but it is seen as a best practice tool and has been applied to many companies successfully. Therefore there should be some consideration to the measurement of the indirect factors that are affected by agility. Making money, being profitable and growing are after all the catchall reasons why most companies are in business. If the agility implementation does not have a positive effect on the money side of the company then there will be a problem with the implementation. The time taken for this effect to be seen in the companies financial reports may be debateable, but some financial measures, as the balanced scorecard recognises, are inescapable.

The objectives and measures used in the balanced scorecard technique are derived from the company's strategy, which must be formulated before the exercise can take place. In this way it differs from the ASF method that aims to help install new strategy tailored to where the company wants to be competitive in the marketplace. The company also may already have a strategy in place, in which case it will be examined by the ASF and implementation issues will be addressed. This is a good piece of flexibility offered by the use of the ASF, it does not try to prescribe a new strategy if a good one is in place. Usually however a new, agile focus is needed in the strategy to make implementation possible and successful for the company.

When the balance scorecard is implemented it focuses on using both types of performance measures, financial and non-financial. The use of these combined performance measures helps to make the balanced scorecard different. 'Aggregate financial measures are used by senior managers as if these measures could summarize adequately the results of operations performed by their lower and mid level employees' (Kaplan R, Norton D, 1996). The book goes on to explain how the performance measures are only being used as a feedback and control system for short-term operations. This is obviously not a good method to base long-term strategy decisions on and is addressed by the balanced scorecard system. The balanced scorecard argues that financial and non financial measures must be part of the information system at all levels of the company and employees at the shop floor level must understand the financial implications of their decisions and actions. This is not emphasised so heavily within the ASF, although some of the measures of capabilities do have financial implications to them. These measures, whichever are chosen to judge capabilities from the ASF, must be displayed and discussed thoroughly with staff of all levels so as implications of actions can be understood. There should always be at least one measure with financial implications within it to ensure that staff understand that their actions have direct effects upon the profitability of the company. This is not made clear in the ASF, and is a point made very clear by the balanced scorecard. It may be worthwhile incorporating in the tools and techniques section some training explaining the importance of financial control to members of staff and having them linked to performance measures. This would give more of a balanced scorecard approach to combining measures and looking at the rounded effects of agility on the company. While the ASF excels in promoting the value creation activities, it may need to have the balance of more traditional business measure for comparison. 'While retaining, via the financial perspective, an interest in short term performance, the Balanced Scorecard clearly represents the value drivers for superior long term financial and competitive performance.' (Kaplan R, Norton D, 1996).

Similarities in the generic model shown of the balanced scorecard and the generic model of the ASF can be seen. This shows that although the two models don't entirely agree there is an element of agreement in the structure and the segmentation. It is essential that a large scale measuring tool is split into separate areas of measurement in order to gain a rounded perspective of the company, market, environment and product. The segmentation of the larger tool gives modularity to the system and allows implementation of parts which are applicable.

One similarity of the two tools is how they aim to create an alignment of strategy by training and educating staff, setting targets and looking at systems of reward. The balanced scorecard uses three distinct methods to ensure this:

'1. Communication and education programs.'
'2. Goal setting programs.'
'3. Reward system linkage.' (Kaplan R, Norton D, 1996)

The ASF aims to perform the same functions as this but does not set out quite so clear guidelines as the balanced scorecard does. The ASF uses its tools and techniques as education programmes, communication is carried out by informing all staff of what is happening and why through the training and implementation of these tools. These tools look at the measures of performance in certain areas and capabilities are identified by the framework as necessary. The tool also looks at best practices and provides targets in the form of bar chart measurements and or radar charts. The reward system linkage is part of the company examination. Often targets set may not represent good agile practice and will therefore need to be changed. This has to be examined on a case by case basis. Reward system linkage can often be an emotional area to discuss and long standing targets / bonus systems which do not reflect upon agile capabilities should be changed. However the impact on production staff should be noted and discussed.

EFQM (European Foundation for Quality Managed) is a model that is used to asses applications for the European Quality Awards. It was introduced in 1992 and is the most widely used organisational framework in Europe. It has become the basis for the majority of national and regional quality awards. It is a constantly developing and researched model and the latest version was released in 2003.

The framework in diagrammatic form looks like this:

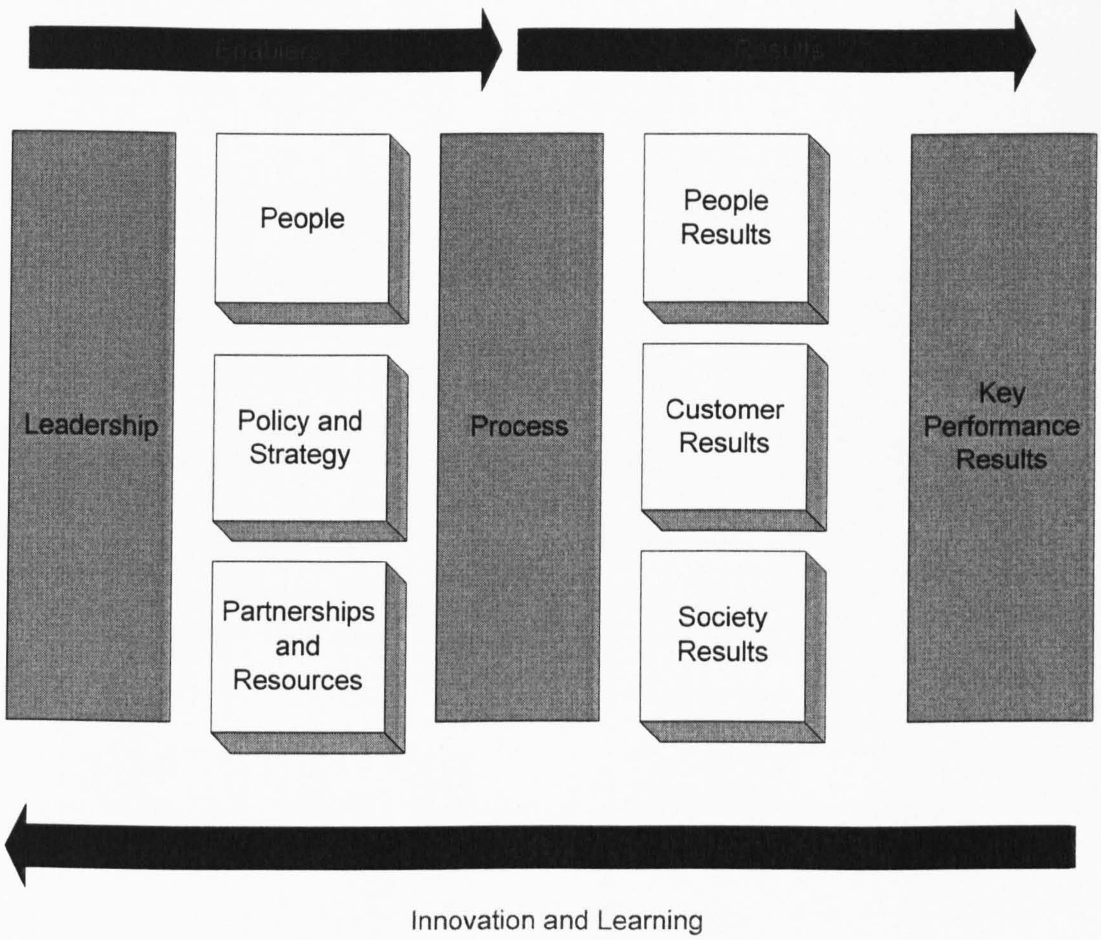


Figure 8: EFQM Diagrammatic model
(www.efqm.org)

The model demonstrated above has become not only a model for assessment but has been widely adopted as a management tool in many companies. Its main application has come in the growth area of self-assessment. Here the model will be examined for the principles of assessment and how it may be applied to an assessment system which involves information from key personnel within a business, such as the ASF framework.

The EFQM model has been assessed as a holistic model and correlation between improved organisational performance and the adoption of such methodologies has been investigated. 'The majority of such studies show a positive linkage' (EFQM Excellence Model www.efqm.org/model).

The EFQM is developed as a non-prescriptive framework which takes account of many methods of achieving organisational performance improvement. The model however has identified some fundamental concepts which are published on the website:

'Results orientation (excellence is achieving results that delight all the organisations stakeholders)
Customer focus (Excellence is creating sustainable customer value)
Leadership and constancy of purpose (Excellence is visionary and inspirational leadership, coupled with constancy of purpose)
Management by process and facts (Excellence is managing the organisation through a set of interdependent and interrelated systems, processes and involvement)
People development and involvement (Excellence is maximising the contribution of employees through their development and involvement)
Continuous learning, innovation and improvement (Excellence is challenging the status quo and effecting change by using learning to create innovation and improvement opportunities)
Partnership development (Excellence is developing and maintaining value adding partnerships)
Corporate social responsibility, (Excellence is exceeding the minimum regulatory framework in which the organisation operates and to strive to understand and respond to the expectations of their stakeholders in society)' (EFQM Excellence Model www.efqm.org/model).

The factors above are of excellence. For a company to achieve excellence using a framework or model for implementation these points should be covered or utilised within the framework. Therefore the question here is, does the ASF model fit these points or cover them somewhere within its assessment / plan formulation / implementation?

To take the points one at a time:

Results orientation: The ASF sets clear targets through capability identification and looks at how different areas and sections of the company can be 'improved' or made more agile. The measurement of this is often carried out on a bar chart or radar graph and gives a visual display of progress. This also keeps a focus on the results of the plan and allows progress and achievements to be shared with all involved in an easy visual manner.

Customer focus: is an important area in the ASF. It is aiming to provide a plan which will allow the company to provide a 'better' product / service to the customer. To do this both market and product are examined closely together and the plan forms around these two elements. The people, process, organisation and operations are geared to provide the good that the market is demanding.

Leadership: is focused on through the development of a strategy with the company and providing a clear direction of where to go. A strategy often adds a constancy of purpose by providing a universal vision for all to share and work towards. It is more often than not the business leaders who are questioned as part of the ASF process. Therefore leadership through the improvement process is captured at the start of the framework

Management by process and facts: is important because it means decisions are informed and based on the market / factory / employee needs rather than a gut feeling with no evidence to support the decision. If information is made clear then decisions are clear to those they affect or influence. The techniques involved in managing an agile production environment encourage visual management allowing all members of the workforce to have access to the information used to make decisions.

People development and involvement: people form an integral part of agile strategy formulation and are given there own section the in the capability indicators reference. This means they are covered by the routine thus preventing a pillar of the system from being missing in the ASF implementation. Agile manufacturing requires heavy people involvement throughout the manufacturing process. This allows decisions to be carried out on an informed basis and provide to customer needs. The system reflects this in the tools used; training and development of the workforce will often be required during the implementation of these tools.

Continuous learning and improvement through innovation: is encouraged in an agile environment. By examining what is happening within the company as well as externally using the ETI system of questionnaires the ASF challenges the way a company does business and looks for ways of improving the systems in place. Continual challenge will only be provided if the companies revisit some of the questionnaire sections and allow further improvements and changes to be made. This does put some onus on the companies involved with using the framework to re-visit some of the work carries out.

Partnership development: Simply by taking part in the ASF companies have formed one partnership, this is used to carry specific expertise and access to a large amount of varied knowledge. There is also a section in the ETI questions which looks at the partnerships formed by companies and measures this. Some of the tools may require partnerships with outside companies specialising in something the company have no intention of doing or does not have immediate capability to install. Examples may include transport management for deliveries and exports, specialist component manufacture, agents and joint development projects.

(Finally) corporate social responsibility: It is covered broadly in the STEEP (Social, Technology, Environmental, Economic, Political) section of the ETI questions. However I would suggest a company also has social responsibility to look after it employees and to some extent their families if the employee provides a major contribution to the family income. There are also issues of health and safety, responsibility to stay in business and stay competitive, to employ people from the local community as well as a whole host of other less tangible responsibilities. It is safe to say that the ASF encourages companies to look at legislation in the section outlined above, it should however also encourage a health and safety program more actively, or at least examine this as part of the framework. Simply by taking part in the ASF exercise it may be said that companies are trying to grow, stay in business and improve the working environment for its employees by examining the functions that are being performed within the company. Other corporate responsibility issues may need to be added to the framework to ensure that this area is covered fully. Areas such as looking at 'fair trade' options and benchmarking this against competitors / customers may be useful. One area of growth is around environmental impact through carbon emissions and the like.

Measuring agility

There are several papers published on systems for measuring agility and implementing an agile plan / strategy. They vary between detailed methodologies to simple plans; some give steps for achieving agility, and, others no help on the methodology between the stages.

The first paper to be examined here are two papers produced by Z. Zhang and H. Sharifi. The first is called, 'A Methodology for Achieving Agility in Manufacturing Organisations', the second is called, 'Agile Manufacturing in Practice, application of a methodology'. Both papers are very similar and are referring to the same model developed by the same people. Therefore the papers will be considered together as one system.

The first paper starts by identifying several factors that should be taken into account when developing a framework for implementation of an agile manufacturing strategy. The work is similar to that done at the beginning of this literature review and consists of some of the same authors. The first to be quoted is Priess et al (1996), 'has proposed four steps for achieving agility, which include understanding market forces, recognising enterprise level attributes, obtaining enabling infrastructures and implementing business practices' (Z Zhang, H Sharifi 2000).

This model does not seem to have moved past the academic format and it is suggested it should be applied to case studies or to test companies to asses the full impact of application.

The framework proposed consists of three main parts. These are Agility Drivers, Agility Capabilities and Agility Providers. 'The first is concerned with "agility drivers", which are the changes / pressures from the business environment that necessitate a company to search for new ways of running its business in order to maintain its competitive advantages. The second is concerned with "agility capabilities", which are the essential capabilities that the company needs in order to positively respond to and take advantage of the changes. The third is concerned with "agility providers" that are the means by which the so called capabilities could be obtained.' (Z Zhang, H Sharifi 2000).

These three areas relate very closely to the ASF framework in that there are direct comparisons between the two models. The 'agility drivers' are related directly to the ETI (environmental turbulence indicators), which are what is driving the push for agility and the changes that are taking part in the marketplace. This gives a set of change factors affecting the business. In the framework proposed by Zhang and Sharifi the tools that they propose to evaluate the business turbulence are based upon a set of questions which produce an output of 1 to 10. The closer the score is to ten the more turbulent and therefore the more in need of agile capabilities the company is. In the ASF system there are a series of questions for the assessment of agility needs and turbulence but they are based on slightly more complicated rules with turbulence indication taking into account the level of control, risk and opportunity that these changes are presenting. (See previous section for details on the ETI questionnaire and turbulence assessment).

There is also a second part to this section in which the assessment of current agility level takes place. This is on a scale of low to high and is difficult to be conclusive or quantitative. It also seems that this is not the most appropriate place to measure agility level, as the determination of agility needs has not yet taken place. If the model determining agility needs were carried out first, the areas requiring little or no agile practices would not need to be measured. The measurement of agility may be efficient and have a methodology which has been researched and tested, but it is not yet known if these measures are relevant to the capabilities the company should be possessing. The ASF system measures after the determination of agility capabilities by using a series of tools and associated measurements that may be applied generically to many situations. Thus the right area is targeted, the measures show current level and future improvement and the system can be used as a feedback loop.

The second section that relates to the "agility capabilities" compares directly to the section in the ASF about the agility capabilities a company requires, the Agile Capability Indicators and its associated pillars. In the ASF this section is a list of capabilities split into the manufacturing pillars of Product, Process, People, Operation and Organisation. Under each section there is a list of the generic capabilities required by that 'pillar', these are classified as sub-sections. The ASF system has an ACS (agile capabilities selector) section looking at the areas of turbulence identified in the first part of the system, this produces a list of capabilities that suit the turbulent factors. In the Zhang and Sharifi paper the capabilities are determined by using a network model in which the turbulent factors are classified into inputs and the agility capabilities are the outputs. The network connections are established by a series of industrial questionnaires and surveys. There are also lateral connections between the capabilities that shows how they affect each other. This is not present in the ASF and seems a useful piece of functionality as it compares cross impacts and highlights other capabilities which could possibly be negatively effected during the implementation stages.

The third area of the Zhang and Sharifi model is the area of agility providers. This is a list of best practices, tools and techniques, which are referred to as agility providers, and as the name suggests provide agility for a company. They are identified through an empirical questionnaire system of case studies and statistical analysis of technique implementation and success. The relationship between capabilities and the providers is shown in an extension of the network diagram and shows the links of the capabilities to the tools and techniques identified as providers. The connection is weighted in the network diagram to show the importance of the connection in enhancing the agile capability.

The ASF framework had no formal link to the tools and techniques that it calls best practice. This may be an area which need development work carried out to ensure a positive and purposeful link from one to the other. It should also ensure repeatability of results and help provide some ranking to the effectiveness of a tool.

Another paper recently published looks at the technique of benchmarking and how it may be transferred to the agility environment. This seams a logical step when benefits have been seen in other areas from benchmarking activities, then why not apply the technique to agility.

The paper first deals with the fear of 'system wide' bench marking of agility. It states that there are a number of levels at which benchmarking can take place:

'Internal benchmarking – benchmarking against internal operations or standards, usually in a multi-division or multinational enterprise.

Industry (or competitive) benchmarking – benchmarking against other companies in the same industry, whether they are direct comparisons or not

Process (or generic) benchmarking – benchmarking generic processes (e.g. order receipt and dispatch processes) against best operations or leaders in any industry.' (Sarkis J, 2001)

'Pozos (1995) presents another category strategic benchmarking, which is defined as:

'Proactive analysis of emerging trends, options in markets, processes, technology and distribution that could effect strategic direction and deployment.'

This shows that there is a research body looking into strategic benchmarking and methodologies or proposed methodologies that exist. The paper goes on to look at the possible metrics that might be examined when the subject of agility is being benchmarked and the possible resources that would be required to undertake this exercise. The paper states 'benchmarking at the organisational and enterprise (extended enterprise) level would be similar to traditional competitive organisational benchmarking, but with special tools and metrics being made available' (Pozos 1995). The problem of agility measurement is described further on in the paper 'with the lack of a discrete discriminator for agility, benchmarking may take on the role of a characterisation and definition tool' (Pozos 1995).

There are several capabilities that could be measured but none are actually suggested in the paper. It is stated in (Sarkis) the paper that the agility forum are 'collecting metrics and building a database of best practices' (Sarkis J, 2001). This could be used to measure organisational agility and would also be useful as a comparison model to the capabilities and best practices set out in the ASF work.
It is apparent from the material studied that this approach has a lot of scope however there appears to be long way to go before a useable system is developed. It may well be another area of research to develop alongside the ASF system to see if the two methods can benefit each other.

The next paper to be reviewed here is a paper by Y Sun and Z Zhang from the Exeter Centre for manufacturing and Enterprise Competitive (XMEC), University of Exeter.

The paper starts off with a definition of what companies need to do in order to achieve agility. 'In order to achieve agility, a company needs to answer three basic questions: (1) where they are, (2) where they are going to, and (3) what actions they are taking.' (Sun Y, Zhang Z, 2006). From the work examined in the previous pages it is apparent that all frameworks try and fulfil these basic criteria and give the company in question some direction to work towards. This is also true of the ASF framework and the others examined in the course of this project.

This paper again looks at splitting the framework into three sections entitled "Agility Drivers", "Agility Capabilities" and "Agility Providers". These are explained in the same manner as before and relate to the ASF in the same manner also.

These are represented in the same diagrammatic format as well:

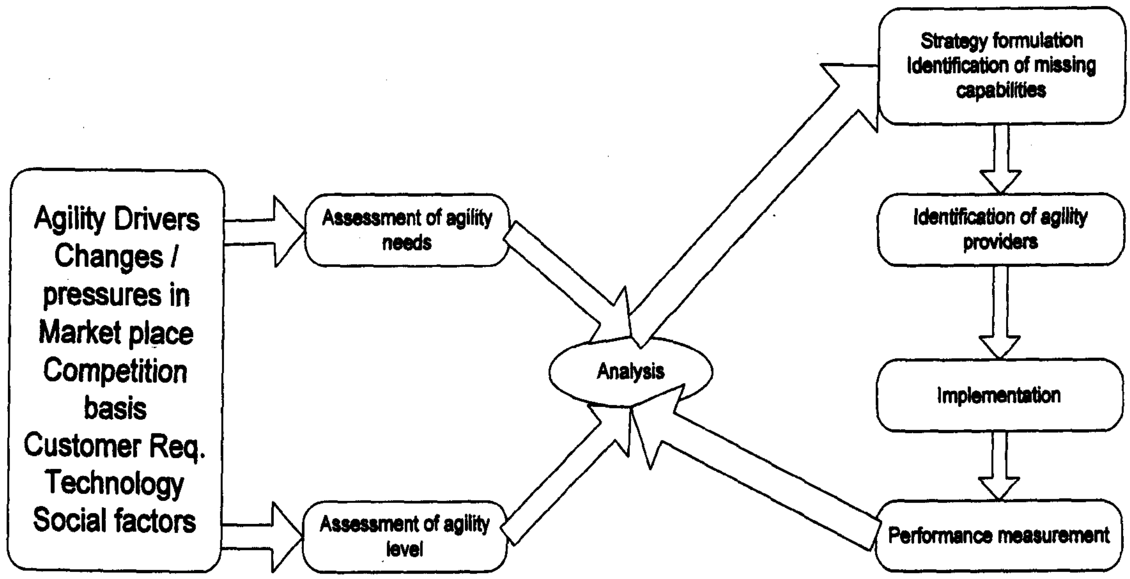


Figure 8: Decision framework for manufacturing (Sun Y, Zhang Z, 2006)

The system has been tested in a number of companies at this point and some modifications have been made to the way in which it performs its functions. It has been found that although the system was reasonably comprehensive it suffers from subjectivity and is qualitative. The paper therefore suggests some degree of benchmarking to look at the inherent capabilities the company has (agility capabilities) and compare these with how well they are being used (agility performance). There is a also a strategy formulation section added here consisting of three new tools to aid the section, 'Agility Assessment Model (AAM), Decision Support Simulation Model (DSSM), Best Practices Provider (BPP)'. (Sun Y, Zhang Z, 2006).

The AAM is used to evaluate manufacturing organisations agility in terms of agility drivers, agility capability and agility performance. The purpose of the DSSM is to provide a benchmark mechanism based on AAM to facilitate best practice detection and agile strategy formulation, where as the purpose of the BPP is to relate best practices for agility improvement to agility capabilities'. (Sun Y, Zhang Z, 2006).

The similarities to the ASF are numerous here, the AAM can relate directly to the ETI questions which asses and quantify the turbulence in the environment. The DSSM helps to identify best practice and the capability scoring ratings, the agility capabilities selector tool in the ASF does this, and the capabilities are measured by a number of metrics and compared to tools in the best practice folder. The BPP relates directly to the tools and techniques in the Best Practices section of the ASF, where industry best practice tools are listed and described for implementation to aid in improving capabilities.

Further, the paper carries on to explain the Agility Capability Index that has been developed to asses a company's five areas, Product, People, Process, Organisation and Operation. These are the categories the Agility Capabilities Indicators are classified into in the ASF tool. They too have measurements attached to each one to allow an assessment of the company's ability to perform this capability. It gives a quantitative measure of performance that can be improved by implementing certain tools if necessary. It also gives an area that can be monitored throughout the implementation procedure to achieve the desired result.

The two different frameworks are extremely similar and both seem to be moving towards performing the same tasks in a slightly different manner. The similarity can be seen as beneficial in validating the methodology behind the frameworks; however both have their limitations and areas for further development.

The next paper examined does not propose a working system of agility assessment and implementation, merely a suggested format in which that should operate and how it may be developed. The paper is entitled, 'On The Measurement of Agility In Manufacturing Systems' (Tsourveloudis et al 1999) the proposed is as follows:

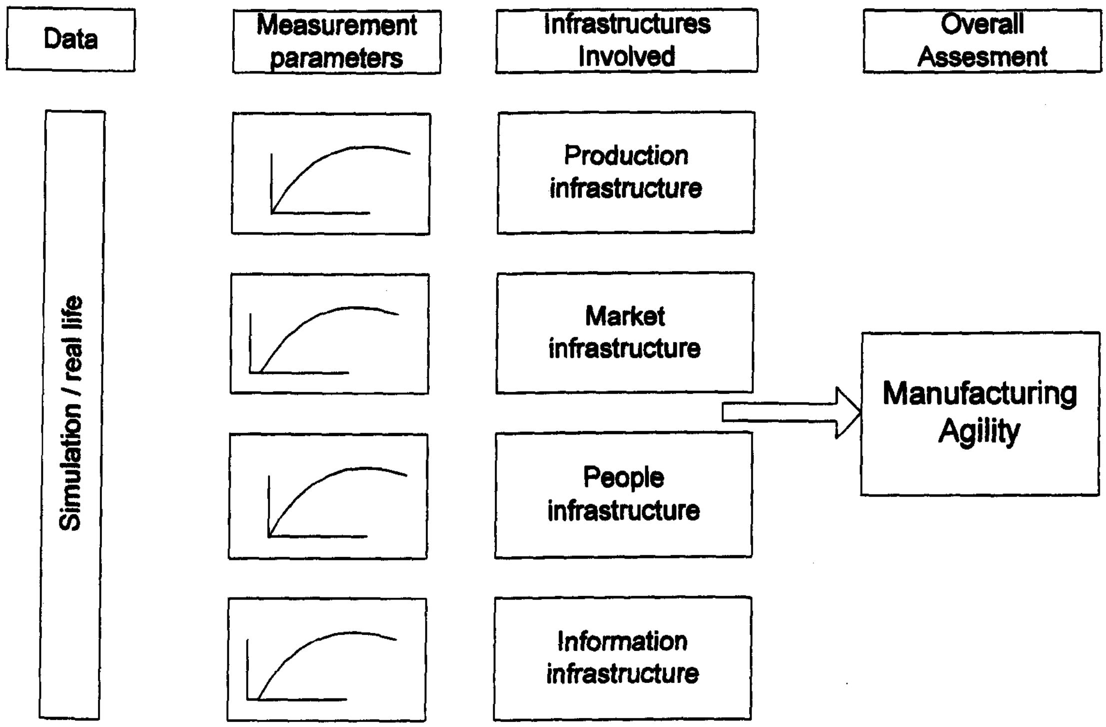


Figure 10: Measurement of agility (Tsourveloudis et al 1999)

The paper is based on a fuzzy logic approach which means that there are measurements and assumptions made by the user to give an overall result.

The example provided in the paper is as follows:

'IF the agility of *production* infrastructure is *low*
AND the agility of *Market* infrastructure is *Average*
AND the agility of *People* infrastructure is *Average*
AND the agility of *Information* infrastructure is *Average*

THEN the overall *Manufacturing* agility is about *low*' (Tsourveloudis et al 1999).

This linguistic set of variables is represented by a set of numerical functions which can be placed into a computer program which will output some information on the average value of the manufacturing agility. This provides a fuzzy logic approach to measurement. It has advantages of user customisation but provides no future direction for the company as suggested is the need for frameworks to do. A company will know form this model, by using expertise in the field of agile manufacturing, if it is High Medium or Low in the area of manufacturing agility. This is assumed to be industry average and will vary upon the 'expert' opinion and experience in that market / industry, but it will not know how it should improve, what the criteria are for it to excel in its chosen market, and will have no strategy formulation taking place.

It is suggested that this paper is of more academic interest than of interest to companies wishing to progress down the route of agile manufacturing. It provides them no help in becoming agile and offers little or no explanation of the results that it outputs to the company. An action plan or series of useful manufacturing tools is not provided.

The next paper to be examined for framework and implementation techniques is one on the subject of lean implementation. This is examined as it is often said that lean is the foundation for building an agile system. It ca also be looked at as a manufacturing strategy and requires its own tools and techniques to fulfil the goals set by the organisation. The paper is entitled 'Framework for a lean manufacturing planning system' (Mejabi O, 2003).

The first part of the paper examines what lean manufacturing is and where it has evolved from. It then goes on to introduce the framework for lean manufacturing planning.

'The lean manufacturing planning framework is based on a seven step process starting with an assessment and data collection for measuring performance levels of lean manufacturing metric. The framework then estimates the cost of waste through an analysis of the quantifiable metrics for developing a lean scorecard. In order to improve performance through implementation of lean manufacturing, planners can select from among the standard lean manufacturing strategies and establish an implementation timeline over a five year period. Implementation budgets are then established based on the particular lean initiatives to be implemented either on a basic or comprehensive level. In addition, expected improvements for the lean metrics are estimated based on the scale of the planned lean implementation. Finally, a financial analysis is used to correlate the cost of waste, cost of lean, and lean savings, into a cash flow and Return on Investment (ROI) summary for justifying the cost of the lean manufacturing implementation.'(Mejabi O, 2003).

The ASF is can also be summarised into a seven step approach to strategy formulation and evaluation and also starts with a data collection and assessment activity. This is true with most frameworks as there must be some information to work with and allow decisions and plans to be made and formulated. The seven stages of the ASF are summarised as follows:

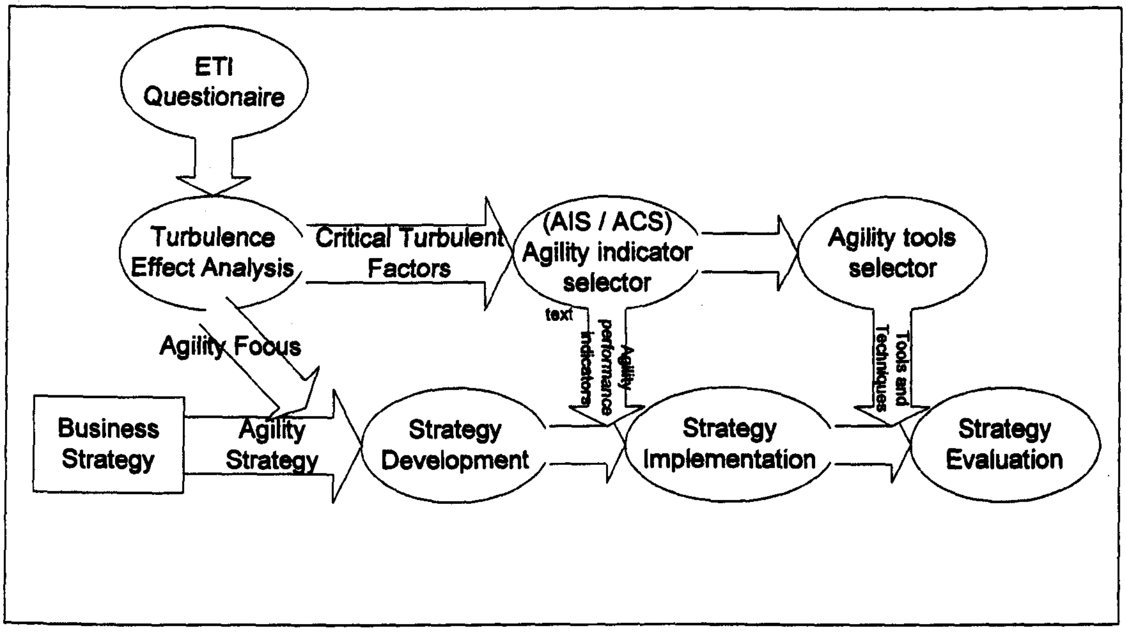


Figure 11: Summary of ASF process (Hetherington 2006)

There are of course other inputs and outputs that should fit around this diagram and the full diagram can be seen in the ASF explanation section of the project.

The frameworks then start to take a slightly different route from each other by examining different aspects of the workplace; one focusing on lean metrics and the other agile metrics. This is to be expected, but in principle the frameworks are evaluating what is to be improved upon, one is measuring waste while the other is measuring the effect of environmental turbulence. Both of the factors are then examined for the critical area generating the most problems and offering large scope for improvement in the company's performance.

The next part of the framework is also similar in the way that tools or strategies are selected to aid with the improvement of the company performance in certain areas. After this however the frameworks start to look at different aspects. The lean tool concentrates on financial measurements of the waste saved, process improvement times and the like. The agile framework uses slightly different measures focusing on agile indicators. The lean framework is good in that often managers are often interested in the bottom line implications of performing some improvement activities throughout the company. This is can be attention grabbing and will motivate them to seriously consider the proposal being put forward.

The ASF does not focus on financial measures instead concentrates upon measures developed to look at agility within the areas of process, people, product, operation and organisation. This may be of interest to manufacturing engineers, the operator of the ASF and some other people involved in the project, but there must always be financial implications in business. This means the company must save, or make extra, because of the techniques being implemented. This may be easy to see in a company trying to mass customize its products and incurring massive costs in doing so. An agile plan that is successful will reduce the cost of doing business to compare with that of a company mass producing a single item. This may be hard to quantify however due to the nature of the hidden inefficiencies and maybe some capital outlay to reorganise components and product families into an easier to manage system. An estimate will always be wrong and in this case it must be wrong in the right direction to some degree, without making the implementation seem pointless.

In summary, financial measurement is a very useful tool and the ASF may benefit from some financial performance indication, but this must be done carefully and can never be taken in isolation.

Within the framework methodology there are similarities between the two systems. The lean paper has identified 17 lean manufacturing metrics and has classified them into four categories of Process Flow, Quality, Financial Measures and Productivity. The metrics all have a unit of measure similar to that of the agile performance indicators, and these are collected together to form a scorecard. The scores of these indicators are plotted on a radar chart, as are those in the ASF framework. Any improved measure can then be shown on a new chart throughout the implementation project as both a monitoring and motivating tool.

Strategy

What is strategy? What does it mean in terms of business and corporations? Who does strategy? How do they do it? These are some of the questions that will be examined in this literature review on the subject of business strategy. This will provide background to the world of strategy and outline how manufacturing strategy can fit into the larger subject of corporate and business strategy. Manufacturing strategy is covered in more detail later where material and literature are examined which relate specifically to this subject.

Strategy is covered in the literature review as the author suggests that strategy is integral to the implementation of agility. Agility is in fact a strategy in itself which translates into operation actions. Agility can be positioned with many traditional strategies and this is examined in this literature review. Companies wishing to become agile will have to make strategic decisions to enable them to utilise their manufacturing capabilities in such a way that they enable agility in the chosen market place. As covered in the previous section Sheridan in 1996 quoted "Lean is a tactic", he says. "It translates into a game plan. But agile is a strategy– you have to think about how it translates into a game plan in your industry sector". This provides justification of why strategy must be examined in alongside the operational implementation of Agility.

Strategy n. (pl – ies) 1 the art of war. 2a the art of moving troops ships aircraft etc into favourable positions (cf. TACTICS) b an instance of this or a plan formed according to it. 3 a plan of action or policy in business or politics etc (economic strategy) [from Greek strategia 'generaliship']. (Oxford English Dictionary 1996).

The definition provided above from the Oxford English dictionary provides a good starting point for the exploration of strategy. The analogy of moving troops, ships etc can be likened to organising workers, departments and equipment into favourable positions. Here favourable positions will mean that the company can achieve its objectives.

Strategy is a hard topic to define and there is little agreement in academia on a true definition for it. This was even claimed in The Economist when they printed 'Nobody really knows what strategy is' (Markides C, 2004). Here it will be examined through various texts and a definition produced which allows us to move on in a satisfactory manner to the subjects of agility, manufacturing strategy and agile strategy. This is an important stage as some clear boundaries must be set for the subject of strategy before the more specialist areas of manufacturing strategy and agility strategy can be examined in depth.

Before strategy is examined further a brief word on company objectives as mentioned in the third paragraph. Objectives mentioned here will most of the time refer to making a profit. It is taken that most companies are in business to make money, whether it be for the owners, shareholders or other. Arguments may be put forward for business objectives which are to increase market share, retain customers or lead the market in technologically innovative products, among others. These all essentially boil down to retaining and making money for the company / shareholders / stakeholders and owners. Money here can mean share price increases, asset building, dividend payouts, improved cash flow and all other recognised methods of generating income. This is a large generalisation but one which covers most businesses. A large section could be written here on business objectives, but, as this is not the aim of this project a very general approach will be taken.

What is strategy?

At the highest level strategy defines what a company is and what it does. This means that company x is known to its customers to supply product or service y. In essence strategy answers the questions; Who is company X? What is company X? What do they supply and how do they supply it?

So strategy defines how a company will meet its objectives. But this is rather vague and seems a little unsatisfactory.

Strategy is a road map or a long term view of where the company is going. It is an awareness of the conditions in the marketplace and what needs these conditions are generating. Strategy is defining what products and services a company will be known for, how these will be provided and how they will be marketed to its customers. Strategy should define the boundaries of a companies operation. Strategy is about breaking the objectives into chunks and making them more manageable by providing resources and setting out operating guidelines to be adhered to.

If a company is wishing change its target markets, products or operations, strategy should direct this. The company should collectively announce that we are now at point A, we want to be at point B, which entails offering a different product / service, operating in a different market, or operating with a different methodology. Strategy defines the resources needed move to point B and change corporate direction.

This does not mean strategy has to be about step change, it is perfectly acceptable for a strategy to say that a company or business unit will remain the same for a period of time. This is still a strategy, although some may argue not a brilliant one, it may however offer stability in areas of the company which have recently been turbulent and are now exploiting a unique position. If this is the case staying still can be beneficial, but, the companies need to be very aware of staying still for too long.

In strategic terms a period of time is often medium to long term. This often helps to avoid the blurring of operational efficiency considerations (short to medium term) and strategic considerations (medium to long). Of course strategy must be achievable by organising operations effectively and efficiently but strategy should not be limited in its scope by current operational performance (OP), OP should be developed to support the strategy and create a unique synchronisation of operations which will be advantageous to the company.

So what is written about strategy in literature?

Strategy is a widely explored subject both in academia and the business world with numerous consulting firms offering strategic services. The prose and definitions above are the work of the author and are written to help define strategy for the context of the work carried out during this research project; here views from other academics and from the business world are explored and compared to what the author has offered. It is also apparent that business and academia struggle with definitions of strategy and a succinct satisfactory manifest of strategy has not become apparent during research.

Several offered include:

'What is strategy? Strategy is the creation of a unique and valuable position;' 'Strategy is making tradeoffs in competing. The essence of strategy is choosing what not to do' (Porter M, 2004)

'A company has to decide on three main issues: who will be its targeted customers and who it will not target; what products or services it will offer it chosen customers and what it will not offer them; and how it will go about achieving all this – what activities it will perform and what activities it will not perform.' (Markides C, 2004)

In the above we can see some elements of agility in that a company must segment its market to be able to target specific areas and offer products at certain levels. We can see that if a company sets up to service a number of areas and provide a product that can be reconfigured extremely quickly to meets a variety of needs they will be planning for agile. Therefore strategy decisions about how to enter a marketplace doing this must be made.

'the raison d'etre of strategy is to ensure that the organisation "boldly goes where none have gone before".' (Brews P, 2003)

It can be seen from the first definition offered here that there is still a considerable amount of effort being put into defining strategy. This paper was written by a respected professor at Harvard Business School and published in its internationally respected Harvard Business Review. Michael Porter has published numerous books yet still felt it necessary to define strategy in a paper published recently. The paper goes on to explain that strategy has of late become confused with operational effectiveness, and this is creating a lack of competition with monotonous companies all moving toward a single point of boredom. 'Operating effectiveness means performing similar activities better than rivals perform them' 'strategic positioning means performing different activities from rivals or performing similar activities in different ways' (Porter M, 1996). The paper states that operational effectiveness is necessary to push the boundary of productivity further forward but this in itself is not a strategy. It is a way of increasing the profits from the operations performed which are working within a framework of strategy to achieve strategic objectives. 'Constant improvement in operational effectiveness is necessary to achieve superior profitability. However it is not usually sufficient.' (Porter M, 1996).

Put another way 'in a world where business is more interested in 'best practice' rather than different practice, is its any wonder that products and services, companies and organisations are all beginning to look the same?'(Kingdom M, 2002). Therefore we can deduce strategy and operational effectiveness must go hand in hand to produce a successful business, but each on their own is not enough. It is the concern of the author that performance measurement and operational effectiveness, along with many other names for the same process, are being seen as replacing strategy. For a strategy to be implemented and to be realised, performance measures or operational effectiveness must be geared to the unique position that strategy sets out. 'The success and continuity of the organization depends on its strategies and performance.' (Porter M, 1985). Performance measures must be geared uniquely as set out in strategy, otherwise using traditional methods of measurement will produce traditional results.

The use of traditional measures for agility must also be forgotten and success should be measured in a different manner. Of course financial success measures are still important, but measures on service and performance should also include areas such as new business enquires fulfilled and new products services developed.

Then second definition sits nicely with the explanation of strategy offered by the author. It states strategy defines who, what and how to target but also who, what, how, not to target; in other words boundary defining. This is a very important part of strategy and what it is. To have no boundaries means many distractions and dilution of resources. To be successful a strategy must aim an organisation at a target and steer it towards that target without moving too far off course. Without these limits a company may never become anything except a diluted mess. To break this down further Robert M. Grant makes distinction between corporate strategy and business strategy. 'corporate strategy defines the firm in terms of the industries and markets in which it competes' 'business strategy is concerned with how the firm competes within particular industry or market' (Grant R, 2005).

The third definition offered from literature states that a strategy should take a company 'where none have gone before'. There is also evidence of this in the business world wherever we look, and many famous companies are quoted as using this approach. 'Go where your competitors can not or won't (Kingdon M, 2002).

The point of differentiation is summed up nicely in traditional literature also when examined closely. Porter states that the six barriers to entry in a market are '1) economies of scale, 2) product differentiation, 3) capital requirements, 4) Cost disadvantages independent of size, 5) Access to distribution channels, 6) Government policy,'(Porter M, 1979). This certainly does throw up some formidable brick walls to prevent entry. It seems that if a company wishes to enter a market the only way here is to be different, don't offer economies of scale, offer bespoke service. Create a brand or marketing ploy to differentiate the product, find a low capital alternative and so slowly but surely remove these barriers by thinking in a non traditional way.

In one extreme, strategy takes calculated risks to bring completely new methods of doing something, 'They take risks to commercialise new products and services that meet previously unfulfilled needs. This also enhances society. Can you imagine your life without cellular phones, ATM's, DVD players, personal computers, Internet search engines...'(Morias R, 2001). In less extreme cases strategy uses existing products and services and makes them work in different ways. One recent and highly successful example of this is the low cost airline industry. Previously it would have been unheard of not to offer food and other ancillary services on a plane. Now there are some very successful players who do just that. No new equipment, just a new way on configuring an existing business model. 'He (Stelios) has increased his fortune not by inventing new products and services but rather by making old ones cheaper and, in many cases, better.' (Morias R, 2001).

The above variation in the actual actions, results and tools of strategy show why so many definitions are short and vague, typically they state something along the lines of 'top management's plan to attain outcomes consistent with the organisation's missions and goals' (Wright P, 1992).

The definitions examined give a flavour as to how hard it is to define strategy but there are some common areas of agreement. For one it has become apparent that strategy is often confused with operational effectiveness. Strategy is a complicated process and strategy must define a perspective from which the company should operate. To end the definition section, one more abridged excerpt about strategy and an attempt to define it is presented from another well known and well respected author(s) 'Strategy is a plan..., strategy is a pattern..., strategy is a position...., strategy is a perspective...., strategy is a ploy' (Mintzburg H, 1998).

To summarise, it is apparent from the many definitions and examples shown here that strategy can be many things. What is shown here is a consensus that for strategy to be successful it must be different, it must be unique in some way and must capture imagination to excite prospective customers. Strategists must be brave and come out of the protective comfort zone to create something brilliant. Playing it safe does not bring rewards; taking a great risk is stupid, there has to be some middle ground. 'At this moment, as you read these words, there is a business meeting where the most amazing idea has come to someone. It started as a crazy thought but as the meeting progresses it got stronger and stronger. But that person remains silent and the idea is lost forever' (Kingdon M, 2002)

From the previous the author would like to offer the following definition of strategy.

Strategy sets out how a company plans to make money over the next defined period of time by being distinct from its competition and forefront in the customers mind. Strategy allocates resources, provides targets and sets out clear guidelines on achieving objectives. It sets boundaries within which to operate to remove temptations from along the path, it defines what the company is, and what it is going to be in the future.

Basic Strategy Techniques and Generic Strategies:

From the definitions relating to strategy previously discussed the term 'generic strategy' at first appears to be an oxymoron. However on closer inspection generic strategies do seem to exist, albeit with some crossover areas. Generic strategies have been suggested such as Porters, 'cost leadership, differentiation and scope' (Porter M, 1980).

These were represented in table format as follows:

Competitive Scope	Competitive Advantage: Lower Cost	Competitive Advantage: Differentiation
Broad Target	1. Cost Leadership	2. Differentiation
Narrow Target	3a. Cost Focus	3b. Differentiation Focus

Figure 12: Porters generic strategies (Porter 1985)

In the diagram Porter extended scope (narrow target) to cover two areas of scope. He suggested that all companies who come into a market or become leaders in markets are utilising one of these generic strategies to leverage their position. In other words they are deploying their resources differently or performing differently from the competition but they will still fit into this model somewhere.

It is very hard to place strategies into generic models as there is always criticism of these systems. They are seen as too inflexible and prescribed to be truly innovative and create a unique position. 'The idea of a generic strategy is in itself oxymoronic' (Brews P, 2003).

In his book, Manufacturing Strategy, J. Miltenberg states that business strategy consists of three parts 'goals, product market domain, basis of competitive advantage' (Miltenberg J, 1995). The goals section states the goals to be 'Profitability, Market Position, Growth and Risk' (Miltenberg J, 1995). As covered in the previous section when defining strategy, it was shown 'competitive advantage' (Miltenberg J, 1995), or a unique position for product was the key feature of strategy. Obviously Miltenberg's book is about manufacturing strategy, but as a key supporter of corporate strategy, surely competitive advantage considerations should come from the manufacturing function too. If a corporate strategy decides on a unique position for product or a unique method of serving an existing product to a new market, manufacturing strategy needs to reflect that.

Manufacturing efficiency was touched on in the definition section, and should be a large consideration as making a brilliant product / service offering in an inefficient manner generates poor return. But offering a product / service combination developed on a corporate level when manufacturing are primarily concentrating on efficiencies does not seem to make sense. Maybe this is the focus of Agility?

Miltenberg's text gives six manufacturing outputs which he believes are key to strategy. These will be covered later in the manufacturing strategy section but are cited here as an example of generic strategies. They are 'Cost, Quality, Performance, Delivery, Flexibility and Innovativeness' (Miltenberg J, 1995). Cost, quality, flexibility, delivery and innovation are well established competitive performance priorities. (Porter, M 1985). These are touted as both generic strategies and performance measurement priorities. They are in fact both and where the blurring occurs between strategy and operational effectiveness. Strategy is not created just by measuring these outputs, by being inventive in one of these areas and measuring its performance in a new way, products and services may be able to take advantage of a new strategic position, creating competitive advantage.

Another selection of generic strategies has been suggested by Mckinsey and company. These are:

'Evolutionary / institution building – line managers drive through reshaping
Jolt and refocus – redesign management process, delayered top management
Follow the leader – sell off weak businesses remove critical bottlenecks
Multifront focus – change driven by task teams
Systematic redesign – core process redesign and task teams
Unit level mobilizing – middle management and front line employee ideas tapped into' (Courtney H, et al 1997).

Although these are touted to be strategies these seem to fall into the category of 'systems of strategy formulation', or 'Strategy Schools'. There are many strategy schools, each of which gives its own methodology for examining information to arrive at a strategy, or at least help formulate a decision on a strategy.

Although generic strategies have been suggested not a large amount of them are published due to the difficulty of classifying all strategies, especially if companies are trying to find a unique position from which to compete, into a rigid framework.

Porters five force model (competitive advantage):

Porter gave a model for competitive advantage in which he stated
'competitive strategy must grow out of a sophisticated understanding of the rules of competition that determine an industries attractiveness. The ultimate aim of competitive strategy is to cope with and, ideally, to change those rules in the firms favour. In any industry, whether it is domestic or international or produces a product or a service, the rules of competition are embedded in five competitive forces:' (Porter M, 1985).

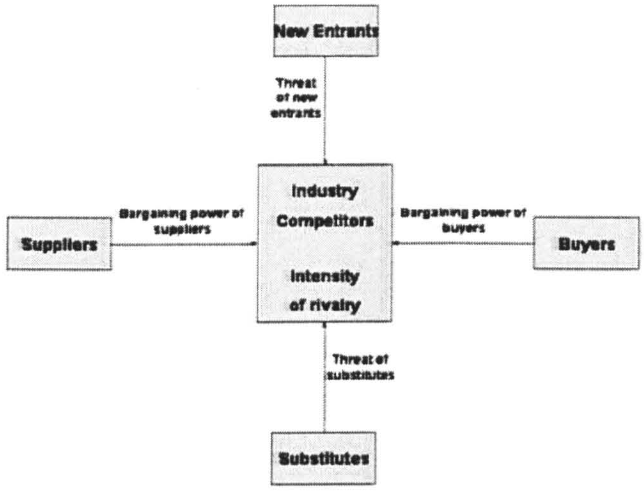


Fig 13: Porters five force model (Porter 1985)

At first this appears rather a rigid view of an industry and an opponent may say that if this model is so, then new companies who understand the five forces better than competitors are able to profit from it. However Porter goes on to state that firms can influence the forces themselves through strategy and this is where competitive advantage can come from. 'If a firm can shape structure, it can fundamentally change an industry's attractiveness for better or for worse. Many successful strategies have shifted the rules of competition in this way'. (Porter M, 1985).

There is however a caveat about altering industry structure. Existing markets can be destroyed and competitors let through the door by not considering all options fully. 'A new product design that undercuts entry barriers or increases the volatility of rivalry, for example, may undermine the long run profitability of an industry,'. (Porter M, 1985). This is similar to the concept of pushing the boundaries of productivity and OE without creating a unique stand point, as stated previously in this chapter.

Other frameworks and models which look at generic forces or models include the Ansoff Matrix and the Boston Matrix.

The Boston Matrix looks at the lifecycle of products and helps to identify where in the lifecycle products are, and therefore what they are likely to do in the future. It is a simple classification into four quadrants and looks at the market share a product is commanding and the rate of growth. The matrix was developed by the Boston consulting group in the 1970's (www.bcg.com) and is an approach for portfolio planning.

It has been said all companies should have products in all four quadrants to ensure a continuation of business as products start to decline. Many companies especially SME's will have a narrow range of products which means when a product starts moving into the Cash Cow phase, and even Dog phase there is no new product to replace the falling or potentially falling incomes. The four quadrants are described as follows:

Dogs: Do not generate cash for the company some may even absorb it. They should be removed fro the portfolio.
? (Sometimes called Problem Child): These have a low share of a high growth market and absorb money as the company tries to grow them, they have the potential to become the future Star and Cash Cow product.
Cash Cow: High share of a slow growth market and generates more cash than is invested in them, should be kept in the portfolio.
Star: These products have a high growth rate and a high market share in a growing market. Generate high amounts of income for the company.

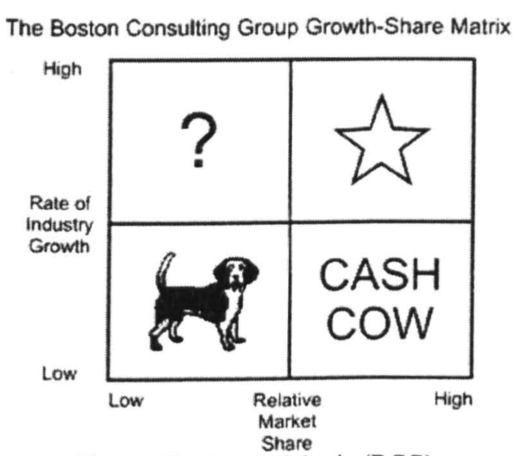


Fig 14: The Boston Matrix (BCG)

The Boston Matrix does not necessarily generate strategy or try to generalise a framework for strategy to fit into. It has been included here because it is an interesting school of thought and may be used as an idea of how or why companies might move into different markets. On the one hand companies may examine their own products and look at how they can move forward in the future. Then can see if the products they currently have in their portfolio support strategic direction for the company. Alternatively classifying competitors' products (although hard to do) is an interesting way of looking at opportunities for growth and strategic positioning into a desired quadrant.

Ansoffs matrix looks at products and markets in terms of new and existing and is traditionally a two by two matrix like the BCG matrix above. Here the diagram shown below is the extended matrix as proposed by Ismail (Ismail H, 2000).

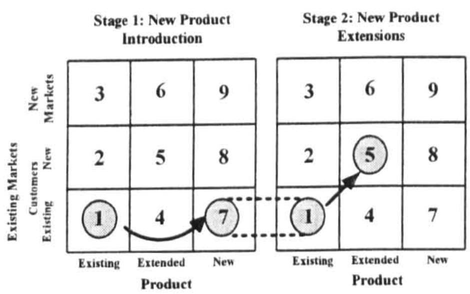


Fig 15: Extended Ansoff Matrix (Ismail 2005)

Ismail proposed that as well as being the new and existing categories on the matrix there is a third category of 'extended'. This covers products with extended features being sold to customers in the existing market. The Matrix is also further specialised by defining the markets in a more specialised way. A new product in existing markets is a separate category to the new markets section. This produced the three by three matrix represented above.

The standard matrix may not have been included here but the addition of extended sections makes the matrix more relevant to strategic decisions. If a company is moving forward and looking at new possibilities then its decisions must fall into one of these categories to give it a unique strategic advantage. If a company is in the bottom left had corner of the grid when it starts, it can choose to look at the way it sells to existing customers and come up with a new solution, therefore making its strategic advantage unique. It can also extend existing products to new customers in a different way, again creating a unique stand point. This theme continues throughout the grid and can aid companies in thinking about how to create a market offering in a unique manner.

Again this is not a tool for formulating a strategy as such, but, can be beneficial in deciding the general direction of the company before formulating the unique selling point the company will take to move in that direction. Using this in conjunction with the BCG Matrix may be interesting especially if looking at competitors with weak products; there may be ways of moving extended products into areas where they are weak and have 'Dogs' or 'Problem Children'.

Along with Matrices, systems have been developed to give principles of strategy, or rules for development of strategy. The paper 'Six Principles of Breakthrough Strategy' (Markkides C, 1999) suggests six areas to aid in developing a strategy which will be fundamentally different from competitors but also extremely successful in terms of its return for the company.

Manufacturing strategy literature review:

What is manufacturing strategy?
What role does it play in creating agility?
How does it fit with other types of strategy?
How is it formulated?
What role does it play in corporate decisions and competitive advantage?

Manufacturing strategy is a much researched topic. There is multitude of literature around the subject and many different views on what it means and what it should contain. Here we look at what the definitions of manufacturing strategy are and how these relate to each other. This section will also examine some formulation techniques for manufacturing strategy and what they mean in practice to industry applying or developing a manufacturing strategy for a company.

Manufacturing Strategy: Manufacturing strategy fits into a firm along with other 'departmental' strategies to build a portfolio of strengths and capabilities that can be called a 'corporate' strategy. All these strategies do not stand alone but are interlinked and supporting of each other and of the end customer. They link to form what we will describe as competitive advantage, that which allows the company to compete more effectively than a competitor in the marketplace. Manufacturing strategy is not often thought about in traditional strategic planning and can often end up being there simply to provide what the strategic planners want. This is done without 'strategic planning' for the manufacturing function.

The part that manufacturing strategy takes in creating agility is one of implementation of the wider business strategy. It translates the strategy of the business into something that is related to the manufacturing arena specifically. Different strategies will require different capabilities from the manufacturing operations. This is something that the current BEA does not take account of and somewhere where the framework with a top down approach will fill a gap in the current knowledge.

Miltenberg states that 'A manufacturing plan or strategy is needed to bring some structure to this complex environment' (Miltenberg J, 1995). By this complex environment Miltenberg is referring to the increasingly complex function that manufacturing is becoming in an increasingly complex market serving complex combinations of customer requirements. Miltenberg also goes on to state that 'Manufacturing strategy focuses on effectiveness first, then on efficiency; that is, strategy seeks to ensure that 1) the right things are being done, and then 2) that the right things are done well.' (Miltenberg J, 1995).

This definition is backed up by further investigation into what a manufacturing strategy constitutes. 'A major benefit of manufacturing strategy is that it provides a means of focussing the attention of corporate management on manufacturing concerns' (Skinner W, 1969). There are also arguments that manufacturing strategy should be raised up to corporate level to prevent a narrow view, which some feel has pervaded industry of recent, and prevents manufacturing reaching its performance potential. 'This article argues that manufacturing strategy can serve as a platform for improving management of manufacturing companies but that such a role requires that strategy be viewed from a broader perspective than the narrow planning which has dominated the literature.'(Keong G et al, 1995). The sentiment here is one of manufacturing taking the back foot and being a provider to the corporate wishes. There is however considerable movement towards Manufacturing providing the drive for corporate strategy and taking a much more leading role in the direction of the company. This has become much more apparent in recent publications around agile manufacturing, where the manufacturing function is seen as a driving force to providing choice and unique solutions to customers. The view that manufacturing could do this has been around for some time. Hayes and Wheelwright hinted at this type of direction in 1984 and again in 1988. 'Manufacturing can be more proactive in leading other functional areas in the contribution towards the development of corporate strategy' (Hayes RH and Wheelwright SC, 1984, 1988).

In more modern literature the view on the position of manufacturing strategy may be summed up by Brown and Bessant. They support the view that manufacturing strategy should not just take a more proactive role, but that manufacturing strategy should be a driving force behind agility and providing competitive advantage. 'In this paper we suggest that the role of manufacturing strategy is an important precursor to achieving agility, including mass customisation, because the range of capabilities needed do not come about by "good fortune",'(Brown S, Bessent J, 2003).

The theory of putting manufacturing strategy at the heart of the strategy formulation process is based upon sound principles. Often companies have formed strategy independent of capabilities of the manufacturing function. 'As a result of this, a state of strategic dissonance occurs not only between the firm and its chosen markets but also within the firm itself, in the mismatch between strategic intent and operations capabilities' (Hammel G, Prahaland C, 1989). In other words the company sets itself up to fail as the manufacturing operations are not geared towards supplying the type of market / product / customer that the strategy has set out to pursue.

Before moving to where manufacturing strategy should be positioned, a brief summary of what manufacturing strategy is:

Manufacturing strategy is a set of 'rules' which guides where the manufacturing processes will be focused. These rules help to make sure that the processes and capabilities are pulling in the same direction and that they aim to provide the right set of outputs to the marketplace. The outputs to the marketplace are decided by the corporate strategy, and, as we have seen the corporate strategy should be developed in conjunction with not only the manufacturing strategy but also other areas of the business. So manufacturing strategy helps to order what can be a complex environment and helps to provide the right product, at the right price at the right time. In agile environments the manufacturing strategy must go one step further and help the business to compete on its capabilities. These capabilities should include creating niche markets, creating solutions products and creating choice for customers with numerous options. The manufacturing strategy in an agile company should help drive the development of the company and its product offerings.

We can see from the last two paragraphs that modern manufacturing strategy is thought to be a part of corporate strategy forming. However it appears that this was not always the case and that manufacturing strategy was not thought relevant. It appears that 'traditional' strategy thought places little or no importance on manufacturing strategy and sees the manufacturing function as merely a supplier of goods to the corporate strategy whim. 'It is generally accepted that the foundations of what is now known as manufacturing strategy were developed at Harvard in the 1940's and 1950's.' (Voss C A, 1995). The development started through research highlighting the many choices of technology on offer, and then the choices of type of management and this leading to the many different ways of competing in industries.

There is also research which promotes the link of manufacturing strategy to corporate strategy by measuring macro factors. Three are suggested by Sackett et al, 'the product and market drivers, the specific manufacturing business processes, and the choice of manufacturing philosophy'. (Sacket P, et al 1997)

It is now very rare to find a researcher or case study which does not promote the benefits of encompassing manufacturing strategy at the heart of a corporate strategy process. Swamidass states that manufacturing strategy is 'the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals' (Swamidass P.M, Newell W.T, 1987). Hayes and Wheelwright propose a model describing what they call four different views or stages in development of manufacturing's' strategic role which sums up this point nicely.

'1 – Internally Neutral: the objective is to minimise the negative impact of the manufacturing function.
2 – Externally Neutral: the objective is to maintain parity with competitors, usually by following industry practice.
3 – Internally Supportive: manufacturing exists to support business strategy. Manufacturing investments are checked for consistency at the business level and the implications of business strategy changes for manufacturing are considered.
4 – Externally Supportive: Manufacturing capabilities shape business strategy in terms of the types of products developed and the ways in which markets area addressed. Manufacturing leads rather than follows and long range programs are implemented to acquire capabilities in advance of needs.' (Hayes R.H, Wheelwright S.C, 1984).

So how can companies go about the formulation of manufacturing strategy? Is there a set of rules and generic strategies and if so what are they? What elements does a manufacturing strategy need to take into account? Most importantly where does the idea of agile fit into all of this?

To start, the work of John Miltenberg, in his book, 'Manufacturing Strategy: How to formulate and implement a winning plan, is examined. Miltenberg suggests that there are four outputs that manufacturing provides to customers. These are 'Cost, Quality, Performance, Flexibility and Innovativeness'. (Mitonburg J, 1995). He also suggests that manufacturers do not supply all of these in equal measure. 'This gives the basis of competitive advantage while recognising that no single production system can provide all outputs at the highest levels. A plan or strategy for manufacturing is needed to determine precisely how the required outputs will be provided at the required levels' (Mitonburg J, 1995). This work suggests then that there is a trade off process to be made during manufacturing strategy formulation. This will also impact upon corporate strategy and therefore strengthens the argument for manufacturing strategy to be a part of the corporate strategy formulation process.

The above argument for manufacturing providing a set of core competencies or outputs that the customer requires is backed up in other research. The fact that other companies are providing these outputs does not mean that all companies are equal. It means that the manufacturing system has to provide these outputs in ways which are consistent with order winning criteria in the specified market that the company operates. 'Manufacturing must chose its process and design its infrastructures that are consistent with the existing way(s) that products win orders, while being able to reflect future development in line with business needs.'(Hill T, 2000).

The last part of this reference is important as it is relevant to agile theories. The company must set itself up so that the capabilities it has now not only serve the existing market, but also the markets that it may want to service in the future. This can be seen as strategy, starting to look at agility and how the company can supply for future with its capabilities. However, agility must go further than this shall be examined later.

There is another view of manufacturing strategy offered in this book, one which states that manufacturing should be used to provide a truly unique process. This however is very rare and to rely on a truly unique process to develop a company business around is very difficult. One such example may be the float glass technique developed by Pilkington. These technological developments may be difficult to find but manufacturing should provide a unique capability to a company in the way that the operations support strategy. This is again how agility looks to manufacturing to enable a company to provide unique solutions for customers in its strategy. Instead of unique process, the company must have unique set of capabilities and a unique angle on the market.

How is manufacturing strategy formed? Manufacturing strategy cannot be developed in isolation. Its development must be in conjunction with other functions looking at how the company wants to serve the market. Hill suggests a five step approach for integration:

'Steps:
1) Define corporate objectives
2) Determine marketing objectives
3) Asses how different products qualify in their respective markets and win orders against competitors.
4) Establish the appropriate process to manufacture the products (process design)
5) Provide manufacturing infrastructure to support production' (Hill T, 2000).

The text expands upon the steps as follows:

'1) Corporate Objectives:
Provides the basis for establishing a clear strategic direction for the business. It also defines boundaries and marks parameters against which the various inputs can be measured.

2) Marketing strategy:
Linked closely to provision of agreed corporate objectives, a marketing strategy needs to be developed, this will include:

Marketing planning and control
Analysis of product markets
Identifying target markets and agreeing objectives in each
The company should also agree the level of service and support or each market and asses resources needed to provide this business.

3) How do products qualify and win orders in the marketplace?
Manufacturing's task is to meet the qualifiers and to provide, better than the competitors, those criteria that enable products to win orders in the marketplace. This is an iterative debate and the company as a whole needs to agree on markets and segments in which to compete.

4) Process Choice:
Manufacturing can choose from a number of alternative processes to make products. The key to this choice is the volume of the product and the associated order winners for the market, therefore current and future trade offs need to be reflected in the choices.

5) Infrastructure:
This is the non process features within production. It encompasses procedures, systems, controls, compensation systems, work structuring and so on. As above some trade offs may need to be made bearing in mind the current and possible future implications.' (Hill T, 2000).

The above is an extremely prescribed approach to developing manufacturing strategy and offers the user a step by step guide to formulation. Other authors offer similar structures.

Miltenberg proposes a three step system for formulating manufacturing strategy which comprises of:

'(1) Where am I?

Determine the manufacturers current location on the PV-LF matrix, and the production system in use. Asses the current level of capability for each manufacturing lever using the manufacturing capability section of the worksheet.

(2) Where do I want to be?
Complete a competitive analysis to determine the market qualifying and order winning outputs that must be provided by the production system, and set 12 month target levels for them. Find the row of outputs on the manufacturing deliverables chart that best matches the required market qualifying and order winning outputs. Determine the production system on the PV-LF matrix that best provides the manufacturing outputs.

(3) How will I get from where I am now to where I want to be? (Miltenberg J, 1995).
If the production systems determined in steps 1 and 2 are the same then adjust the manufacturing levers on the levers section of the worksheet, so that the production system is better able to provide the market qualifying and order winning outputs at the target levels. Make sure that these adjustments are possible with the current level of manufacturing capability.

If the production systems determined in steps 1 and 2 are not the same, than make adjustments to the manufacturing levers on the levers section of the worksheet, so that: The current production system changes to the desired production system, The required market qualifying and order winning outputs are provided at the target levels, The adjustments can be made with the current level of manufacturing capability.

If this cannot be done, return to step 2 select different market qualifying and order winning outputs and repeat step 3.

Miltenberg's strategy formulation is based around a framework of logic which looks at a number of variables of the manufacturing system. In this respect it is more in depth than the Hill (2000) method of manufacturing strategy formulation. However it runs in a similar vein in terms of the ground covered. The layout and flow of materials, products and volumes and manufacturing levers are simply more detailed and prescriptive methods for choosing process choice and infrastructure.

Again the market qualifiers and order winners for the system are examined and taken into account as an integral part of developing a manufacturing strategy. The one danger of this is that new and agile markets can often be developed by companies changing the order winning criteria. Good examples of this can be seen when manufacturers segment mass markets by looking at different demographics within the customer groups. These can then be more specifically catered for. Therefore the author would propose here that as well as qualifiers and winners there may be order segmenting criteria for the market place which can help to create niche values for the customer. By adopting the above approach of looking at traditional order winner and qualifiers the companies are always followers and never innovators. A good example is given here when companies try to follow Japanese techniques without developing capabilities for their own market types:

'While organisations may be revitalised by adopting prescriptions of Japanese success, two problems remain:

1) Chasing, copying and adopting other companies techniques only achieves 'stay in the game'. But because other companies have a lead of several years, they are more accomplished at playing that game.

2) Too many companies are trying to adopt too many solutions which are in conflict. A common and serious problem has become inconsistent, non congruent manufacturing policies that have been tailored by individual specialists.' (Harrison A, 1998).

The above is not an argument for ignoring manufacturing techniques that emerge from elsewhere but is a cautioner to not follow blindly because others have had good results with the same techniques. It is by installing techniques and capabilities that are unique and provide a unique angle that the customer is most satisfied a fit with market is achieved. Hayes and Pisano highlight this type of problem:

Thinking that improving manufacturing capabilities is the same as manufacturing strategy. It is the capabilities which are valued by the customer which are hard for competitors to duplicate that have maximum strategic impact.
Failing to recognise that new practices build new capabilities that can form the basis for a new manufacturing strategy – if they are recognised and exploited' (Hayes RH, Pisano GP, 1994).

So with the techniques described above, what is really examined for manufacturing strategy design. 'The most common manufacturing strategy framework has consisted of 'process', or how strategy is made, and "content" – the constituents of manufacturing strategy. (Mils J, et al 1995).

Mathews and Foo extended this framework to include 'process and content, performance, constancy and implementation'. (Mathews J.P, Foo S.T, 1990). Other frameworks also include similar items, for example Pettigrew suggests 'process, content and context' (Pettigrew A.M, 1992). Where his view of context included both external factors such as STEEP (Social, Technological, Environmental and Economic) and internal factors such as structure, cultural and political facets. The definition of context used here by Pettigrew is also similar to that used by Leong et al (Leong G.K, et al 1980) and Anderson et al (Anderson J.C, 1991).

The factors are covered quite neatly in the ETI framework proposed by Ismail et al, described at the beginning of this thesis. The ETI system however is simply gathering data and analysing the effects of these factors on the company. The formulation and pulling together of this information needs to be done at a later stage.

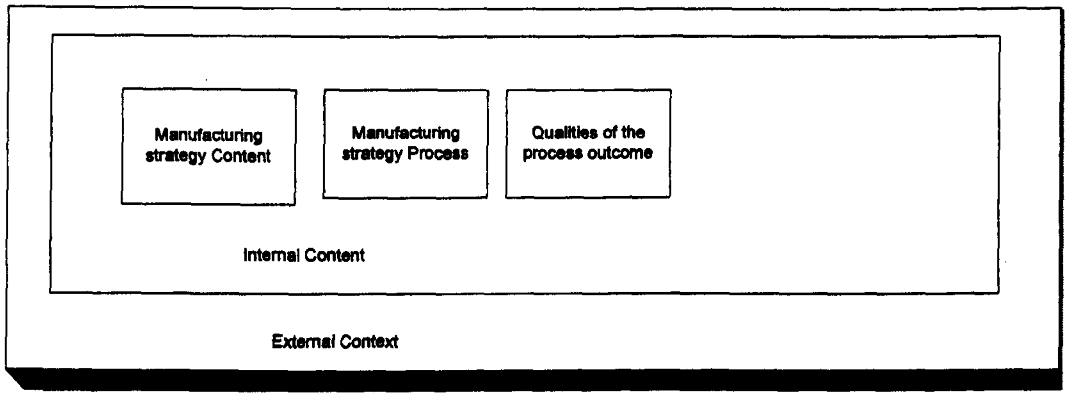


Fig 16: A framework for the design of manufacturing strategy process (Mills J et al 1995)

For the time being we will look at the amalgam of these factors as suggested by John Mills et al. (Mills J, et al 1995).

'The central focus is the manufacturing strategy process, the design of which is contingent on the content model(s) chosen and the required qualities of the outcome of the process.' The second element allows capture of influences in the strategy design process which 'includes important strategy design criteria.' The internal and external content sections are added to allow 'many of the contingencies studied in business strategy literature but rarely used in manufacturing literature to be included' (Mills J, et al 1995).

In the above model the manufacturing strategy content includes majority views found in literature and potential extensions and modifications and covers manufacturing objectives

Manufacturing Objectives: Here Skinner suggested that manufacturing objectives could be classed as cost, quality, delivery and flexibility, and indicated that there were tradeoffs between them all. This are very similar to the manufacturing outputs that Miltenberg suggested and, Skinner, as Miltenberg, also suggests that there is a trade off between all these competencies or objectives. This later became a contentious statement and in 1990 Schonberger stated, 'World class manufacturing strategies require chucking the (trade off) notion. The right strategy has no optimum, only continual improvement in all things' (Schonberger R.J, 1990).

Manufacturing strategy content also involves looking at the decision areas for manufacturing strategy (manufacturing strategy process) and here there are several factors which appear again and again in this area of literature. The common factors include:

Plant and equipment
Labour and Staffing
Product design and engineering
Structure and Management

These decision areas can be compared to the Agile Capability Indicators from the Agility Centres' BEA system and each of these fits into a category of agility indicators. It helps to show that the capabilities being measured in depth are indeed important to manufacturing strategy and the overall capability of the company. Plant and equipment can fit into the process pillar, the labour and staffing issues are covered in the people pillar, the product design area is covered in the product pillar and the structure and management decision area can be covered in the organisation pillar.

Here it is worth noting some of the generic strategies that manufacturers have been known to use. As in the literature on corporate strategy there are many names for these strategies and ideas, here we will touch on just a few.

Telesio examined companies' worldwide and classed strategies into: Cost based, technology based and market driven. (Stobaugh R, Telisio P, 1983).
Roth and miller identified three groups of strategies: Caretaker, innovator and marketer. (Roth A.V, Miller J.G, 1989).
De Meyer stated a further three groups: high performance product groups, manufacturing innovators and marketing oriented. (De Meyer A, 1990).

The above examples of generic manufacturing strategy all relate back to Miltenbergs manufacturing outputs of Cost, Quality, Performance, Delivery, and Innovativeness. The scale that they occupy lies somewhere within these categories and so might at first glance make sense. However Hill refutes the argument for generic type strategies as the marketplace in which companies operate is too complex for a generic framework to be applied. 'perhaps this quest [for generic strategy application] will only be set aside when firms realise that, despite their best intensions, the reality they need to manage embodies a diversity and dynamism that makes categorisation impossible and hence irrelevant.' (Hill T, 2000).

The final stage of the framework shown above is that of manufacturing strategy assessment. In this case it follows the Hayes and Wheelwright framework for what manufacturing strategy should do:
Support the firms competitive success factors
Be consistent with business and other functional strategies
Show internal consistency between manufacturing decision areas (Hayes R.H, Wheelwright S.C, 1984).

The importance of constancy between manufacturing strategy and business and corporate strategy is well documented and has been covered already in this literature review. It is also covered in this section of the framework but will not be re-iterated here.

A more complex framework is proposed by Sackett et al but this will not be examined here as the merit of examining another framework which covers much the same seems to hold little value. However the same paper proposes a decomposition map which shows a six step process where 'corporate vision can be cascaded down and the manufacturing technologies and programmes can be cascaded up,' (Sackett P.J 1997).

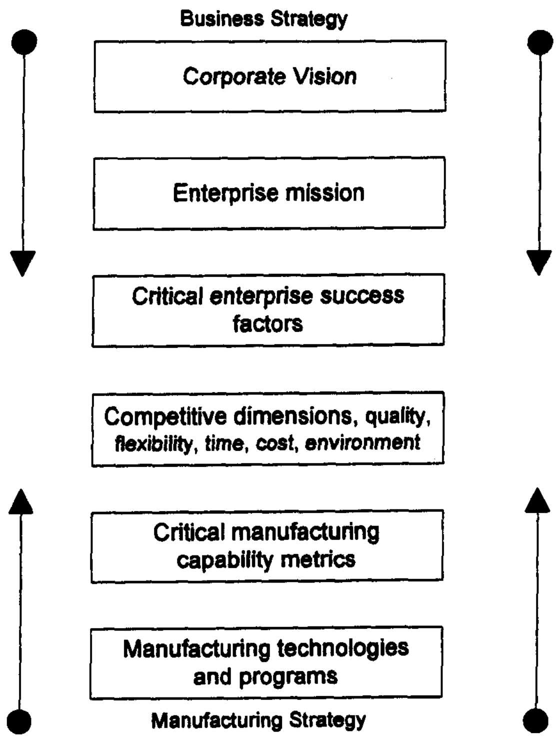


Fig 17: Customising Manufacturing Strategy (Sackett 1997)

We have seen from the research and papers investigated above that strategy and manufacturing strategy are key to driving competitive advantage. It has also become apparent from the research that the manufacturing strategy must be a big part of corporate strategy to be able to provide the necessary competencies that drive the advantage sought by the business. The way in which manufacturing provides these competencies is not by aligning businesses around manufacturing or manufacturing around businesses but by having a combination of both and allowing a multidiscipline discussion on what the 'angle' on the market may be by combining the skill sets available to the company. Manufacturing strategy therefore is integral to making corporate decisions and to ignore manufacturing strategy is to prepare for competitors to overtake.

However, companies that solely use manufacturing as the competitive advantage without considering other areas of the business also take a narrow view. Strategy should play a major part in creating competitive advantage by applying a clear manufacturing strategy that supports the business strategy in the chosen marketplace. This marketplace should be decided upon by utilising the competencies manufacturing can provide and developing these to produce a unique output combination. It should also be noted that generic manufacturing strategies can be seen as old hat, although most strategies will be able to be pigeon holed into a generic type formulae of some sort. They should not be used exclusively to develop a manufacturing strategy for competitive advantage; they should be used to aid and assist at best.

The next chapter outlines the research methodology to be employed in the development of areas highlighted through the two literature review chapters. It will outline the purpose, scope and areas examined.

Chapter 3

Research Methodology

This section is to outline and discuss the methodology to be used in the project. It will look at research design and practices adopted for gathering information and testing new work (data collection and analysis methods.) It will also outline the structure of the project highlighting areas of development that have been highlighted from the literature review.

What is research?

First of all, what is research? Several points that may be considered when looking at this question are:
Research is a process of enquiry and investigation
It is systematic and methodical
Research increases knowledge (Ranjit, K 1996)

These suggest what research is but why undertake research? Many reasons are given for carrying out research but some of the more common reasons are summarised below:
To generate knowledge
Explain a phenomenon or occurrences
Provide solutions to practical problems
Generate new models and hypothesis
Construct or create a new system or procedure
Or a combination of the above reasons (Bogden, R.C., and Biklen, S.K 1992)

The research carried out on this project fits the basic criteria set out above for defining what research is and why it is carried out.

The project will investigate the possibility of adding a tools selection framework to an existing system improvement tool, the ASF, this will automate that part of the consultation process. It is also investigating the possibility of placing the framework within an IT tool to aid further development and further automate the framework. Finally the research aims to look at the existence of paradigms of agility and how they sit with strategy. This section will look at how strategy can be 'tested' for agility through the use of agile paradigms. The research uses case studies to test developments made. The automation and development of IT sections to the framework may be used in further research projects when developing a fully automated online system for use by individual members of staff within a company, or other system developments.

The research then aims to increase knowledge of agility and show directions for its further development through paradigm examination.

The research is split into distinct stages to give a structure to it. This means it can follow a sensible chronological order.

Research methodology

The stages of research that this project will go through are as follows:

Review previous work from Liverpool University Agility Centre on the Agile Strategic Framework. (Secondary research).

Review other work in the area of frameworks used for identifying manufacturing problems and implementing solutions. This may also look at frameworks used in other businesses. (Secondary research).

Develop system / framework for tool identification and selection after the first stage of environmental turbulence assessment has been carried out. This will show how tools can help the company best combat turbulent factors. It will also show how other areas of the business may be affected by the use of these tools. It will aid selection of tools to strengthen a particular capability which has been show to be weak. (Primary research).

Validate the framework developed by a recognised validation technique. In this case Toulmin's theory of argument is suggested for validation as it provides a structure to the reasoning behind placement of objects within the framework. (Primary research).

Look at the use of IT to automate parts of the system to generate a faster tool / assessment framework. (Primary Research).

Apply framework to case studies. This is to test the framework on already completed projects which were successful. It can then be seen if the framework produces data similar to that used in the successful projects. (Primary research)

Discussions and improvements to the framework. It is not expected that the framework will generate the right answers all the time in the first version. Therefore some suggestion will be made here for improvements to the framework for it to work more effectively.

Review literature on strategy and manufacturing strategy and where they sit with agility (secondary).

Examine the existence of paradigms of agility, how these may fit into a framework and what they might be. TRIZ (Teorig Resheniya Izobretatelskikh Zadatch) (Theory of Inventive Problem Solving) will be examined here for possible fit into product / agility lifecycle comparison. It is proposed here that the evolution of manufacturing can be compared to the evolution of the product design cycle. Solutions to the manufacturing agility lifecycle can be drawn from comparisons to the TRIZ methodology (primary).

Research Levels

The research is split into two levels. The first examines the operational level by utilising the existing work done on the evaluation framework and developing this further. The second level of research is looking at the strategic level. It can be seen in the IDEF diagram below where the split for the two types of research comes. The development of the operational type work comes through the tool selection tables and the Ishikawa work carried out. The development of the strategic work comes through the use of the TRIZ product development cycle compared to the manufacturing agility lifecycle. These two distinct areas are highlighted in the literature review work, split into strategy work and the framework development through examining existing manufacturing systems and work already done in the area of framework development.

The strategy development area of the research gives a unique position on the lifecycle of manufacturing systems. It will aid in ensuring strategy gears a company for agility and steer the company in the right direction. The research focus is on the operational level first and then the strategic level to aid in clarification of capabilities. It makes the system less fuzzy as core competencies are addressed first followed by the higher, strategy type decisions. The operational level provides information that will affect the strategic level decisions and therefore the operational level must come before the strategic implementation.

It should also be noted that the generation of operational level tools and techniques, although validated using Toulmin (see later in this chapter), Paretos rule has generally been applied that 80% of the time the tool will affect these 20% of pillars of agility giving an automation element to the system.

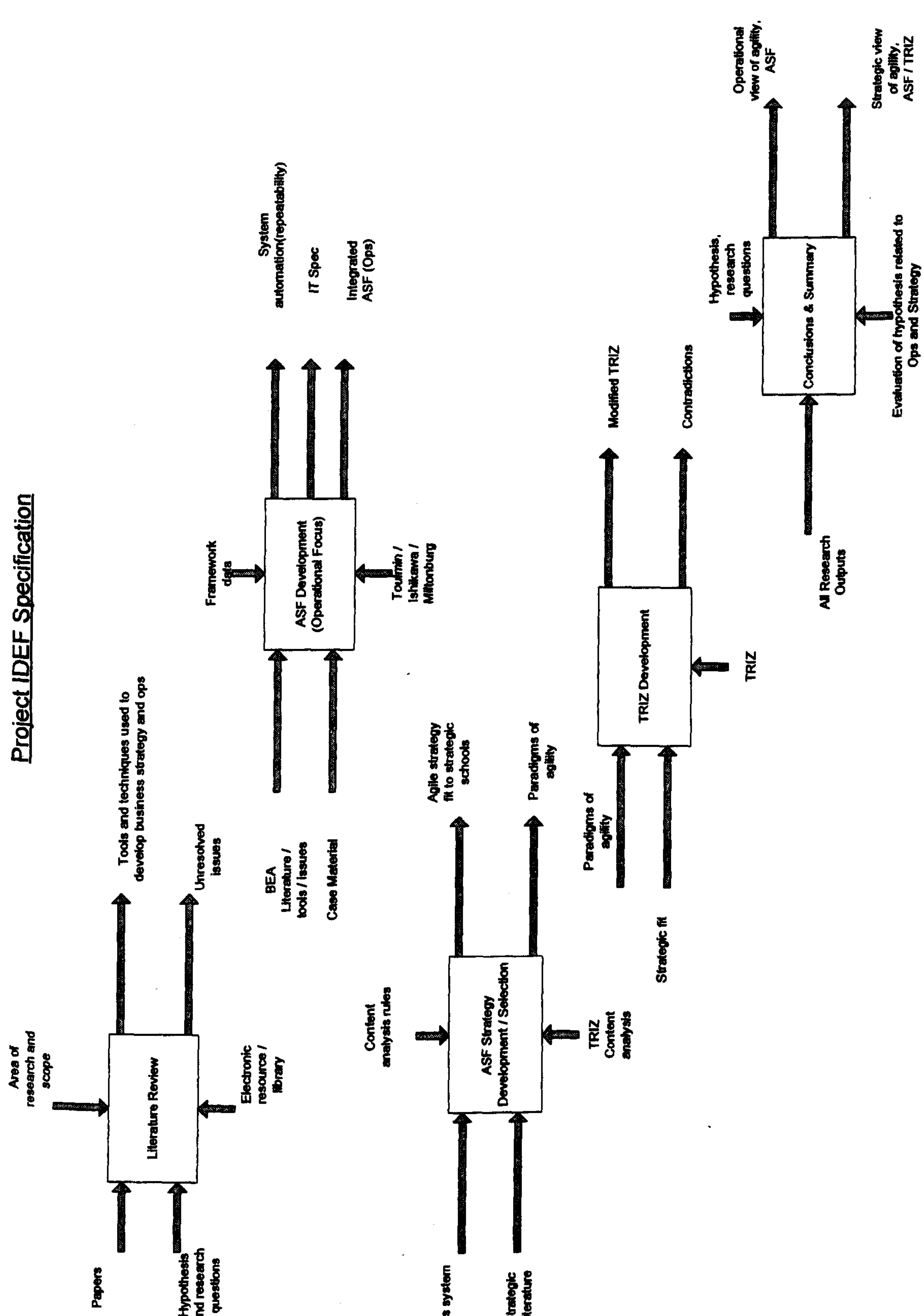


Figure 1: IDEF of proposed project research process (Hetherington)

Validation

The research is being both conducted and validated by applying the system to case study examples; this suggests another method of validation should also be employed to give a balanced reasoning behind the frameworks suggested by the author. Toulmins Theory of Argument is used to validate the framework and some of the other areas of the project. Toulmin is a well respected philosopher in social science where qualitative research appears frequently. He is often used to structure arguments for and against, and to look at reasoning behind pieces of research in the social field. The methodology of Toulmins theory of argument provides a structure to building a case for or against and allows for exceptions to be taken into account. Although this research project is applied to engineering or manufacturing problem solving and frameworks, a large amount of the research done is using qualitative methods. Therefore the validation process of the results suggested should reflect this. It is the authors belief that Toulmin offers a structured methodology for explaining the arguments for placements of tools and techniques within the framework and will aid in understanding the way that the process has been developed.

Toulmins validations also lend themselves to inductive research, which this project tends towards. This means observations are made which lead to broader generalisations and theories. Patterns are highlighted from the observations, in this instance case studies and real workplace experiences, which then leads to formulate a hypothesis, this is explored and conclusions are drawn in the positive or negative to the hypothesis offered. This is then the theory. This is often called a bottom up approach with deductive research working the other way round, top down.

In this project the theory is tested in a number of ways to lend some deductive reasoning to the approach. The theory is validated using a recognised technique from Toulmin and then tested as in deductive research on case studies from real applications.

The two approaches take the following paths:

Inductive:

Observations → Patterns → Tentative hypothesis → Theory

Deductive:

Theory → Hypothesis → Observation → Confirmation (or not)

Toulmin Validation

Toulmin's theory of data and arguments will be used to validate the reasoning behind the cross impact tables in the project. This section offers a short introduction to Toulmin's system, its origins and applications. It then shows a sample of the method used for each tool, and the ACI it is associated with on the tables, a case based Toulmin argument of its placement and impact rating. This provides an alternative method of validation to that shown in the fishbone diagram section, which was based on logical arguments from personal experience and reading material on the subjects of the tools suggested. This is to give a varied technique and show a structured approach to the system design; it will also provide a valid and useful framework as the end product. The next chapter will use case studies and the comparison of the tools used to show how reliable the tables are in replicating the case results.

Toulmins logic is used here to validate as it is a useful tool when looking at qualitative data to validate through evidence of case study application. It is proposed that the data to form the claim around will come from finding case study examples of where an application has been used. The advantages here are that the model relies on actual data to construct an argument around. This is particularly useful in this research project as the author is aiming to create a system of tool selection that is repeating successful results. However Toulmin offers a model that looks like it is completely decontextualised, in reality it offers one version of universality and cuts of exploring the character of that universality. In this case this does not pose too much of a problem, as long as the case study is successful.

The system being developed is not intended as a panacea but rather a tool to suggest the most useful tools to a company facing a certain situation. Each tool will have to be evaluated for corporate fit before implementation.

Stephen Toulmin is a modern English philosopher who was interested in the role that argument played in rhetoric. He was also a respected expert on the idea of argument and the structure that it takes. He has published two books relating to the subject, The uses of arguments (1958) and Introduction to reasoning (1984). His argumentative techniques are based on the process of reasoning; logical reasoning asks readers to draw conclusions from relevant, sufficient and representative evidence. 'Through Toulmin's thorough understanding of the natural, rational thought process of the human mind, he was able to formally give a title to the natural progression of argument. He broke the barriers of inductive and deductive reasoning. Instead of using complicated syllogism, Toulmin divided his form of argument into three simple terms; claim, grounds/ data, and warrant' (Smith L, Boulduc T, 1997). He called this model, Toulmin's Theory of Argumentation.

Toulmin's methodology is often suggested for bridging the gap between experts in a particular field and someone else who needs to understand the information being given to them, (e.g. scientist explaining to a policy maker in government), but does not have the expert scientific background required to go into minute detail. The theory aims to not to be overbearing but to allow the reader to digest the unbiased information so that they may re-think the argument from their own position. In issues of morals or values the Toulmin theory is especially effective because of its un-alienating style.

As a research tool Toulmin can be used in two ways:
'to identify and analyse your sources by identifying basic elements of an argument being made and to test and critique your own argument' (Main, J 1997). In this research the tool is used in the first way to identify and analyse sources providing data which either prove or disprove the theory of where items have been placed on the tool selector table. This use of Toulmin provides a way to test the argument of how manufacturing tools affect the ACI's.

Here it is particularly useful because a judgement call need to be made which will affect the implementation process. The judgement can be backed up in Toulmin's argument process using case study examples.

The model that Toulmin set out in his work is based upon six aspects of argument that are common in any field. The model looks like this:

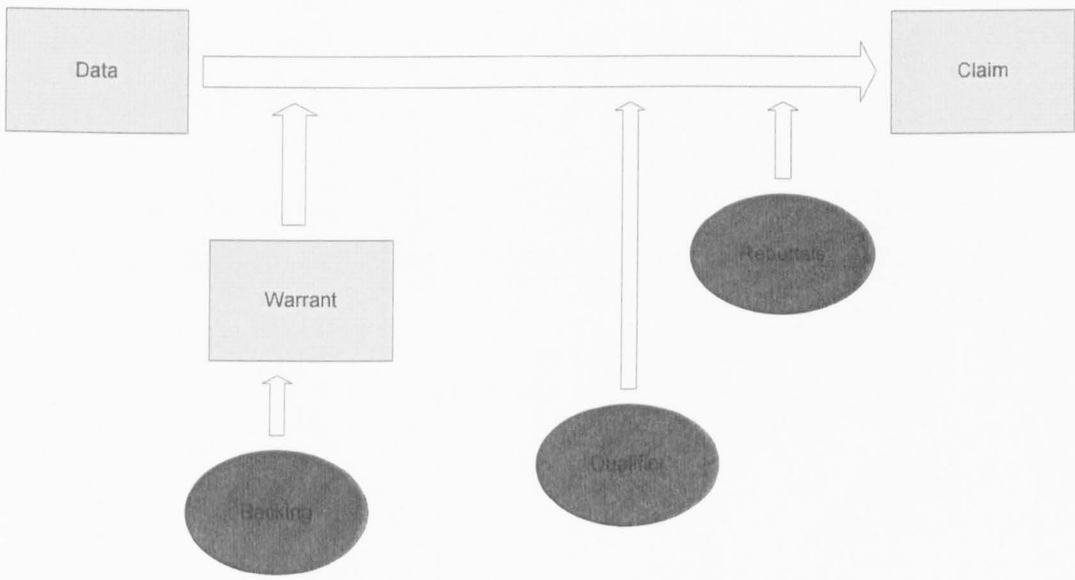


Figure 18: Toulmin's theory of argument (Smith, L and Boulduc T 1997)

The terms used in the diagram are explained on the following page.

'Defining the terms (Sparks, R 1997):

The Claim: A proposition, opinion, theory or contention, to state to be true; assert a statement that something is true

The Data: Information drawn from a specific case that supports the claim, information organized for analysis, facts or figures to be processed from which conclusions can be inferred.

Warrants: laws, principles or premises that apply to the case; authorisation or justification, something that assures, proves or guarantees. To give proof: beer witness to; vouch for.

Backing: precedents or historical cases that led to the establishment or warrant in the first place: aid, support

Qualifiers: The degree of confidence with which the claim is asserted to be true. To modify, limit or restrict

Rebuttals: anomalies or contradictions that must either be explained away or excluded from consideration for the claim to be true.'

A short example of Toulmin's model is given below.

Claim: Don't eat those mushroom's
Claim + Reason: Don't eat those mushroom's they're poisonous
Grounds: They are poisonous
Warrant: Eating poisonous things makes you ill
Backing: Being ill is not a desirable state.
Qualifier: My book, written by a fungi expert, claims this mushroom is poisonous to humans. It is written by an expert therefore likely to be true.
Rebuttal: Unless you are suffering from a condition in which you like to be ill, hypochondria for example.

It should be noted here that claims should be clearly stated and qualified with good reason, (this is good practice), claims and reasons should be based on reasons your audience are likely to accept. All parts of an argument need support, but warrants and rebuttals are particularly vulnerable, effective arguments anticipate objections. The rebuttal can be stated as an opinion and can leave the audience to make up their own mind from the case presented.

This is a very simplistic example to demonstrate how the theory works. It will be applied to the design stages of the framework for tool selection to justify the placement of tools, Agile Capability Indicators (ACI's) and the like.

Classification of research

Types of Research

Hussey and Hussey (1997) classified research into four different categories

1) Purpose of research; exploratory, descriptive, analytical / explanatory or predictive research
2) The process of research; qualitative or quantitative
3) The logic of research; deductive or inductive
4) The outcome of research; applied research or pure research

By using these categories the type and style of work undertaken throughout the project can be shown.

The purpose of the research is descriptive. It is to investigate and define a framework for tool selection that can have practical application as part of a system already developed and trialled.

The process of research will be discussed in more detail later but covers both qualitative and quantitative aspects. Due to the nature of the subject the main research will be qualitative with some quantitative to back up outcomes and arguments.

The logic of research again covers both aspects (deductive and inductive) but lends itself more to the inductive style. This is due to the selection of Toulmin's theory of data and arguments to validate large areas of the project before being tested in a more quantitative method on case study material.

The outcomes of the research will be applied. As described above the framework will be used as part of an existing system to evaluate a company and its business environment.

Process of research

As mentioned above both quantitative and qualitative research will be used during the project. Quanitative research is only used in a very small manner when compared to the use of qualitative. The two specific areas where outputs will be compared quantitatively are the case study outputs compared to the outputs from the tool selector table and the pillars identified in the IT system compared to the cases studies. Here they are defined and explained and an outline of where in the project they will be used is given.

Quantitative research

Quantitative research is based on statements such as "anything that exists, exists in certain quantity and can be measured" (Willie Klondike 1904). This is a philosophical position and is a widely accepted one in social science in the past century. It became more accepted of recent times though that qualitative and quantitative can work closely together and that both play an important role in research of today. By using both methods together a situational responsiveness is given, whereas by using only one method, a slanted view to the research may be given.

Quantitative research is concerned with the measurement of a variable, determining the quantity of something and expressing this numerically. During the project information will be gathered, processed and validated. This is mainly a qualitative process of research which will lead to a quantitative analysis of some of the information processed.
The Oxford dictionary defines this as:
'**Quantitative analysis** n Chem. Measurement of the amounts of the constituents of a substance (Thompson D, ed 1996).

When undertaking the research, numerical data will not be gathered it will be generated from analysing the framework in comparison to the case studies. This means that the information gathered is qualitative information which is then processed to give some quantitative information to the reader. This numerical information produced will be the quantitative part of the research and will serve mainly as a testing and validating tool to the framework developed. Some statistical analysis may be applied to this information but this will generally remain uncomplicated processing of numbers. Quantitative data will be used in this project to refine and cross check qualitative knowledge generated.

Qualitative Research

Qualitative research is a primary research technique as opposed to the secondary processing of numbers in quantitative analysis as outlined above. It differs from quantitative research in the following ways:

The data is usually gathered using less structured research instruments

The findings are more in depth as it makes use of more open ended questions.

The research is more intensive and flexible allowing greater attitude to probe into issues which may be unearthed in the research process therefore sometimes changing the direction of research

The research cannot usually be replicated or repeated, giving it a low reliability on its own (hence quantitative comparisons)

Analysing the results in a qualitative method can be much more subjective

Some of the most common methods used in qualitative research are:

In-depth interview

Focus group

Projective methods

Case study

Pilot study

In this research the main qualitative research method is case study analysis based on an in depth interview technique developed as the BEA system by The Agility Centre (Ismail, H, et al, 2000).

Because analysing the results can be more suggestive than quantitative methods both will be used for this research project. This is to aid in removing some of the subjectivity when analysing how well the framework identifies appropriate tools for application. As well as removing subjectivity, aspects of reliability of the research will be addressed. The final section of the project examining agility paradigms will be almost purely qualitative based making use of grounded theory techniques and content analysis.

A concise definition of qualitative research is difficult to generae because of the large area that it encompasses. Bogden and Biklen (1992) define it as 'searching for patterns, discovering what is important and what is to be learned and deciding what you will tell others'.

Methods of Research for Operational Level

Literature review

The literature review forms a large part of the research undertaken and provides both background information on the system already developed at The Agility Centre, The University of Liverpool, as well as evaluating parts of this system. The literature review also looks at other frameworks which are used in the area of manufacturing and how they are applied. It evaluates the different methods employed, looks at good and bad aspects of each, and compares them to the framework being developed in this project. Some of the types of literature examined are; papers written on measurement of agility in manufacturing, papers written on other measurement frameworks in other sectors, such as environmental review, books on various manufacturing tools which use frameworks for assessment and other planning and control methodologies which give a map for improvements to the workplace.

Case Studies

Case study examples of the system used at the moment will be used during the research to look at the type of tools used by companies at the moment. This will give some basis to build the tables for the framework on and will aid in designing which tools go where in the tables. By combining this with research undertaken into different tools and techniques used within manufacturing, the effects of the tools implemented can be identified.

Case studies used here are essentially based on interviews which have been used in earlier research. These case studies have used the questionnaire in the BEA to solicit information about certain areas of the business, this is applied through the interview technique. This is advantages to the project as it uses primary data collected in the context of the research The target audience is correct (SME's) and the system development can be seen through the successful application of manufacturing tools. This provides a set of 'desired' outputs to compare the outputs of this research to. The case studies have one major advantage in that they provide a set of ready data that the author can draw on with minimal time constraints and that have been applied across a large period of time. In some cases several months or years. It would not be possible for the author to spend this amount of time gathering the required data.

The disadvantages of using this sort of data is that 'interviewing is time consuming and expensive' (Kumar R 1996). Therefore to combat this problem this research problem is using mainly interview already carried out by the Agility Centre. The Richardsosn Cases study shown later in the project is the only one which is carried out by the author. The quality of the data depends on the 'quality of the interaction and the interviewer' (Kumar R 1996). It is something that will provide a variable when looking at the case study and there is no way of rating the quality of either interaction or interviewer. The case studies selected have had successful implementations and for the purposes of this research have therefore been seen as useful data to compare to.

The case studies to be used in this research are also for the trialling and validation of the framework for tools selection. This framework should identify the same types of tools to impact the same turbulent factors and strengthen the same weak agile capabilities as in the case study reports. The case studies have been put together by members of the Agility Centre and a PhD student from the Agility Centre. They use the BEA audit tool as developed by the centre to look at company's performance in the chosen operating market. The types of tools used in the case studies will be compared to those identified by the framework.

A numerical comparison of how many tools are identified correctly will be done to compare the validity of the developed system. This will show percentage agreements between the case studies and the framework and highlight areas of the framework that need to be modified to give total agreement with successful case studies. Total agreement however may not be required, as the case study may not be the perfect solution. In this case an argument will be put forward for not changing the tool selection framework.

Best practice tools have been developed and added to by examining applications in industry through case study reports. See appendix 2 for tools developed and a selection of case study validation.

Types of research carried out for strategy level:

Research into Agility:

This section looks at where agility is generated from during the lifecycle of the manufacturing system. The manufacturing lifecycle will be compared to the product development cycle and the generic solutions that TRIZ can offer in this area. The hypothesis is that there is a comparison with agility and that paradigms can be sought to be used as a 'strategic filter' to aid in implementation of agility at this higher level. The TRIZ type framework was then developed for use in agility lifecycle, strategic type decisions. Traditional schools of strategic thought are examined through literature review and the theory developed using the following techniques.

Grounded theory:

What is grounded theory: 'theory that was derived from data, systematically gathered and analysed through the research process....theory derived from data is more likely to resemble the reality' (Straus A, Corbein J, 1998).

Rather than beginning by researching and developing a hypothesis, the first step is data collection, through a variety of methods. From the data collected, the key points are marked with a series of codes, which are extracted from the text. The codes are grouped into similar concepts in order to make them more workable. From these concepts, categories are formed, which are the basis for the creation of a theory, or a reverse engineered hypothesis (Kelle, U. 2005).

In this section the research was focused on content of published material on the subject of agility. Many different papers and journals have covered the subject and it is proposed that by studying content of these and the relationship of agility to the real world situation a theory could be born about the paradigms of agility. Therefore content analysis of documentation was used to develop grounded theory on the principles of agility. Grounded theory allows hypothesis to emerge from data being studied, as opposed to testing pre-conceived hypothesis.

As content analysis can be very time consuming and results difficult to record the software package NVIVO was used to develop the qualitative project. This meant electronic copies of papers were obtained and loaded into the NVIVO package for content analysis. This formed a package where by the project was structured around certain factors which emerged from the data being studied.

Content analysis

Content analysis is used in this project to look at the current research focus on Agility. Here documents and papers are examined using content analysis techniques to look at how other researchers are using the term agility and what it means in their research, the context in which it is used. This helps to look at Agile paradigms by focusing the research and putting into context what is already known or widely published. This content analysis will look into factors that are common to companies practicing agility and will identify some key factors which companies must adapt, relate to, or test for, if they wish to perform in an agile manner.

Why is content analysis used? What are its advantages and disadvantages? How was the sample set up in this project to make best use of data?

Content analysis is used here as is has some advantages for the type of material being fed into the research. The research methodology is to 'examine a large amount of data' (Krippendorf K 1980), as demonstrated by the original TRIZ research, and content analysis is one such method which is capable of dealing with large amounts of data. It accepts 'unstructured data' (Krippendorf K 1980 which is essentially what we are feeding into the research process by using other peoples research papers. It is also an unobtrusive technique which means that there is no need for the researcher to seek out data from sources which may be time consuming e.g. interviewing etc. Another major reason that content analysis has been used is that the research does not plan to propose a finished article, (akin to the TRIZ system) rather a segment of what is possible and a direction for future research. Content analysis is a suitable tool for this type of work, content analysis summarises rather than reports all details concerning a message set. This is consistent with nomethetic approach to scientific investigations (i.e. seeking to generate generalizable conclusions), rather than the idiographic approach (i.e. focusing on full and precise conclusions about a particular case).' (Nuendorf K.A.2002).

There are some disadvantages of content analysis as a research tool.'Although a good content analysis will answer some question, it is also expected to pose some new ones, leading to revision of procedures for future applications', (Krippendorf K 1980). As stated in the previous paragraph this is not a problem for this research as it is aimed at providing a starting point for the paradigms of agility rather than a complete finished article related to the TRIZ system. Other disadvantages include it is time consuming coding data, even on computer; 'it can disregard context and is limited to recorded information.' (Walkman N. E., Fraenkel J. R., 2001). It is not anticipated that these disadvantages will hinder the research although they should be remembered when referring to the conclusions of the analysis performed.

The content analysis is being carried out using the software package NVIVO to help look at available material. It helps to store and record progress electronically and so speed up the process of coding data and researching themes or strings of a subject. The project uses a grounded theory approach whereby the hypothesis of the research is not stated beforehand but 'emerges' during the course of data inspection. However to make things somewhat easier to research the data was assumed to fall into one of several categories.

Firstly the context of the definition for agility was assumed to fall into one or more of the following categories: Product, Process, People, Operations, Organisation. These relate to the pillars of agility defined in the operational part of the research and allows for parity between the two sections of research. This means that the research is limited to making Agility fit into one or more of these categories but allows a certain focus in the manufacturing definition of agility. It also means that the context of agility can also be related to some manufacturing tools that have been identified in previous research as Best Practice and classified under these headings to develop Agile Capabilities.

The research outlines some basic questions to answer and moves forward from here. These questions are not designed to constrain but merely to start the research moving and allow an exploration of available data. The basic questions outlined in the NVIVO model are:

What is agility?
What is agile manufacturing?
What is agile strategy?
What are the paradigms or factors that are required for, or to generate agility?

The examination of papers and literature is expected to produce some definitions of agility as mentioned above. This will be through definitions being complementary to each other and providing supporting evidence. It is expected to find that definitions are more heavily geared to one pillar or another or spread across two or three. The pillars are Product, Process, People, Operations, and Organisation, as defined by the Agility Centre at Liverpool University. This will help to show where focus of research has taken place and perhaps where some areas are lacking. This could also be because some pillars do not provide a great deal of agility, we may call them facilitators not providers.

It is not expect to find a ready list of paradigms assembled from many different researchers but some key facts will appear that may help shape the thoughts about these.

The NVIVO project was constructed to code up project data from published research journals. The nodes of coding have been given above. Once all these coding sections had been applied to the relevant areas of the paper they were examined for patterns and associations generating the paradigms of agility found from the research.

The larger the number of papers explored and examined the more results and the more confident of those results the researcher can be, however time constraints have an effect and this study can be viewed as a pilot to a much larger project. This is especially true when directly compared to the TRIZ system developed for product development. The system required many man-hours of development and was completed by a large number of researchers working concurrently. This may be possible for this type of project in the future and may form some further work that can be carried out in this area at a later date.

When it came to selecting the papers to be coded there were a variety of methods reviewed, these ranged from Random sampling like cluster sampling, to non random techniques like quota sampling. Because random sampling techniques call for all the population to be known then this was not a practical method to apply to this research. The entire population of Agile Research could not be known.

The author decided on convenience sampling as the best technique to use. This does have some draw backs in that it can be seen as non representative and that it is 'used all too frequently' (Neuendorf K. A., 2002) This sampling technique does however allow a selection of data to be coded and to give some goo preliminary results without a large amount of effort in trying to make the sample process entirely random.

The next step was to decide a sample size suitable for the research. Several factors were taken into account here, particularly time constraints of coding large amounts of material and the fact that the research is aiming to generate a pilot of a much larger piece of research. Several sources were consulted on sample size and it was decided to take 96 samples which should give a 95% level of confidence in the results with a sampling error of + or – 10%. (Neuendorf K. A., 2002).

Therefore the sampling size was set as 96 minimum and the material used was that available when performing literature searched for the subject of Agility. This did throw out a large and varied range of data and provides a good starting point for the research to code.

Summary

In summary this section has laid out the strategy and methodology for gathering data, conducting the research analysis of the information gathered to formulate a hypothesis and then offers two methods for testing the results and offering improvements to the system. This should lead to a serviceable framework for further research and automation modules to be built on to. This section shows that the research has had careful planning for purpose and content and has outlined the scope of the project in broad terms. It has also explained the different types of research and looked at some of the strengths and weaknesses. This exploration and planning has developed a methodology that makes the most of the strengths in each particular area and counters any measures of weakness with alternative or complimentary techniques. This will aid in the development of a valid system.

The next chapter looks at the development of an automated tool selection system adding to the existing framework. This is the start of the operation level research.

Chapter 4

BEA Systematisation Development

Cause and Effect Analysis

This section of the project is looking to develop the Agility Strategic Framework system further by developing the way in which tools are identified an implemented after companies have undertaken a BEA.

The authors aim here is to develop a series of tables that show cross impacts and allow for tool selection from the turbulent factors identified. These tables will ultimately allow automation of the system and will speed up the process for creating an implementation plan by providing a reference library for all the tools that the table suggests for implementation. It also gives some robustness to the system whereby repeatability is increased as the operator of the framework is no longer left to choose tools from the knowledge and experience they have.

The author also aims to here to develop a table that shows how the tool may negatively impact upon other areas of the business. This is to stop any implementations having a detrimental effect on areas of the business not being closely examined. The tool again should allow for automation of the process and produce a list of capabilities that should also be monitored while implementing improvement tools to highlight any possible weakening of capabilities.

The tables will be developed using Ishikawa diagrams formed from the subsections of the ETI questionnaire. It is proposed to develop these Ishikawa diagrams to visually show how the sub-sections are being impacted by external forces. This first stage development uses the cause and effect diagram to display the root cause of turbulence within the sub-factor. The root causes from this first stage of development are then placed on a seconded diagram to relate these causes to capability indictors (ACI) for the sub-factor. These capability indicators will need to be strengthened to deal with the issues highlighted in the initial diagram.

The advantages of using Ishikawa diagrams to develop the thinking behind the cross impact tables are that the diagrams help to develop many possible causes and it immediately sorts the ideas or cause into categories for easy validation. In this case validation is carried out later through the use of Toulmin. There are some disadvantages of using Ishikawa diagrams. They are not particularly useful for extremely complex problems, which in this case we are not dealing with. However they also tend to show similar causes again and again. This must be managed through the development of the diagram with the group so that the same causes are not repeated and thought is put into finding alternative areas for investigation.

The group used to help develop the initial diagrams was gathered from the Agility Centre at the University of Liverpool and is a team of people who are also used to operating the BEA tool. The team consisted of Ismail, Christian, Poolton, and Toward, facilitated by the author. The later development of the diagram relating the ACI to the root cause was carried out solely by the author.

The methodology followed for developing the diagrams is as below:

'1)Agree on problem statement (In this case the statement is taken as on of the factors of turbulence from the BEA)

2)Brainstorm major categories of problems (Here the major categories were classified at the pillars of agility so as to be able to categorise root cause into these pillars and later link in the ACI)

3) Brainstorm all possible causes, asking why does this happen (in this case ideas were gather from the Agility Centre staff for developing the first diagram, these initial ideas were placed on the diagram and then compared to the ACI's to link in ACI to the root cause of turbulence)

4) Ask again "why does this happen?" to generate deeper understanding

5) Analyse Diagram. Investigate the likely causes further. (In this case the causes were related to the ACI in a second diagram to be able to show which had an impact on the turbulent factor)' (Tague N 2004).

From the ACI identified tools must be examined which can have a positive impact on the capability indicator and therefore the sub-section. This can be done through examining the way the capability indicator is measured, referencing case study material and best practice literature and utilising experience of tool implementation. It is at this point that a list of tools is developed against each ACI and can be put into a reference table format.

It is proposed that the reference table format will then be given ranking on the impact that these tools will have on the capability indicators. The ranking system will take the form of high, medium and low and is for information purposes and is not meant to constitute a scientific measurement but offer guidance on which tools are more appropriate than others. This will be covered in a later chapter however, and for now the focus will be on developing the Ishikawa diagrams.

The Ishikawa diagrams developed will highlight from easy glance where the focus of agility should be for a particular turbulent factor. The branch of the diagram that is most heavily populated will show that this is the pillar in which agility is generated and robustness must be created for that particular sub-section. This will therefore have the added benefit to the ASF of a quick and easy look up for agility focus and will highlight the most important pillar to the company.

Outline of Diagram Development

Each diagram was developed from a sub section in the BEA folder; they cover the areas Rivalry, Changes in Manufacturing and Product Performance. The areas were selected at random from the BEA file and were not chosen from the same pillar, i.e. STEEP, Intensity of Competition, Dynamic Customer Requirements and Supply Chain Turbulence. This ensured a good sample that would be representative when transferred to the development of the tables for use in the whole of the framework.

Examining the ways in which the agile capability indictors would affect each sub section developed the diagrams. This is because the capability indicators are general and do not affect all of the sub factors. For example, sub factor product performance is not affected by the capability of employee skills flexibility. In this case product performance is looking at the features of a product compared to a rival and evaluating the way a product performs its desired functions. Although employee skills flexibility may affect the delivery this is not covered in this particular sub factor, it is dealt with elsewhere in the overall audit.

Once the three sub sections had been chosen each capability indictor in turn was examined and assessed for its effect on the sub section. This was done by looking at the individual measure applied in the sub factor, then comparing them to how the capability would directly affect the sub factor, and in what way. This then either gave a link to the sub factor or not (as in the case above), and was placed accordingly on the diagram on the correct branch.

Once the diagrams had been drawn the capabilities populating each branch were explained to give clear reasoning about how the sub-factor and capability would be affected and look whether this was a positive or negative link.

While the reasons and effects were being examined, tools which would help this area were also suggested to give a fuller and more rounded view of the possibilities. This also helped to develop the tables in the next section by referring back to the types of tools suggested, this information was then used I the development of the cross impact tables.

On the following pages the diagrams are shown with the reasoning behind each placement, some of the tools suggested are also highlighted. The validation section of the project deals with the tables only as these are the items to be used in the system development and aid in the BEA audit process.

Intensity of competition
Sub-factor
Rivalry

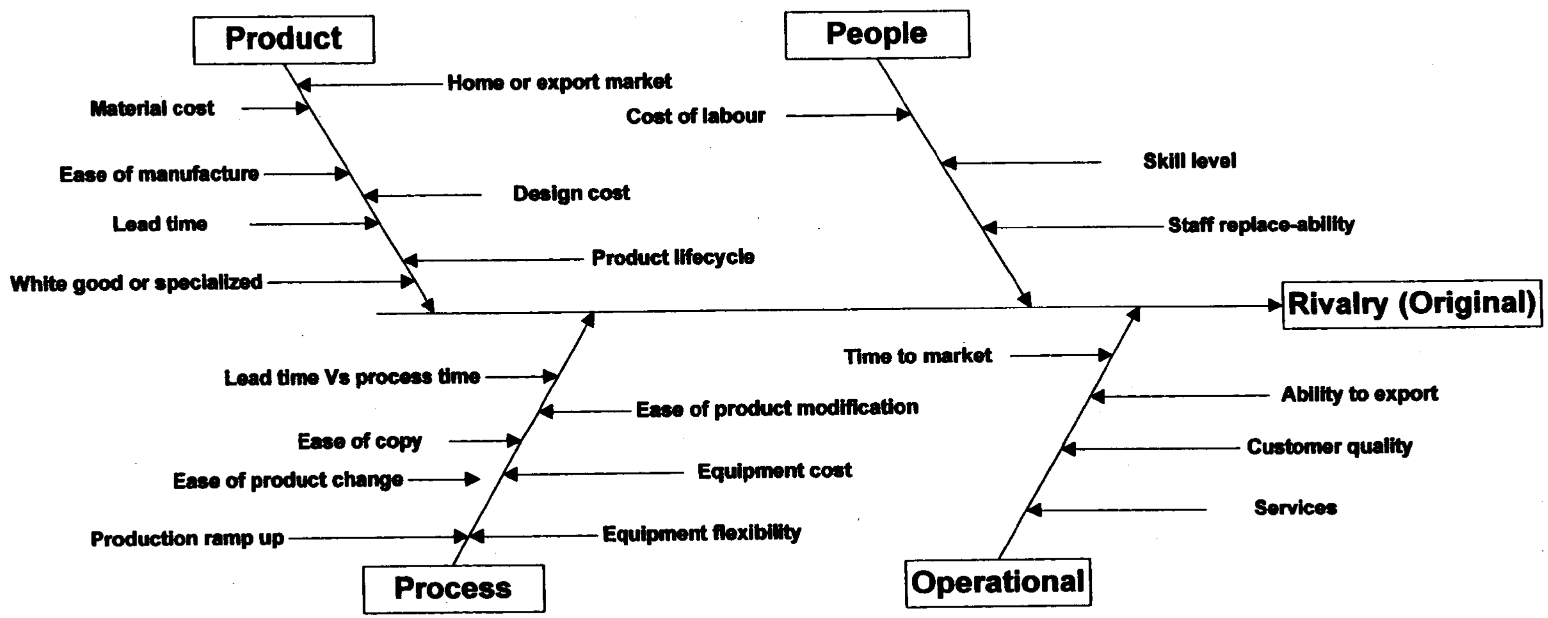


Figure 19: Intensity of competition Ishikawa (Hetherington 2007)

Explanation of development of the first Ishikawa diagram

Pillar: Intensity of competition

Sub factor: Rivalry

Rivalry, the sub-section of Intensity of competition, looks at factors relating to organisations operating in the same market who are considered to be direct threats to the target organisation, the competitive behaviour and performance of these organisations, and the impact of such behaviour / performance on the target organisation. This sub-section also addresses those factors that can be attributed to the company's products and the market perspective, or both as a comparison.

This and the following explanations for placement of ACI's and diagram development are not supposed to act as a mechanised validation process but merely to act as an insight into the thinking behind the diagrams development. The validation, using a recognised mechanistic, approach is covered in the Toulmin Validation section of the project.

The first diagram, without the ACI issues on the branches was the starting point for the rest of the fishbone diagrams. This diagram (shown later) is a cause and effect analysis of the rivalry sub section of the ETI manual. Rivalry forms the backbone and the four pillars are placed on as the 'bones' of the diagram. The four pillars are what the ACI's can be sub categorised into, Product, Process, People and Organisational. This classifies the ACI's into distinct areas that have an effect on the manufacturing outputs of a company. This is a similar classification to the way Miltenberg splits down the manufacturing outputs into sections. (Miltenberg J, 1995). [There are actually five pillars from the ASF but the operational pillar is not included as further work needs to be done in this area to develop ACI's (agility capability indicators) and other performance measures.] For more in depth information regarding the ACI's, the pillars and framework theory, refer to the introduction of the project. This describes in more detail the full system used for analysis. (The ACI abbreviations are listed in the abbreviations and common terms list at the start of the project).

This first diagram was used to record generic factors that affected each of the four bones of the diagram. It was a starting point for the development of the Product, People, Process and Operational ideas that would affect agility in a company. The factors that have the biggest effect on the rivalry sub section were linked to the ACI's developed by the agility centre in previous work. This first section was to develop understanding of where the ACI's came from and some of the thinking behind them. It was interesting to relate some of the ideas that written down in this initial stage to the ACI's. For example one of the ideas shows how Staff Replace-ability translates directly to the ACI C2 Replace-ability. Another was customer quality again relating the indicator D1, issues such as lead time and scale-ability were also mentioned. This confirmed that the initial development was along the right lines and that the ACI's were comparable with some of the ideas I had for factors that may affect a company's performance.

The next stage was to then develop the diagram into a fishbone containing the relevant ACI's on the 'bones' relating to the sub factor being examined, in this case rivalry. The original diagram containing the first pass analysis was used as a basis for this second diagram. The factors highlighted were compared to the list of ACI's and relevant factors were inserted onto their pillar (e.g. my idea of staff replace-ability translates to → C2 Replace-ability (ACI) on the People pillar).

Two points to note here, as mentioned before the operational agility was not covered and the pillar for people has quite a small number of ACI's, this may be an area which can be developed in the future to provide further measures.

Once this diagram was complete a validation was necessary to further to show that the factors are true reflections of manufacturing outputs and the influences that affect them. For this the text of John Miltenberg in his book Manufacturing Strategy (Miltenberg J, 1995) was referred to.

In this text Miltenberg outlines six manufacturing outputs which cover all outputs that manufacturing can generate. These are as follows.
Cost, Quality, Delivery, Performance, Flexibility and Innovativeness.
The definitions of the outputs are summarised in the table below: (Miltenberg J, 1995)

Manufacturing Output	**Definition**
Cost	The cost of material, labour, overhead and other resources used to produce a product.
Quality	The extent to which materials and operations conform to specifications and customer expectations, and how tight or difficult the specifications and expectations are.
Performance	The product features, and the extent to which the features or design permit the product to do things that other products cannot do.
Delivery time and delivery time reliability	The time between order taking and delivery to the customer. How often are orders late and how late are they when they are late?
Flexibility	The extent to which volumes of existing products can be increased or decreased to respond to the needs of customers.
Innovativeness	The ability too quickly introduce new product or make design changes to existing products.

Fig 20: Miltenbergs manufacturing outputs (Miltonburg 1995)

In this first development of the cause and effect diagram the ACI's were checked against Miltenbergs manufacturing outputs. Simply examining how each ACI would affect the manufacturing output either positively or negatively did this. If it can be argued that there is some effect generated on one of Miltenbergs outputs it can be argued that the ACI is a genuine factor that can be used to aid improvement and therefore is a valid point in the BEA system. The full validation and reasoning behind the placement of effects is found in the Toulmin validation section of the project.

The arguments used in this first instance can be found in the appendices of the project. (Appendix 3)

The following table shows a summary of where the ACI's were placed within the manufacturing outputs of Miltenberg. They may of course fit into more than one area but this table is not meant to be exhaustive. It merely demonstrates the fact that the ACI's do indeed have relevance on the output(s) of manufacturing.

Outputs	Delivery	Cost	Quality	Performance	Flexibility	Innovativeness
ACI's						
	B1	B6	B2	A1	B2	A6
	B4		C2	A6	B4	A2
	C2			A2	B1	
				A6		

Fig 21: ACI Compared to Miltenbergs Manufacturing Outputs (Hetherington 2007)

For a complete list of the capability indictors and the meaning of the abbreviations used (A1, A2 etc,) please refer to page 8 and the Abbreviations and Common Terms list.

These diagrams helped to develop a proposed methodology for taking the system to the next stage of automation by taking the system a little further towards the route of. The methodology was as follows:

Develop an Ishikawa (fishbone) diagram of one sub-section; in this case Rivalry, this forms the backbone of the diagram with the four ACI pillars as the offshoots. (People, Product, Process, Operational)

Fill in the Fishbone with causes effecting this subsection

Relate these ideas to the ACI's developed to check that both systems will agree with each other.

Re draw the fishbone diagram with the ACI's placed on the branch which needs strengthening to help the sub factor become more robust and make the company more agile in this sector, i.e. which capabilities does the company need to take on to combat this sub section if this sub section was weak for them.

Check ACI's fit into Miltenbergs manufacturing outputs / strategies.

This also gives focus of where the main area of concentration should be – in other words a simple agility focus tool.

Explain the reasoning behind each placement of the capability indicator.
Place the ACI's in a table and cross reference these with the Best Practice tools available from the Agility Centre. This will create an action plan list of tools that will affect the capability indictors to improve company performance.
Develop a negative impact table to show where tools may cause weaknesses when applied if precautions are not taken.

This methodology for development seamed rather cumbersome and long winded so after careful re-consideration and consultation with the project supervisor and Agility Centre staff it was refined and adjusted.

This methodology became:
Develop fishbone diagrams of sub-sections using the ACI and pillars which when strengthened increase capability of the company for that sub-section.
Explain the reasoning behind the placement of the capabilities for each sub-section.
These first two steps help to think about how the company could become more agile and responsive in the marketplace and how the capability indicators affect the company if they are strengthened or weakened.
Use this to develop a tool selector table for each ACI which helps to select the right tool for the right capability. The table will show where applying a certain set of tools and techniques will strengthen capabilities.
Develop also a table that shows how capabilities may be weakened by applying certain tools or techniques to other capabilities. i.e. a cross impact table to show where capabilities might be diminished when applying tools to other areas if the pitfalls are not recognised.
Apply these tables to case study examples to test the results.

Therefore a set of capability cross impact tables needs to be developed to be able to apply the above methodology.
These tables are:

Tools selector table which shows which tools strengthen which ACI's giving a quick reference as to what tools could be used to improve the weak capabilities of a company. The table gives some degree of impact also in the form of High Medium and Low to guide in the priority selection of tools and techniques.

ACI Vs Tools table which shows where capabilities might be weakened by tools being applied to other areas. This will flag up areas which need to be monitored carefully if any of the cross impacting tools are implemented.
ACI Vs Miltenberg table to show that the capabilities are affecting manufacturing outputs and that the ACI table that is being used is a relevant and appropriate tool to help strengthen the capabilities of a company.

ACI Vs ACI table that will highlight any potential cross impacts of strengthening capabilities. It will flag up if there is any possibility of another capability becoming weak as one becomes strong. This table will simply show positive and negative impacts on the other capabilities. The negative ones will be the most important as this means a loss of some capability. A loss of capability may not be a bad thing as the market in which the company is operating may not require this capability but it must be examined. Companies must also be careful not to loose capabilities that they may later come to rely on to enter or develop in a market.

These tables will be developed and explained later in the project.

Intensity of competition
Sub-factor
Rivalry

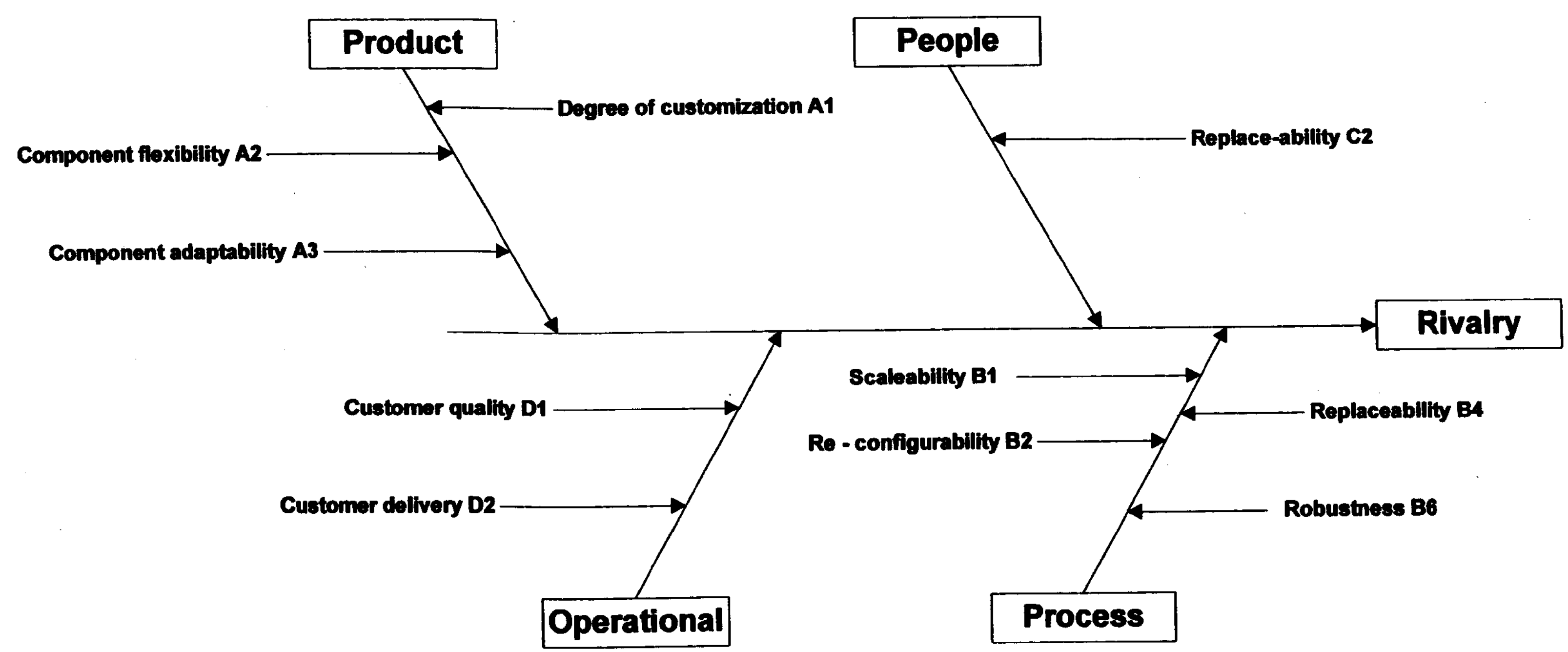


Figure 22: ACI placement on Intensity of Competition (Rivalry) Ishikawa (Hetherington 2007)

Placement of ACI's on the Second Rivalry Diagram

Rivalry sub factor looks at factors relating to organisations operating in the same market who are considered to be direct threats to the target organisation, the competitive behaviour and performance of these organisations, and the impact of such behaviour / performance on the target organisation. The factor also addresses those factors that can be attributed to the company's products and the market perspective or both as a comparison.

This was the second diagram to be generated for the sub factor rivalry. Some of the other sub factors that are examined during the questionnaire section are: Competitor, Market share, Price rivalry, Delivery performance, New Products and Alternative Products.

The ACI`s identified as affecting this sub factor are as follows:
A1 Degree of customisation
A2 Component flexibility
A6 Component adaptability
B1 Scaleability
B2 Reconfigure – ability
B4 Replaceability
B6 Robustness
C2 Replace-ability
D1 Customer Delivery
D2 Customer Quality

The reasons for the placements of the ACI`s on the fishbone diagram are as follows: (This will not cover every reason for the placement of the ACI but will cover the most relevant points and try to look at some of the knock on effects on the rest of the business, some tools are highlighted that may impact on the weak capability. The validation process can be found in the Toulmin validation section).

Product

A1 Degree of customisation. The degree of customisation will impact on the choice that the customer perceives they are getting from the manufacturer. This may be something that is highly desirable, like in the car market, or not at all, a large amount in the white good industries. If competitors are offering large amounts of choice and customisation to their products and the market likes this choice, a company offering small amounts of customisation or none at all will not survive. This therefore becomes crucial to the market the company operates in. To look at customising products companies should use tools such as cellular manufacturing and BPR to re design how the product is assembled to allow for different components and structure to be put in at the appropriate point in the manufacturing cycle. Looking at the number of shared components and platforms may help as these can serve as many different products based on the same platform, like cars which share floor plans, e.g. golf, TT, Beatle are all based on the same floor plan but are completely different products.

A2 Component flexibility. This is again much the same as above. Companies need to be able to offer choice easily to the customer without causing a large increase in price to the end user. Mass customisation techniques should be examined and benchmarking market leaders or competitor's products would be useful here.

A6 Component adaptability. This capability helps to keep costs down while offering choice to the customer in customising their product. For much the same reasons as above it is important in many industries. Other sub factors that this may impact on are market share, which may be increased by offering a greater range of choice, and new products which may be generated from existing components but with new features and look or feel about it. This feature may benefit from BPR techniques where the re design of components or products may help share platforms.

Process

B1 Saleability. By having the ability to scale operations up or down according to the demand from customers, a company will be able to offer shorter delivery times and better service to the customer. If a rival can supply an alternative product quicker, then customers may go else where for the product. Therefore the ability to produce quickly and efficiently is vital in holding onto the customer. Some tools that may be used for increasing the saleability of the production facility are: BPR, Layout restructure to give a quicker flow through of product, multi-skilling, cellular manufacturing and SMED.

B2 Reconfigure-ability. The ability to achieve new goals quickly and cost effectively can help respond to trends in the market, combat a rival's new product and achieve customisation, which is desirable to the customer. This may help to achieve more market share through differentiation of the product or may help to develop a new product that can be brought to market before a competitor. Similar tools to above should be used here to help with reconfigure-ability issues.

B4 Replace-ability. The ability of a process to utilise alternative sources for the same goal is important in getting products to the customer. It means in busy periods products can still be manufactured and delivered on time allowing an advantage over rivals who may not be able to do this and so deliver late. It also means that if there is a production line that is not busy, the line can be utilised for an alternative, costs can be kept down, allowing competition on price rivalry. Techniques to use here to strengthen this sector could be BPR (business process re-engineering), layout restructure and cellular manufacturing.

B6 Robustness. If a process is robust from a demand, reliability and maintenance point of view then that process should be able to deal with varying amounts of products, have few or no breakdowns and produce good quality product, therefore needing few readjustments. Robustness will increase delivery performance and will stop extra costs being incurred. This means there are several areas that the company can perform better in. It means stability in the manufacturing process which can lead to better performance of the company due to less re planning, less unscheduled breakdown, less scrap and re-work and more on time delivery. Tools which help this area perform better include, TQM (Total Quality Management), 5S, 6 Sigma, OEE (Overall Equipment Effectiveness), Kaizen / kaizen event, Poke Yoke and FMEA (Failure Modes Effects Analysis).

Operational

D1 Customer Quality. Placed here for rivalry because the quality of your product delivered to your customer will determine customer satisfaction, it can also be an order winning criteria for certain industries and is certainly a minimum entry requirement in most. People buy brand names because of a perception of quality; examples include BMW and other 'German' car manufacturers who offer a perception of quality and features on the cars they sell. This can be used to gain market share and as a differentiating factor in your product or service. Some tools that can be used to improve customer quality are benchmarking against competitor to make sure that your spec is at least as high as or better than competitors. Once the spec of the product is correct then maintaining the spec can be done using tools such as 6 Sigma, TQM or SPC to maintain processes within parameters.

D2 Customer delivery. Again secures repeat orders from existing customers who may also measure supplier performance and have a minimum standard of delivery criteria that suppliers should meet. By meeting these standards and gaining a higher rating the business becomes more secure. A reason customers may impose such strict delivery times may be that they are also manufacturers and are working to JIT or other tight delivery schedules and the delay of one part of being supplied to them is costly and causes problems to changes in manufacturing for them. Customer delivery becomes crucial in the white good market, as consumers don't expect to have to wait for the T.V. they have bought; they want to take it home. This means that scheduling and planning for demand, and making sure stock outs never occur, affects the delivery to the end customer here. Some tools in this scenario may be re-order point control on stock, Kanbans from retailers and a manufacturing system which can be quickly scaled up or down. Other tools to effect delivery may be reducing the manufacture time through BPR, looking at tools such as SMED and 5S to aid reduction in manufacture time and increase capacity to allow for quick scale up or down depending on demand.

Changes In STEEP
Sub-factor
Changes in Manufacturing

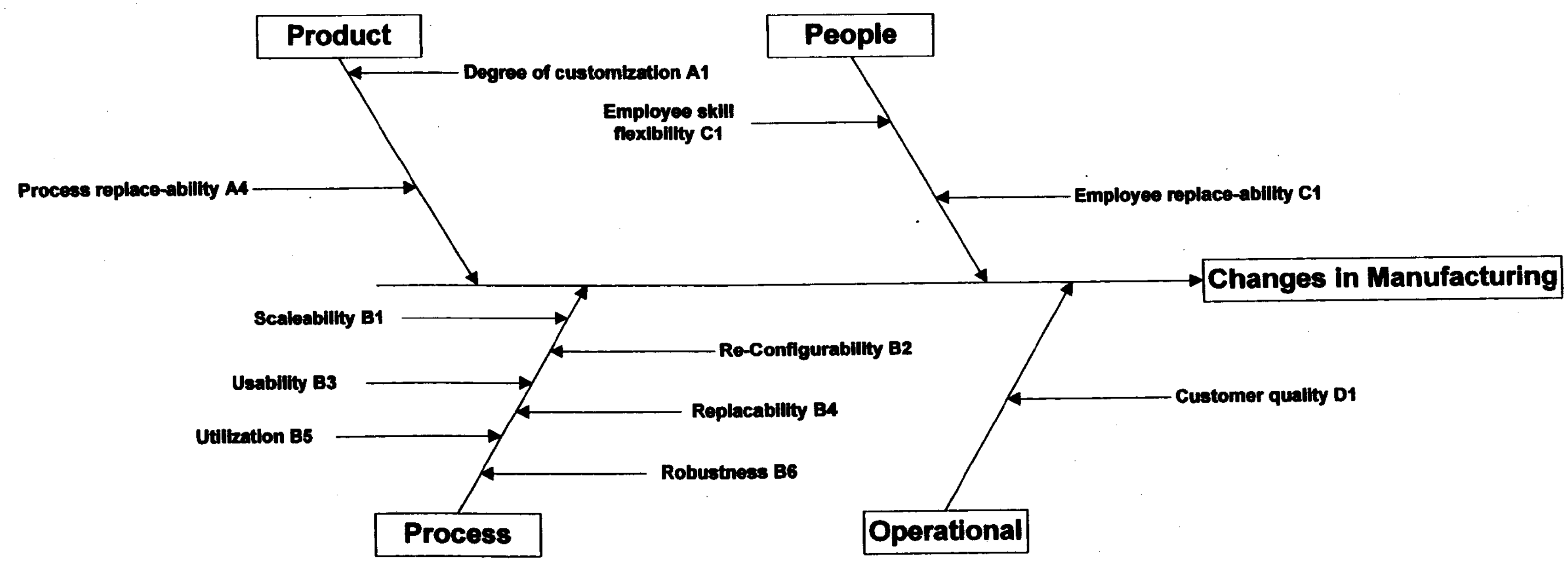


Figure 23: ACI placement on changes in STEEP (changes in manufacturing) Ishikawa (Hetherington 2007)

Discussion of placement of ACI`s on 2nd fishbone diagram

Pillar: Supply Chain Turbulence

Sub factor: Changes in manufacturing

Changes in manufacturing looks at the process of producing saleable product through the activities of the manufacturing workforce and processes utilised, up to and including packaging.

After the initial diagram and the methodology had been completed I decided that I needed to produce at least two more diagrams. This was to see where the relevant ACI`s fitted in with the pillars and sub factors of the ETI system, and to produce something to work with when looking at tools and techniques and the cross impacts of these on each other and on other areas of the business.
The third diagram to be produced was the changes in manufacturing diagram. This sub factor of the ETI looks at areas such as labour force size, training needs of the company / staff, productivity, accidents per employee, capacity, changes in process for improvements, and defect rates, among others.
The ACI`s identified as affecting this sub factor are as follows:

A1 Degree of customisation
A4 Process scaleability
B1 Scaleability
B2 Re configurability
B3 Usability
B4 Replaceability
B5 Utilisation
B6 Robustness
C1 Employee skills flexibility
C2 replace ability
D1 Customer quality
D3 Customer volume

The full list of definitions and explanations of the ACI's can be found in the appendix 2.

The reasons for the placements of the ACI's on the fishbone diagram are as follows: (This will not cover every reason for the placement of the ACI but will cover the most relevant points and try to look at some of the knock on effects on the rest of the business and some tools that may impact on the weak capability. The validation process can be found in the Toulmin validation section).

Product:

A1 Degree of customisation: This will have an impact on many factors within the manufacturing unit of the company by adding or removing complexity to the BOM (Bill Of Materials) and to the manufacturing processes themselves. It means if the company are offering a high level of customisation the BOM can potentially be quite large and the right parts need to be added to the right product. It means the manufacturing processes may have to change or adapt for different options and so the system will need to be flexible enough to do this. One example may be a paint spraying operation. With only one or two colours the planning and control of this operation is easy, once the number of colour options become high then the change over from one colour to another become more complicated. This means the planning of this operation is crucial and also the change over time needs to be minimal. Tools to be used here would include SMED (single minute exchange of die) to reduce changeover and possibly an MRP (Materials Requirement Planning), ERP(Enterprise Resource Planning) and Production Scheduling system to ensure the same colours are processed in the most economical order sizes. As the degree of customisation increases so do the chances of stock outs, and part defects if not managed correctly. Capacity could be reduced if not properly controlled at the receipt of order and manufacturing planning stage.

A4 Process replace-ability: Process replace-ability looks at the ability of components and products to be manufactured by alternative machines. A situation may arise where a particular product line has a large amount of orders, if the company has the ability to make these products on alternative machines, some of the spare capacity from other product lines could be utilised to fulfil customer orders. It will mean employees training in all product lines and being able again to swap between products quickly and efficiently. It may have training implications for the staff and also productivity issues if the alternative machines cannot operate at the same speeds as the intended machine for the product. In the worst case there may be increased defects or employee accidents. This area will help the company become more responsive to customer orders if managed correctly and may be useful in situations such as unplanned down time or planned maintenance time when machines are unable to run. Another advantage of having one machine able to perform many operations is in minimising schedule changes. To change schedule many times is time consuming and difficult especially in long lead-time production. The number of times a job needs to be rescheduled can be reduced if spare capacity can be used to house the job to be moved. Process replace-ability may also help with the introduction of new product ranges or lines, where by some existing plant and equipment may be able to be utilised for the new product. If many machines can be used for the new product lines they will not encroach on the capacity of the existing lines which can be moved to alternative machines, cells, manufacturing areas, to continue production. Cellular manufacturing may be considered here to give replace-ability.

Process:

Process agility in changes in manufacturing is all relating to how to keep the changes under control and producing the desired product in the most efficient and timely manner.

B1 Scale-ability. This will effect the changes in manufacturing depending on how easily the company can scale up or down production to match its current demand. This has effects on the sub-factors including labour force size and employee training, staff turnover and days off per manufacturing employee. It will also effect the throughput to capacity, number of set up and tear downs, number of machine breakdowns and on the planning side, stock out and rejects.
For process agility machines and processes need to be able to take on extra capacity quickly and efficiently without having increased breakdowns and or maintenance issues.

By having processes which can ramp up or down quickly, and the necessary staff to perform these operations, scaleability will help reduce the number of changes to manufacturing and keep the production process flowing smoothly. To help with staff agility more staff should be multi skilled, which means they can transfer from other areas of work. Another option may be to have a core of staff trained on all the operations which require skill and knowledge and take on agency staff or other temporary workers to perform unskilled tasks which aid production at busy periods.

B2 Re-configurability. This looks at the ability of processes to be easily re configured to achieve new goals efficiently and cost effectively. By having machines able to do this, manufacturing can continue unhindered with the minimum of disruption. This may be to new products, different product lines or for R and D purposes. If machines and processes can be re configured easily then defects should be kept to a minimum, which will help to keep costs down and manufacturing changes under control. Effectively re configuring a process should also mean that breakdowns on the machine do not occur regularly which again keeps the processes under control and the manufacturing process flowing. SMED, BPR and design for manufacture may be considered here for tools to help strengthen the re-configurability aspect.

B3 Usability. The ability to utilise resources available is key to keeping the changes in manufacturing under control. It aids processing of scheduled jobs and helps to reduce tear down and set-ups in alternative areas of the factory. It also means throughput to capacity is kept at maximum which is especially important during busy periods. This fits nicely with a multi-skilled work force that is able to utilise the resources available to produce as much as possible from what is available. It helps to reduce costs and maximise the usage of equipment. One tool that measures the usage of the equipment is OEE (overall equipment effectiveness), this looks at the percentage of time a machine or piece of equipment is busy producing good quality products. Productivity is maximised for the resources available and schedule changes are reduced as the planned work can take place on time and with the right quality.

B4 Replace-ability. This capability helps to keep changes in manufacturing under control in much the same way as usability does. By using alterative sources for a process, maintenance can be undertaken during busy periods, breakdowns and R and D can be scheduled in. It also increases throughput to capacity and allows schedule changes to be reduced, or the effects of them reduced. Tools to look at here are SMED, allowing tools to be exchanged quickly and efficiently, and also BPR (business process re-engineering). This may need doing to allow the purchase or design of machines that are capable of producing many different products and carrying out many different types of operations. Cellular manufacturing may also be a good tool to use here so that machines with varying capabilities can be placed together. This can be done in the form of cells and should be a consideration in the design of the production system

B5 Utilisation. By increasing utilisation of a machine, the value adding time is increased, throughput to capacity should be increased and productivity should be increased. This will help in delivering the products to customers on time and will help during busy periods when ramp up is needed. Increasing the value added amount of time and reducing the non-value added helps to reduce process cost making the cost of the product lower, which helps with profit margin. Labour force size will remain the same while the turnover per employee will be increased bringing the factor a lower score on the ETI questionnaire. It will also mean that there is more control in the scheduling area with more capacity to play with but with no extra machines. It may mean shorter runs of products become acceptable in terms of value as long as there is a SMED implementation of the changeovers. Other tools used here to increase the utilisation will be OEE, 5S (to allow all the appropriate tools to be on hand) and Kaizen or Kaizen events that aim to take out the wasteful non-value adding processes.

B6 Robustness. This is an important factor in reducing the amount of downtime, rework and scrap that a process is subject to. If the process is robust then it is more productive, it makes better quality products and requires less re-planning upon breaking down. Tools to increase robustness might be TPM (total preventative maintenance), 5S to allow the correct tools to be used on the machine and not cause damage or scrap, and SMED to reduce the amount of time the machine is idle during changeover, but also to produce a set of procedures which will eliminate mistakes during the set up of crucial machines.

People

C1 Employee skills flexibility. This is important to changes in manufacturing as the workforce need to posses the skills to deal with any changes in manufacturing that need to take place. It means that the changes will be made more efficiently if staff are adequately trained to deal with many types of process, product, or machine. It also helps to cover unexpected absence or holiday within the workforce and allows the planned production to go ahead. This helps to deal with the turbulent factor of changes in planning. The number of employee suggestions should increase if staff are multi trained as many different skill sets will be looking at the process in a critical way and fresh ides will be put forward. This will help the company if they are embarking along the Kaizen route of improvement and wish to be continually improving how they perform operations. To get the skill level of the workforce up to the desired level a skills matrix should be drawn up and the core of staff, and skill sets identified. This will help to show gaps in knowledge that can be filled via training. A multi-skiling exercise then needs to take place whereby all staff are given targets of tasks and products to learn, teacher / mentors should also be assigned. Staff should then be tested on the skills and the matrix updated until the target number of staff can perform the required number of operations efficiently and effectively. This should help to reduce percentage defects, which are another factor within the changes to manufacturing set of questions. If the percentage defects are reduced costs in this area should be reduced or kept under reasonable control.

C2 Replace-ability. This is crucial if only a small number of people are trained in certain tasks. As many people as possible need to be trained in each area so that if unforeseen problems occur the job can still be carried out. This means if members of staff leave or take holiday the process can continue to run effectively. Again multi-skilling of the staff allows many people to be trained in operations, but key operations, where there are few members of staff available to perform the operation, need to be identified first. This can help in many of the sub factors in the changes in manufacturing section, it can help with reducing breakdowns if maintenance staff are fully multi-skilled. It can help with set ups and teardowns and productivity can be increased by new ideas coming in from staff who have recently been trained. All of these add up to make changes in manufacturing more controllable with less re scheduling having to be done around staff skills and more geared up towards the demand of the customers on the company.

Operational

D1 Customer Quality. This identifies over a period of time how often the customer receives products with defects. If this can be reduced the largest effect is in the perception of the customer of quality of the product and reliability of the supplier. The effect on changes in manufacturing is quite large also. It helps to reduce costs of the processes by producing right first time and not having to use raw materials to produce scrap, it will also reduce the amount of re-work carried out. This will effect the planning of the production system if products have to be re-manufactured as the customer will probably require the re-manufactured products quickly and so this new order will have to move ahead of all the scheduled jobs already in production. It also has implications for the planning of raw materials and components, as the production planning system may not have re-ordered components if the product has already been manufactured and shipped. This will place pressure on suppliers to bring forward orders and re-supply certain components. By having to re supply the customer it may be necessary to perform extra set-up and tear down procedures which have not been planned for, and this will reduce the capacity of the manufacturing system, meaning current orders are not delivered on time.

Many tools are available to help with increasing customer quality ranging from 5 S organisation of the workplace to ensure the right components and materials are going into the product in the first place, Poke Yoke or fail safe devices that stop the product being produced in the wrong way, to much more complicated monitoring of processes such as 6 Sigma and TQM (total quality management) techniques where processes are monitored between control values and production stopped if the product is seen to be moving out of control.

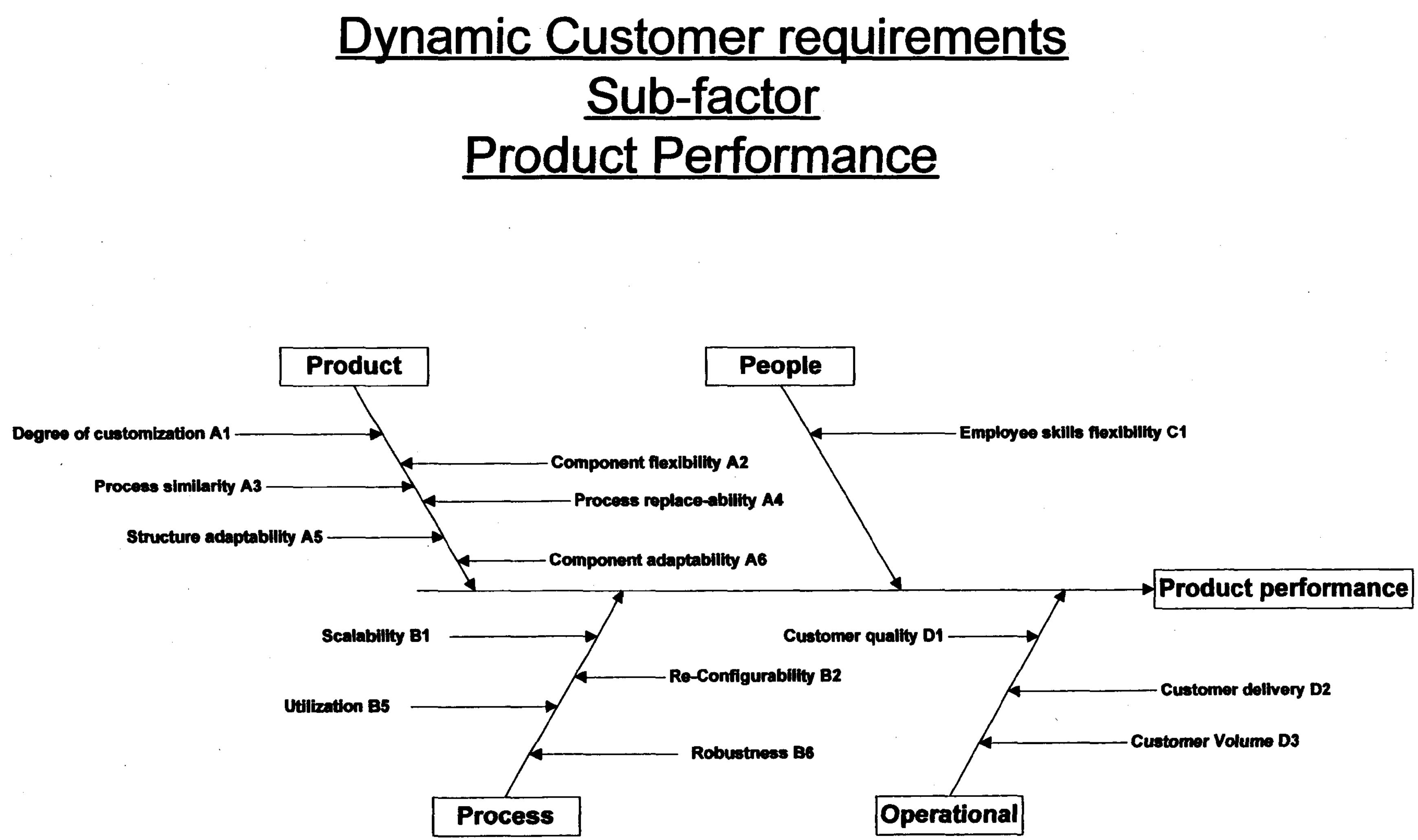


Figure 24: ACI placement on Customer Requirements (product performance) Ishikawa (Hetherington 2007)

Explanation of placement of ACI's on 3rd fishbone diagram

Pillar: Dynamic Customer Requirements

Sub factor: Product Performance

Product performance looks at change caused by customers that determine the performance of an organisations product(s) within the business environment, thus having an impact on internal business operations in terms of Time, Quality, Cost and Flexibility.

After the initial diagram and the methodology had been completed two more diagrams were completed – generating more data to work with. This was to see where the relevant ACI's fitted in with the pillars and sub factors of the ETI system, and to produce something to work with when looking at tools and techniques and the cross impacts of these on each other and on other areas of the business

The third diagram to be produced was the Product Performance fishbone diagram. This looks at areas such as: Product sales returned, finished stock turnover, Delivery failure, Quality failure, Repeat orders, product demand, BOM levels, and Product variety, among others.

The ACI's identified has affecting this sub factor are as follows:

A1 Degree of customisation
A2 Component flexibility
A3 Process similarity
A4 Process replace ability
A5 Structure adaptability
A6 component adaptability
B1 Scaleability
B2 Re-configurability
B5 Utilisation
B6 Robustness
C1 Employee skill flexibility
D1 Customer Quality
D2 Customer delivery
D3 Customer volume

The full list of ACI's can be found in the appendix 2.
The reasons for the placements of the ACI's on the fishbone diagram are as follows:

(This will not cover every reason for the placement of the ACI but will cover the most relevant points and try to look at some of the knock on effects on the rest of the business and some tools that may impact on the weak capability. The validation process can be found in the Toulmin validation section).

Product Agility

A1 Degree of customisation. This will impact on product performance because of the demand that customers place on the company for features in the product. If there is a small amount of customisation of the product then it may cause a larger demand for products. It may also start customers demanding more customisation, which will impact on the design, quality and cost of a product if the company are not geared to offer this amount of customisation. If the company are not set up to offer highly customised parts then there may be a large amount of customer returns due to quality issues. It will also imply high levels of WIP as de-coupling points will be inserted, these will become large if not set up correctly to deal with the customisation. It means high uncertainty of demand and so companies tend to keep high levels of stock to deal with customer orders. It helps to stop long lead times developing. It does however lead to high cost of WIP, quality defects though damage in storage and this lead to a reflection in price of the cost and complicated BOM's with numerous levels.

If customisation is arranged properly the company can have flexibility to manufacture many different products using similar platforms and standardised components which share part BOM's (Bill of Materials) with other products / product ranges. There are some calculations available from the Agility centre that helps to develop this. There is also a matrix that shows how customisable the product, and product range is in the current format.

Tools which help to impact here on some of the customisation problems of flexibility, high WIP (Work In Progress), and complicated BOM may be: Kanban replenishment, maybe from a de coupling point to help judge the rate of stock usage, Cellular manufacturing, 5S organisation of the workplace and supply chain management to ensure the Kanban system is possible with current suppliers.

A2 Component flexibility. This capability again helps with customisation issues that may arise from the customer demanding better 'performance' from the product. If a component can be supplied from alternative sources and used in an array of products then there are several benefits. The supply of a component may be internal or external depending on the process. Benefits of component flexibility will be a reduction in the BOM complexity across the product range; this means less stock is needed and less numbers of components to manage the flow in and out when customers place orders. This also helps with the stock turn calculations, as there will be less stock which sits around for a long time, as a larger percentage of orders will use the stock items. This should also improve delivery times and reduce the amount of late deliveries to customers helping to secure repeat orders an increase product demand. Again there are tools developed within the Agility Centre to help deal with this type of issue. Matrices can be drawn up and used to see how many products use specific components and how this number can be increased and how this can be managed. The aim is to develop a range of products that can have common components up to a point very late on in the production process. This point is the decoupling point whereby all products will be the same until here, they will then have different modules bolted on to give different performance and features. Similar tools to above will be used here to manage the components and ensure that they are utilised in the most effective manner.

A3 Process similarity. The ability of components and products to share operations allows a smaller amount of machines to be used within the factory space and should increase the amount of time each machine is being used. If one machine can make fifty products instead of one machine for each product there is obviously a large capital saving. In reality one machine would rarely be able to replace fifty but a smaller number of machines performing more varied operation make the company more responsive to the demands of the customer. This will help with the sub factors of price, product variety, stock levels and utilisation of machines.

The best tool for this is to create cells (cellular manufacture) which can handle a number of products from the range available to the customer, the cell should be able to take in a common framework for the products available and add, remove process and parts in a number of ways which make the product unique in features and design. Cells should be designed carefully to accommodate as many products as possible but should be designed around the products in the range with as many common features as possible. This means similar operations are taking place to develop highly different products. This approach should also reduce the lead-time of the product to customers as tooling and machine issues with changeovers from one product to the next are minimised. Within each cell, Kanbans should operate to keep the right amount of materials and minimal stock within the area. JIT (Just In Time) and benchmarking may also be useful tools here depending on the market and required lead times and whom the company is to benchmark against.

A4 Process replace-ability. The ability of components and products to be manufactured on alternative machines is of importance because of scaleability issues with highly customised product ranges. If machines are so specialised that they can only produce one product range or one product then problems arise when large orders are received. It means even if there was a decoupling point behind, this one machine becomes a bottle neck process. Process replace ability needs to be effective and controlled in an appropriate manner to ensure quality issues don't arise with unsuitable machines. Again having multiple machines should mean that the WIP could be reduced at the de-coupling point, which enables higher stock turn and reduction in costs.

The Agility Centre have developed some matrices to look at this and help with deciding how machines should be organised in cells to aid multi machine processing of parts. Cellular manufacturing, JIT and Benchmarking are all tools to have an effect here. 5S would also help to some extent with the organisation of the machines and the materials to be processed. While cellular manufacturing is being carried out the layout and routings of parts / materials should be considered to make it easier for products sharing processes to travel similar routes.

A5 Structure adaptability. A6 Component adaptability. These two will be covered together in this section as they have similar implications to the manufacturing system and similar tools to help cope with the problems they will throw up. When designing new products / product families or groups of products, using some of the existing materials from the current product ranges BOM will aid in keeping the BOM to a manageable level while still offering other customisable features. It means existing processes and machines can be utilised with minimal retraining of staff in the new product range and it also means that current components / structures in stock are now being spread over a wider range of products which will increase stock turn. In theory using the existing components and structures means that quality and price should be a known quantity and if the quality of the existing components is good then it should remain so for the introduction of new products.

Tools to help here would be design for manufacture, design for assembly and a careful examination of existing processes, procedures, BOM's and problems within the assembly of existing ranges.

Within the product section a number of tools and techniques have been covered to give improved agility in this area. Some provisos have to be given as well as some of the weaknesses that may occur when embarking along this route. When reducing BOM complexity and essentially cutting down the number of suppliers to company will be left exposed to a number of factors. One supplier will provide a large quantity of components in a large number of products meaning if anything happened to this supplier then there will be massive implications on the production facility. It means the company are sensitive to price increases from this supplier and this may be unavoidable due to the amount of leverage which can be placed on the supply chain. This may also lead to another problem with kanbans, which are known to be insensitive to demand. If demand increases dramatically then the re supply of kanbans may not happen quickly enough leaving stock outs and the collapse of the manufacturing system. This needs to be monitored carefully and in busy periods the size of the kanbans will need to be increased to give more time for replenishment. The company may also want to invest in new technology to bring certain key functions in house. This will allow greater flexibility when designing and processing components. It will also help to reduce sensitivity to the supply chain. Another alternative would be to do some supply chain optimisation and form partnerships that allow a close working relationship. There are also design considerations when trying to reduce the number of components in a product. The BOM of the family of products in which components feature needs to be considered carefully. This is to avoid complication of the larger family BOM when simplifying one products' BOM, if components are removed or substituted in one product how does this affect the use of the component in other products in the family?

Process Agility

B1 Saleability. Scalability helps mainly on the delivery performance of the product. When a large order or several large orders are received being able to scale up the production process to help deal with the extra demand will mean fewer or no customers are let down on delivery dates. Being able to scale up production may also help if current customers change the quantity part way through manufacture. If an increase is wanted and the company can efficiently scale up production this should not disrupt planning too much. The other sub factor this may have an impact on is the number of times a customer is placed on hold. This will be reduced if the capacity can be increased for demand matching purposes.

Tools which are effective here are: cellular manufacturing, layout restructure, SMED and OEE, depending on what the bottleneck to increasing production is.

B2 Reconfigure-ability. Process reconfigure-ability helps in three ways for this sub factor. It can help to achieve the demand placed on current products by reconfiguring processes to make the product or product range with high demand, therefore helping to meet delivery criterion. It can help with mass customisation issues by allowing different components or sub assemblies to be added and give different functionality. This is important here because by having a quick re configuration of process the products can be produced quickly, efficiently and cost effectively.

Tools that would be commonly used here are mass customisation tools, (see agility centre work on mass customisation matrices), BPR, and possibly FMEA if the reconfiguration is causing problems with the product range.

B5 Utilisation. This looks at value added and non-value added activities. With less non-value adding activities the product will be manufactured quicker and will cost less to produce, therefore meaning a more competitive product. It may also make space for some customisation to take place instead of a non-value added activity. Utilisation will also help delivery aspects much as above. Similar tools would be used here but the machine / process should be examined carefully and any waste removed with Kaizen, SMED and other such tools. OEE should be used to measure how effective the machine is before and after applying the tools.

B6 Robustness. This is important for all the same reasons as above. But, it is also important when the customer is specifying a product in being able to change to new goals, deal with new demand and have low breakdown or failure rates. Robustness of a process will allow many variations in product size shape colour for example and will still be able to produce at a stable rate. It is important to meet customer demands not only on delivery but also on quality and functionality.

Again the tools applied to other process areas can also be applied here. To give process robustness however it should be designed in from the beginning. Therefore BPR may be a good idea with processes that are now extremely un-robust. Machinery can have tools such as TPM used, and installing 5S will help with keeping things in order and allowing a smoother flow of products, tools and information. 6 Sigma and SPC can also be applied to a process but the parameters must be chosen carefully as over engineering and over scrupulous quality control can be as bad as none at all. It can turn a perfectly acceptable process to the customer to one with high scrap rates, always running out of the control parameters and causing high cost.

People Agility

C1 Employee skills flexibility. This is important to a products performance for some of the issues talked about earlier. If cellular manufacturing has been introduced employees need to be able to operate many of the processes and machines within the cell. This will aid completing orders on time, improve quality with proper training of the staff and allow work to continue even if some staff are on holiday or absent from work. Busy product lines or areas can have extra staff sent to them and other cells may be converted to manufacturing busy product lines. It is particularly important in mass customisation environments to have multi skilled staff who will be able to fix and manufacture a variety of components to the core frame to give the product its customisation.

Tools to be used here should include multi skilling, maybe process deskilling so each process is split into smaller and smaller manageable tasks which can be quickly learnt by a number of staff and so many people can be trained to assemble a variety of products. 5S may also help here because of the order it give to the production area. Each tool and job should have the correct equipment to hand which makes identifying tasks easier, there should also be visual management of standards, go no go photos, diagrams, gauges etc.

Operational Agility

D1 Customer quality. The quality or perception of quality that a customer has of a product is a major factor in the performance of a product. If a product is designed to be a quality item with many features and a long life then this is what it must do and the design and manufacture process needs to fulfil those needs. As opposed to a disposable or short life product that needs to perform a small number of tasks and is expected to break or be thrown away. Customer quality will help to achieve repeat orders and will give the company a good image, something which is a motivator to staff as well as prospective customers. Failing on quality due to poor internal performance means costs are incurred / increased which has a knock on effect on profit and margins. Manufacturing systems need to be flexible enough to deal with mass customisation issues if needed and still produce products which are of perceived good quality. As discussed in previous ACI's in this section, the mass customisation of products needs to be performed in a specific way that enables products to be made effectively and efficiently. If the product is a standard good with minimal or little customisation then it still needs to fall inside the parameter expected by the customer. Tools to help improve quality include 6 Sigma, TQM, BPR, 5S and SPC. Some of these tools may not be suitable for some processes, especially 6 Sigma and SPC, which may impose controls on processes too tight and therefore cause large amounts of scrap.

D2 Customer delivery. Quick delivery is not always an important factor to customers. Some products that are perceived as high quality may benefit from a longer lead-time adding to the air of exclusivity. The majority of products however do not fall into this category and need short lead times and guaranteed delivery dates. Companies should meet these dates as often as possible to gain repeat orders, quick turn around of stock, avoid any shelf life issues and manage demand more carefully. Delivery performance is gained through many sectors of the company, and so many tools effect the delivery time. Essentially shorter processing time will give better on time deliveries. Often issues regarding customisation will slow down the processing times by having complicated BOM's. Here as talked about in the process agility section, appropriate decoupling points, re order levels and stock and inventory management need to take place to allow flow though the factory. Because of this the tools recommended here for impact on delivery are 5S, BPR, layout restructure, Cellular manufacturing, possibly MRP and possibly JIT systems.

D3 Customer volume. Looking at customer volume will give some idea of product lifecycle, market reaction to the product and how healthy the product or family of product is. Obviously market considerations and competitor's market share may also need to be considered here to give a better picture. It is worth looking at to find out if the market is responding well to any changes in the product and maybe trigger some more in depth market research. This area has no particular recommendations but is mentioned in passing as it may be important to keep an eye on the types of customers being serviced and look at where large volumes of sales are coming from.

This chapter has covered how and why the Ishikawa diagrams have been developed. The next chapter will cover how the tables for cross impact are developed from the Ishikawa work. It will also highlight how the tables will be used as part of the ASF and what value they bring to the framework.

Chapter 5

BEA Systematisation

Tool selection automation

This chapter covers the development of the cross impact tables from the Ishikawa diagrams in the last chapter. The tables to be developed here are:

Tool selector table

ACI Vs Tools (-ve impact)

ACI Vs ACI

Tools Vs Tools

ACI Vs Miltenbergs manufacturing outputs

The tool selector table will be used in the ASF to provide robustness in selection of tools for strengthening capabilities. It will take out some of the ambiguity associated with the selection of tools to improve the manufacturing system. It will also mean that the ASF produces consistent and repeatable results.

The ACI Vs Tools negative effect table will be used in the ASF to highlight the possible negative effects of implementing tools. It should be used after the tod selection table to show which areas of the business may be weakened after implementation. It will again give a consistent approach to highlighting where the ASF operator should be looking during implementation to avoid the negative impacts.

ACI Vs ACI shows the cross impact of capabilities on each other and can highlight potential issues in capabilities that are not being focused on while one is being strengthened to combat existing turbulence.

Tools Vs tools is similar to above in that it shows how tools interact with each other while being implemented

ACI Vs Miltenbergs manufacturing outputs shows generically that the capability indicators fit with the outputs of manufacturing as stated by Miltenberg and that they are therefore generically valid capabilities to be enhancing when developing the performance of a manufacturing company. This table will not be used in the ASF implementation but is here for information purposes.

The cross impact tables have been developed from the fishbone diagrams by examining the placement of causes against the turbulent sub sections and evaluating the tools suggested here on impacting the sub factor in a positive manner. When looking at the tools, I have examined text and case studies to look at the effects that they have had or are supposed to have from their definitions and literature, some of these definitions have come from the list of 'Best Practice' tools developed at the agility centre to compliment the ASF, the other tools have been researched and there definitions are included in the appendices. I have also drawn upon my own experiences from the company I work for and projects I have worked on to look at how the implementation of these tools has affected the company and it capabilities. This has then given me a list tools which will have a positive effect on the capabilities. These have been checked for in the Best Practices folder at the Agility centre and the definitions examined. If they are not included they have been researched and defined from case studies where they have been applied and worked, and from literature available on the theory of the tools, the case study data from new tools in included in the appendices of the project. The tools have then been defined in the appropriate structure (in the same manner as the rest of the best practice folder) and placed into the appendices in the back of the project (appendix 3). The tools are defined, tips and tricks are listed, and things to watch out for, the benefits and the capabilities they affect are also included. This has helped to develop and improve the range of tools that are available for selection and hopefully provides for wider industry background and different types of markets and products.

The list of tools available is not definitive and will be added to over time and new tools become available or new case studies come to light highlighting the use of different tools to affect the ACI's.

As well as listing the positive effects in a high medium and low priority on the diagrams the negative effects on other capabilities must be considered. This was done after the diagram of the positive effects had been drawn in the manner explained above. The negative effects of each tool were considered by thinking of one tool at a time and moving down the list of capability indicators. At each indicator the effect of the tool was thought of as nil, positive (in which case there would be a high medium or low ranking in the space on the table) or negative. If negative was the answer the effects were examined in more detail and again considered on a high medium and low scale.

The high medium and low scale given on these diagrams is not judged in a particular mathematical way; instead it is based on the feeling gained during the research of the type of effect seen when implementing the tool. It is also based upon the authors' own experience when implementing such tools and the effects they have had on the company. This means that some disagreement may arise from the scale of high medium and low but this is seen as less important here than ensuring the effects of the tools are noted. The aim of the tables primarily is not to capture the scale of effect but to capture the effect that a tool will have on capability so as to provide a definitive reference and then secondly, to give a flavour of the degree of effect, either positive or negative.

Each diagram on the following pages will have an explanation attached to it showing why it has been represented in the way it has and what its purpose in the research is. A short explanation of the way to use the table within the larger system will also be included here. For full validation please see the validation section of the project where an explanation and recognised method have been employed to aid in ensuring the validity of the tables.

For a complete list of the capability indictors and the meaning of the abbreviations used (A1, A2 etc,) please refer to page 8 and the Abbreviations and Common Terms list

Tools Selector Table

	ACIs																	
Tools	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	C1	C2	D1	D2	D3
Kanban	**m**								**l**								**l**	
MRP																	**h**	
Mass Customisation	**h**	**h**			**h**	**h**		**l**								**m**		
TQM												**h**	**h**			**h**	**m**	**h**
6 Sigma												**h**	**m**			**h**	**h**	**h**
5S				**l**							**h**	**h**		**m**	**m**	**h**	**h**	**m**
BPR	**m**					**m**	**m**	**m**		**m**	**h**	**h**	**h**			**h**	**h**	
JIT							**m**				**m**		**l**			**h**	**h**	
SPC												**l**				**m**		**h**
OEE							**h**		**m**		**h**	**m**	**h**			**h**	**m**	
Multiskilling							**h**							**h**	**h**		**m**	
Kaizen / Kaizen event		**l**	**L**			**l**			**l**		**m**	**h**	**m**			**m**	**m**	**m**
Cellular Mnfg	**m**						**m**	**m**		**m**		**l**						
Layout Restructure							**m**			**m**	**m**						**h**	
Process Deskilling							**l**					**m**		**l**	**m**			
Benchmarking	*	*	*	*	*	*		**m**			**m**					**h**		
SMED	**l**						**m**			**h**	**m**						**m**	
Poke Yoke												**h**				**h**		
FMEA	**l**						**h**	**h**	**m**		**h**	**h**				**h**	**m**	

Table 1: Tool Selector Table (Hetherington)

Cross Impact of ACI's With Tools And Techniques

Table Showing Negative Impacts Only

	ACIs																	
Tools	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	C1	C2	D1	D2	D3
Kanban							**H**							**L**				
MRP		**M**		**L**			**M**							**L**				
Mass Customisation		**L**					**M**	**H**		**M**		**M**		**M**				
TQM			**M**	**M**				**M**	**L**					**L**				
6 Sigma					**L**	**L**								**M**				
5S		**M**	**M**	**M**	**M**	**M**												
BPR				**M**										**H**				
JIT		**H**					**H**	**M**				**H**		**L**				
SPC				**L**							**M**	**H**				**M**		
OEE				**L**			**M**							**H**	**M**	**L**		
Multiskilling															**L**			
Kaizen / Kaizen event														**L**				
Cellular Mnfg											**L**			**L**	**L**			
Layout Restructure							**M**					**M**						
Process Deskilling																		
Benchmarking	*	*	*	*	*	*												
SMED												**M**						
Poke Yoke		**H**	**H**			**H**												
FMEA	**L**		**L**		**L**	**L**												

* Depands on where the company is placed in the market and who they are benchmarking against

Key
H,M,L = High Medium and Low negative impact on ACI

The negative impact here is more important as the table will identify areas of the business negatively effected by work being carried out. Therefore some counter measure may be used to stop the negative effects.

Table 2: ACI Vs Tools Negative impacts (Hetherington)

Cross Impact Of ACI's With Each Other

ACI's	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	C1	C2	D1	D2	D3
A1			N	N	P	P	N	N			N	N		N	N	P		P
A2			P		P	P					P					P	P	P
A3				P			P	N	P									
A4							P				P						P	
A5						P		N								P		P
A6								N								P		P
B1								N	P	P	P	P	P				P	
B2									N				P			P	P	
B3												P	P				P	
B4														N			P	
B5												N	P		N		P	
B6																P	P	
B7																		
C1															P	P	P	P
C2																P	P	
D1																		P
D2																		P
D3																		

Table 3: ACI Vs ACI (Hetherington)

Cross Impact Of Tools And Techniques With Each Other

Tools	Kanban	MRP	Mass Customisation	TQM	6 Sigma	5S	BPR	JIT
Kanban		P				P		P
MRP			N			P		P
Mass Customisation								
TQM					P			
6 Sigma								
5S								P
BPR								P
JIT								
SPC								
OEE								
Multiskilling								
Kaizen / Kaizen event								
Cellular Mnfg								
Layout Restructure								
Process Deskilling								
Benchmarking								
SMED								
Poke Yoke								
FMEA								

Table 4: Section of Tools Vs Tools (Hetherington)

	ACIs																	
Tools	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	C1	C2	D1	D2	D3
Kanban	**m**						**H**		**l**					**L**			**l**	
MRP		**M**		**L**			**M**							**L**			**h**	
Mass Customisation	**h**	**h**			**h**	**h**	**M**	**H**		**M**		**M**		**M**		**m**		
TQM			**M**	**M**				**M**	**L**			**h**	**h**	**L**		**h**	**m**	**h**
6 Sigma					**L**	**L**						**h**	**m**	**M**		**h**	**h**	**h**
5S		**M**	**M**	**M**	**M**	**M**					**h**	**h**		**m**	**m**	**h**	**h**	**m**
BPR	**m**			**M**			**m**	**m**		**m**	**h**	**h**	**h**	**H**		**h**	**h**	
JIT		**H**	**h**	**h**			**H**	**M**			**m**	**H**	**l**	**L**		**h**	**h**	
SPC				**L**							**M**	**H**	**l**			**M**		**h**
OEE				**L**			**M**				**h**	**m**	**h**	**H**	**M**	**h**	**m**	
Multiskilling							**h**							**h**	**L**		**m**	
Kaizen / Kaizen event		**l**	**l**			**l**			**l**		**m**	**h**	**m**	**L**		**m**	**m**	**m**
Cellular Mnfg	**m**						**m**			**h**	**L**	**l**		**L**	**L**			
Layout Restructure							**M**			**m**	**m**	**M**					**h**	
Process Deskilling												**m**			**m**			
Benchmarking	*	*	*	*	*	*		*			**m**					**h**		
SMED	**l**						**m**					**M**					**m**	
Poke Yoke		**H**	**H**			**H**						**h**				**h**		
FMEA	**l**		**L**		**L**	**L**	**h**	**h**	**m**		**h**	**h**				**h**	**m**	

* Depands on where the company is placed in the market and who they are benchmarking against

Key

H,M,L = High Medium and Low negative impact on ACI

h,m,l = high medium and low possitive impact on ACI

The negative impact here is more important as the table will identify areas of the business negatively effected by work being carried out. Therefore some counter measure may be used to stop the negative effects.

Table 5: Full ACI Vs Tools (Hetherington)

Cross Impact Of ACI's And Miltenbergs Manufacturing Outputs

ACI's / Miltenberg	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	B7	C1	C2	D1	D2	D3
Cost	\			\	\	\	\	\			\	\	\			\		\
Quality	\			\				\				\		\	\	\		
Delivery		\	\	\			\	\	\	\	\	\		\	\		\	\
Performance	\	\		\	\	\		\	\		\			\		\	\	\
Flexability	\	\	\	\	\	\	\	\	\	\	\	\		\	\	\	\	\
Innovation	\	\	\	\	\	\		\						\				

Miltenbergs manufacturing outputs show what mnaufacturing privdes its customers. These six outputs are therefore used as the basis for strategy and are used to provide a better service or product than competitors. The ACI's identified and used by the ETI system must therefore fit into this framework of outputs to provide value to the customer and also provide a basis for companies to differenciate themselves from a competitor.

This list may not be exhaustive but it shows that the outputs and ACI's do match up and corralate to each other. This shows that the stratagies produced from the system are valid and applicable to real life manufacturing outputs.

Table 6: ACI Vs Miltenbergs Manufacturing Outputs (Hetherington)

Definitions of ACI's:

Product

A1 Degree of customisation
A2 Component flexibility
A3 Process similarity
A4 Process replacability
A5 Structure adaptability
A6 Component adaptability

Process

B1 Scalability
B2 Re configurability

B3 Usability

B4 Replacabiltiy
B5 Utilisation
B6 Robustness
B7 Effectiveness

People

C1 Employee skill flexability
C2 Replacability

Operational

D1 Customer volume
D2 Customer delivery
D3 Customer quality

Tool List:

Kanban
MRP
Mass
Customisation
TQM
6 Sigma
5S
BPR
JIT
SPC
OEE
Multiskilling
Kaizen / Kaizen
event
Cellular Mnfg
Layout
Restructure
Process
Deskilling
Benchmarking
SMED
Poke Yoke
FMEA

Explanation of Cross Impact Diagrams: Why and How Developed and How They Will Be Used With BEA Audit

ACI Vs Tools Complete:

This table was the first table developed in the series of cross impact tables. It was designed to show where all the ACI's and tools cross-impacted on each other in both a positive and negative way. Both the positive and negative impacts were given priorities in terms of high medium and low. The positive impact was given a lower case letter for their ranking and the negative impacts were given a capital letter. This was chosen to be this way round as the capital letter is warning of a negative effect to the company which is the opposite of what is trying to be achieved therefore needs to be heeded very carefully.

From looking at this table you can see that it is very crowded and contains lots of information. It was therefore hard to use as a tool selection technique by looking up a particular agile capability and following the column down to see which tools Affected it, and in what way (i.e. high medium or low). It was planned that the same table would be used to note down the negative high medium and low impacts (the ones in capitals). However, when the information had been placed on the table it was obvious that this could not work as some tools needed both a negative and positive impact in the space provided as there are certain areas and industries that the tool would not be suited to.

Therefore this table was split into two separate tables, the Tool Selector Table, showing the positive impacts tools has on capabilities, and the ACI Vs Tools negative effects table, highlighting areas of caution where capabilities may be weakened. These tables are explained below.

Tool Selector table:

This table as explained above is used for looking up what tools should be used to influence a capability in a positive way. If a capability has been identified as being needed by the company to combat environmental turbulence this table should be used to look at which tools to implement and strengthen the company's position by being able to absorb variation and changes (turbulence). [There is a tool on this table called process deskilling which has not been included because after consideration, case study examination and research it has been decided that this would not be the best course of action to promote agility]. The previous work on the Ishikawa diagrams will give some idea of agility focus by showing which branch of the diagram is most heavily populated. This will give an easy to identify 'Agility Focus' to the project which will show which pillar will be generating agility for the particular position the company is in.

There are three more tools suggested at the bottom of the table that may be included in the future, they need some more research however. These tools are, design for manufacture, design for assembly and total preventative maintenance.

Design for assembly and design for manufacture will be included in mass customisation techniques in some cases but may want to be applied separately. This will require some further research. The TPM (Total Preventative Maintenance) tool would be used to influence the robustness, quality and other issues. This tool could be inserted straight into the table and simply needs examining which capabilities would be affected and in what way. The definition of the tool is included in the new tools definition in the appendices but as yet hasn't been inserted due to lack of validation.

ACI Vs Tools Negative effects only:

This side of the cross impact was developed to show that implementing some tools may have a detrimental effect on other capabilities. It is for information purposes only as some capabilities may not be important for a company, if that capability has nothing to do with the product and markets in which they operate. In other cases it serves as a warning that some problems may occur and to watch out for them. A good example of this would be the Kanban tool, which if not carefully implemented could detrimentally affect the scale-ability of a company. The lot size needs to be sufficient to keep production running and allow a refill of a kanban bin, card or space; if production speed increases dramatically then the size of the kanban may be inefficient. This table does not warn of the specific affects on capabilities but flags up areas of concern. It is useful in its current state as a reference to check on how production systems will be affected. This may be enough functionality, although it would be desirable in some cases to generate a matrix of information that shows the specific problems encountered by implementing tools along with some suggestion of how to counter the negative effects to the business. As in the table above the factors are prioritised into high medium and low effect.

ACI Vs ACI:

This is again an informational table to show where impacts occur on other areas of the system. These are simply assigned P (positive) meaning the capability is strengthened enhanced or complimented in some way, or N (negative), which means the capability is detrimentally effected. This table was produced to show how strengthening certain capabilities may have an undesired effect on the company's other capabilities, although it should be noted here that the negative effects encountered are mostly small and may not have much impact on the business. Again a reference section where the impacts can be looked up and countered may be useful in some way but this would be quite time consuming to produce and is not necessary to benefit the working of the system, therefore hasn't been included, it may however be developed in the future. This table is mainly for interest purposes as the capabilities should never have a dramatic effect on each other, they should simply be more, or less, when compared to each other.

Tools Vs Tools:

Again this is mainly an interest table. This section is intended for use as a reference section to look at the tools chosen for implementation and see where two tools may clash or compliment each other. As in the previous table this uses the classification of P (positive) and N (negative). It may help in choosing when to implement tools so that complimenting tools are implemented together (at the same time in the project) and tools with a detrimental effect can be kept separate from each other. Again a nice feature for the future may be some sort of reference explaining some of the impacts and how they can be enhanced or avoided but this again is suggested for future work.

ACI Vs Miltenbergs manufacturing strategies:

This section of the table is really a tabulated check on the validity of the agile capability indicators. Although much research has gone into identifying the capabilities chosen, they are checked here under Miltenbergs work from his book Manufacturing strategy: How to formulate and implement a winning plan. (Miltenberg J, 1995). This is because some of the work running concurrently to this project is looking at strategy formulation for the company being examined. So by checking that the capabilities fit into suggested strategy drivers or identifiers for the company being examined makes good sense. It also give some good explanation why the capability indicators are used and if the company has already decided on its strategy, it can be seen from this table what kind of capabilities they will need to be focusing on the achieve agility.

Tools Added to the Best Practice Folder to Aid Capability Improvement

During development of the cross impact tables it was noted that some ACI were lacking in tools that had a positive impact on them. This was seen as an area of development and so new tools were researched and inserted into the tables to aid in the strengthening of capabilities for companies being examined. These tools were chosen from case study material, previously implemented projects, the authors own experience and researched methodologies for manufacturing improvement.

The tools have been defined in the same manner as the rest of the best practice folder and are ready for inclusion into this folder. The definition can be found in the appendices of this project. The tools defined are:
Benchmarking
SMED (Single Minute Exchange of Dies)
Poke Yoke (failsafe devices)
FMEA (Failure Mode Effects Analysis)
Kaizen (Continuous Improvement Technique)
TPM (Total Preventative Maintenance)
Multiskilling
Cellular Manufacturing
Layout Restructure

The validation section of the project shows case study examples of these tools being applied and the results that they have had on real products and industries. This is done to help justify the tools inclusions into the best practice folder and is one of the reasons for the large validation section in the project. The tools are shown in action and then each Agile Capability that the tool effects is taken in turn and an explanation offered as to why and how the tool strengthens and improves the companies capability to be agile.

This process was carried out at the beginning of the table development to allow all the positive and the negative impacts to be considered before deciding on whether or not to keep the tool in the system. This is why Process Deskilling, although showing on the tables, is greyed out and not included. It was decided after examining the technique that this did not offer agility and had too many negative impacts on other areas.

This chapter has shown the table development process from utilising the Ishikawa diagrams as a starting point. The Ishikawa still have a function after these tables have been developed as they provide an easy to use agility focus identifying which pillar is providing agility in a particular instance. The tables developed here will give function to the ASF by ensuring a consistency of approach to the implementation of tools, it will also reduce the need for the operator of the system to be highly skilled in the use of the tools and techniques.

The formalisation of tools and technique generation provides an important starting point in the automation of the system using computer-generated questionnaires. Because there is now a process of tool recommendation for the turbulent factors, a computer-based system may now be developed to allow remote operation of parts of the ASF. This will be examined later in the project and a structure will be proposed for this model.

Chapter 6

Toulmin Validation of Tables

Below are some examples of how the Toulmin Logic Tool has been applied to validate placement of Manufacturing Best Practice Tools onto the tool selector table.

Best Practice tools were placed on the tool selector table to provide a cross reference or look up system so that the ACI identified in the audit as critical can be cross referenced with tools that effect the ACI with either a High, Medium or Low impact.

For each placement of a manufacturing tool a Toulmin model has been created. The model shows a set of data pulled from a case study which has either been published as part of research in manufacturing techniques or has been conducted by The Agility Centre. This data then supports a claim made regarding how the tool effects the ACI in question. The grounds, warrant, qualifier and rebuttal are all examined in a similar way and where possible have been taken from literature published in the public / academic domain.

In the first example for Kanbans the data is taken from a case study written by Sharp regarding the effectiveness of Kanbans in reducing WIP and increasing flexibility in the supply chain. The grounds for stating the argument in this case are taken from a case study material book whereby a manufacturing tools purpose has been defined. In this first example the other parts of the logic tool have been formed using the authors experience of manufacturing and production management.

In each example the source of data is clearly stated and the reasoning explained through the Toulmin structure. Not all examples are published in the project to avoid large amounts of data being collected in published material.

Kanban:

Tool: Kanban

ACI's effected (weighting of effect, h, m, and l): A1(m),B3(l),D2(l)

A1: Degree of customisation (m).

Data:

With the IT supported system, whenever an order is received, screen-based Kanban trigger points and order quantities can be adjusted immediately to pull through the required materials. Combined with automatic Kanban creation and instant delivery, this makes supply chains more responsive to changing customer demand. Another benefit is precise control of stock held at each cell, providing a sufficient buffer without excessive inventory or capital tied up in work in progress (WIP). (Sharp R, 1999).

Claim and reason:

Kanbans will affect degree of customisation in a positive way because they allow many parts to be stocked line side of a production facility in small kanban bins. This means as a product passes the operator can select one of a number of components and move the product on. Kanbans will help to control the stock level of these multiple parts and ensure that the cost of stock is not too high, but also ensure the production line does not run out. Kanbans also help to install a visual management system on the shop floor to enable easier production control.

Grounds:

'Kanban is a production control, stock control tool. Used to organise factories and control inventories'. (Hill T. 2000)

Warrant:

Kanban size must be sufficient to provide a quick lead time by allowing a small amount of stock to be held and processed, but, should not be so large that this stock costs lots of money and runs the risk of damage, obsolescence or will expire due to shelf life.

Backing:

The tool Kanban was originally developed in Japan for the automotive industry to allow a shorter lead-time on production with no extra cost. It was developed so that stocks are pulled by demand and therefore replaced by demand, i.e. stock usage will match demand giving re ordering and replenishment to match demand. It means simple inventory controls are used even when there are large numbers of parts in the production system. It means a large amount of components can be stock controlled simultaneously and provide large amounts of customisation with high stock turn and low inventory costs.

Qualifier:

This tool is used extensively in highly customisable environments with the highest quality standards and provides an efficient cost effective way of controlling stock. It is therefore industry tried and tested and has been applied to many products, services and industry sectors.

Rebuttal:

Environments that are engineering one off projects are unlikely to be able to utilise Kanbans for all components. There will be some commonality of items throughout the product range such as nuts and bolts which will see benefit, but one off projects which require a total engineering process from design to construction will be unlikely to benefit highly.

B3 Usability (l).

Data:

'Kanban is a simple replenishment system that is triggered by a real demand-pull system. Since the trigger is based on a real time need, it is accurate and effective. It is not susceptible to data-entry delay, data-entry error. Kanban works well when integrated with storage at point of use and other visual systems.' (www.superfactory.com)

Claim and reason:

Kanbans help usability because they offer a replenishment strategy on the shop floor helping to ensure machines always have materials available to process into product either for the customer or the next operation along in the process chain. Kanbans help to ensure inventory is always available to a process as shown in the quote below. This factor is a low on the tools selection table because the machines also need to be able to deal with this type of part and process it correctly for the next stage to be able to utilise it in production.

'Kanban is a production control, stock control tool. Used to organise factories and control inventories'. (Hill T. 2000)

Grounds:

Kanban is a tool used to manage the flow of production materials around the factory according to demand. It ensures that stock-outs do not occur and production matches demand from the customer.

Warrant:

Kanban size should be sufficient to allow for many variations in demand and should not incur large costs in terms of material storage. They also need to be used and replenished correctly to ensure stock outs do not occur.

Backing:

Kanbans were developed to aid in keeping production systems flowing and material and components readily to hand. Because material is being replenished at the rate of usage machines and operators will always have work available to them.

Qualifier:

As above this tool is used in highly pressurised environments where downtime on a machine will cost a large amount of money. The technique is therefore well proven.

Rebuttal:

Will only be as effective as the machine is. If the machine is always experiencing downtime for other reasons than stock outs introducing a kanban system will not help. Other tools must be used to ensure the system is optimised. Kanbans are not flexible to demand and large demand may mean that the kanban size has to be re-adjusted to allow the refilling of the kanban to take place effectively. A common problem will be to use too small a kanban and the system fails due to stock out.

D2 Customer Delivery (I).

Data:

'CUSTOMER PULL - The concept of 'pulling' value through the production system is contrasted by most systems, which either MAKE-TO-STOCK (MTS) or 'PUSH' batches through via a MASTER PRODUCTION SCHEDULE or MATERIAL REQUIREMENTS PLANNING (MRP/MRPII) software. 'Push' systems produce without regard to demand or the requirements of downstream processes. The difference may seem insignificant, but in reality, pull systems can further (and significantly) reduce costs and improve throughput/delivery.

Implementing 'pull' means redesigning the entire system of production from the point of view of your customers. The system does not begin production until an order is received from the customer. This order triggers the entire production system, from the supply chain through each production process. Some of the tools used to implement CUSTOMER PULL include:

Kanban production scheduling

System-wide inventory reduction planning

Heijunka scheduling

Just-in-Time manufacture

Supply Chain Management

Kaizen Blitz/Improvement Workshops

Decoupling of MRP/MRPII systems from production scheduling

True 'customer pull' may not be realistic in all manufacturing environments. Portions of the system (based on operational requirements or significant cost factors) may require the development of a HYBRID system (a pull system which contains certain push elements). Such hybrid systems are still very effective at reducing costs and improving responsiveness to customers.' (www.nwlean.net).

Claim and reason:

Customer delivery is a capability indicator of some importance especially in consumer markets. Processes being delayed and out of sync with each other often delay delivery to the customer. This can also happen because of bottlenecks in the system, poor management of the processes within the factory as well as other reasons. Kanban replenishment can help to stop the material shortages that damage the flow through the factory and keeps production flowing. It offers a visual management tool to allow stock and production control

Grounds:

As previous Kanban will react to the customer and with the right size of Kanban a range of products can be offered at short lead-time and with greater variety.

Warrant:

Again depending on the product, the right size of kanban and the right de coupling points need to be chosen to avoid the pitfalls of stock but still allow fast production of the end good for the customer. The processes must be optimised and the operators must use the kanban in the correct manner.

Backing:

Industrial customers or other businesses may be included in the kanban system, expanding the production line to the supply chain and integrating with key suppliers and customers to create a truly streamlined process. This means all the deliveries and demands in the system are reflected in the correct manner and the Forester effect is neutralised.

Qualifier:

This is shown to be true in many real industrial examples and many theoretical models. The Beer Game, is based on this principle and easily demonstrates the use of kanban and the Forester effect.

Rebuttal:

If the kanban system is abused, the re-order points are incorrect or demand increases extremely and continuously, the kanban system will fail and delivery will not be improved.

This chapter shows the methodology applied to each manufacturing and highlights the case material used in the Toulmin system to validate the placement of the tool in the cross impact tables.

The next chapter uses case study material to compare the results that the tool selector table generates with the actual tools used in the case study at the time of implementation. These results show in real life how the table may be of use and provide a contact to application within the ASF. It also provides a small amount of quantitative data whereby the level of agreement of the case study to the tool selector table output can be compared. There should be a high level of agreement between the two if the case study was shown to be successful; this will show that the right tools were implemented in the case study and that the system selects these tools for implementation, thereby repeating successful implementation of manufacturing techniques.

Chapter 7

Case Study Comparisons / Validation of the Selector Tables

To test the system of cross impact tables developed three case studies have been selected from the work carried out at the agility centre, these case studies identify the needs of the company and have had tools and techniques applied to them which were suggested by the operator of the assessment. The results from the case studies have been recorded and these will be used to see if the cross impact system developed matches up to and provides the same results of as the case studies. There may be some mismatch here as certain tools may be more applicable to others in certain industries but the tools actually used should be suggested by the cross impact system, and should provide good results for the company in making it more capable to deal with the market forces it is experiencing.

The three companies to be examined through case studies are: Richardsons Healthcare Ltd, Daryl Industries Ltd, and RS Clare and Co Ltd. All three are SME's based in the Merseyside area and have undertaken improvement projects and worked with The Agility Centre at The University of Liverpool. A brief background on each company is given below.

Richardsons Healthcare Ltd

Richardsons Healthcare has been in operation for over fifty years producing mattresses for operating tables, which are subsequently used within hospital operating theatres. The company provides practical and innovative solutions to eliminate secondary ailments, caused by pressure points on certain parts of the patient's body when immobile for periods of time during theatre. The company has 22 employees and a turnover of just over £1M.

Daryl Industries

Daryl industries are an SME based in Wallasey, Merseyside. The company's business activities are dedicated to the design, manufacture and distribution of shower enclosures, bath screens and water delivery systems. The company is located across three sites. The head office in Wallasey carries out the company administration and design activities. A short distance from the head office is the manufacture and assembly units of the company. And based in Skelmersdale there is an anodising plant that specialises in bright anodising processes to create metalwork for the assembly plants.

Until recently Daryl found that their market position was moving up market, having a strong reputation for design innovation and quality of service. They had experienced growth at a rate of 25% per annum, comparing to a 5% per annum growth in the shower enclosure market generally. In the upper end of the UK shower enclosure market, being worth about £90M, Daryl had an 11-12% share. A number of export markets had also been opened up, providing approximately 5% of turnover.

Daryl Industries pursued the strategy of agile manufacturing as the basis of their approach to the market position they wish to occupy. Driven by increased market competition, the company identified a need to become more responsive. For that reason they designed a new, mass customisable product family, denoted as series 2000, aiming in providing increased product customisation and shorter lead times. Additionally they constructed a new production facility for their anodising plant in order to improve the quality issues of their products.

RS Clare and Co. Ltd

RS Clare and Co. Ltd was founded in Liverpool in 1748 at the start of the industrial revolution. With its origins in lubrication technology it has diversified during the 20th century to develop Thermoplastics, Epoxy and Polyurethane production facilities. The company has 54 employees and an annual turnover of £12M, which is split between lubricating greases, surface coatings, road markings and contracting.

Explanation of how the system will be tested in the case studies

Each company has undergone an assessment using the ETI (Environmental Turbulence Indicator) model and has been assessed on a number of pillars of the model, depending on what is judged to be affecting the company the most at that point in time. The four pillars are Intensity of Competition, Dynamic Customer Requirements, Supply Chain Turbulence, and Changes in STEEP.

Within each pillar there are sets of attributes that further define the pillar and shape its focus in terms of changes that affect an organisation within the business environment. From these attributes, questionnaires have been derived. This gives turbulent factors and agile capabilities that need to be in place to allow the company to deal with environmental turbulence. The company is assessed at how well it meets each of the capabilities. The part of the project being tested here is what tools should be used to help improve each capability. In the case study the tools have been selected manually by the operator. This project will give some structure to the way in which tools are selected, therefore the tools used in the case study will be compared to those that are given by the table for each capability indicator identified. The results will then be compared. Here the case is outlined, the capabilities shown and the tools from the case study and the newly developed framework shown side by side. The results will be analysed in the next section. For more information on how the ETI framework operates please read the literature review section of the project.

Daryl Industries Ltd

Daryl's environmental analysis focused on two pillars of the framework, Customer Bargaining Power (CBP), and Changes in Manufacturing (CM). A short summary of the report followed by the tools used and the suggested tools from the tool selector table developed follows. The full case studies are available in the appendix 4.

Customer Bargaining Power:

Of the twelve factors examined in customer bargaining power, six presented changes. The factors presenting change were as follows:
Market capacity Utilisation (Increase)
Number of customers in company's customer base (Increase)
Returning Customers (Increase)
% of customers for whom the company is now the preferred supplier (Decrease)
% of customers dictating delivery date (Increase)
No of specials (Increase)

Changes in manufacturing:

Fifteen out of the twenty four factors in this section provided a change. These are outlined below:
Labour force size (Increased workforce)
Training needs (Increased needs)
Productivity (Low decrease)
% Defects per employee (Increase)
Throughout to capacity (Decrease)
No of changes for process improvements (Increase)
No of set ups and teardowns (Increased trend)
No of machine breakdowns (Not increasing in number but provided more threat)
% productive time lost due to breakdowns (Increase in time lost)
Schedule changes (More changes)
% products made to stock (Wanted to reduce made to stock)
% defects (Anodising showed increased defects)

Packaging variations per product (Increasing trend)
% total stock that is misplaced (Low increase)

The next stage in the analysis was to undertake the Turbulence Effect Analysis (TEA) and produce a TEA model, which would lead to a Turbulence Priority Number (TPN). This gives some priority to the factors in the model first. This is not as important for the analysis of the framework. What we are interested in are the tools suggested for action against the priorities. Therefore this section has not been included but is available in the full case study report.
The Agility Capabilities Selector was next applied to the results to look at the specific capabilities that are needed to either strengthen up to deal with a problem or are need to combat change. This is the Link A and Link B section of the capabilities selector.

Link A is a potential change of the sub factor may weaken a specific sub capability leading to deterioration of time or scope performance. By identifying which capabilities have been weakened by change the decision maker may look for solutions that will enforce those capabilities and improve performance level.

Link B. High levels of this capability may absorb the impact of a potential change of sub factor. By measuring the current level of that capability the decision maker can identify areas that require improvement in order the company may cope with that change.

The following links were attributed:

Market Capacity Utilisation: High market capacity utilisation indicates enhanced customer bargaining power, since more products in larger variety are available, and thus it increases competition. That may become and initial driver for agility and requires high levels of all the performance aspects. For that reason, all the ACI's may be used in order to identify areas that need improvement. For this purpose, it was considered that Daryl could absorb the impact of any change of the sub factor and thus been given a **Link B.**

% Defects: Due to high levels of production it was found that recurring errors would have a detrimental effect on the process efficiency. To eliminate the 'pipeline effect' the configuration of the product components along with process capabilities would affect the robustness of the processes and the products. For this purpose, it was considered that a change in sub factor would have detrimental consequences on company objectives and thus has been given a **Link A.**

The ACI's in Daryl that needed to be put in place and strengthened are as follows. All of section A on the product side need to be strengthened to deal with any changes or a link B. Percentage defects and management of stock which are process considerations and a link A, specifically B6 and B2. Then there are the people skill levels and utilisation, which is section C1.

The tools that were suggested and implemented in the case study were split into two areas; one was the implementation of mass customisable products to deal with the market capacity utilisation issues. The second was the area of process and people enhancement to deal with these changes. The process improvements were carried out first to give the capabilities for new products and methods of production, and help smooth the existing product manufacturing process, which would give a clearer scope on the product improvement side. The tools to be implemented are as follows:

5s

Cellular manufacturing

Cultural change and training

Factory re layout

Quality program

Stock control such as Kan ban

Mass customisation

To compare these tools to the ones suggested in the framework of tool selection developed the Agile Capabilities to look up on the table are as follows:

Section A Product Agility

Section B specifically B6, B2, B3

Section C People skills, part C1 Employee skills Flexibility

The tool selector table is used and each of the ACI's is looked at and cross-referenced with the list of tools and the suggested impacts. The results from the table (tools and there suggested impact, high medium, low,) are as follows:

Results of Tools Selection for Daryl Case Study			
Tools	Section A		
Kanban (m)			
Mass Cust (h) [four times]			
5S (l)			
BPR (m) [two times]			
Kaizen (l) [three times]			
Cellular Manfg (m)			
SMED (l)			
FMEA (l)			
	Section B2		
Mass Cust (h)			
BPR (m)			
Cell Mnfg (m)			
Benchmarking (m)			
FMEA (h)			
	Section B3		
Kanban (l)			
OEE (m)			
Kaizen (l)			
FMEA (m)			
	Section B6		
TQM (h)			
6 Sigma (h)			
5S (h)			
BPR (h)			
SPC (l)			
OEE (m)			
Kaizen (h)			
Cellular Mnfg (l)			
Poke Yoke (h)			
FMEA (h)			

Table 7: Tool selector results for Daryl

The next section of results shown here are the negative impacts these tools could have on other Agile Capabilities. This has been developed to show the user where other impacts may occur and what to watch out for. The tools suggested in the results above are used to look up the negative impacts on the ACI Vs Tools –ve table. The results have been tabulated and are as follows:

Results of negative impacts for Daryl	
	Capabilities Effected and Magnitude (H,M,L)
Tools	
Kanban	B1(H), C1(L)
Mass Customisation	A2(L), B1(M), B2(H), B4(M), B6(M), C1(M)
5S	A2(M), A3(M), A4(M), A5(M), A6(M),
BPR	A4(M), C1(H)
Kaizen	C1(L)
Cellular Mnfg	B1(L), B2(L), B5(L)
SMED	B6(M)
FMEA	A1(L), A3(L), A5(L), A6(L)
TQM	A3(M), A4(M), B2(M), B3(L), C1(L)
6 Sigma	A5(L), A6(L)
SPC	A4(L), B5(M), B6(H), D1(M)
OEE	A4(L), B1(M), C1(H), C2(M), D1(L)
Poke Yoke	A2(H), A3(H), A6(H)
Benchmarking	
Multiskilling	C2(L)

Table 8 Negative impacts of tools on ACIs for Daryl (Hetherington)

Richardsons Healthcare Ltd

Richardsons environmental analysis focused on one pillar of the framework which was dynamic customer requirements, specifically the section under product performance.

It was found from the report that the biggest factor in this sector was percentage of orders lost or cancelled due to price.

There are several factors identified from the case study that need to be strengthened to improve the response of the company to customer orders and to reduce internal costing. The product drives agility for Richardsons as each product is bespoke to one customer and cannot be offered to any other customers. The agility for the company will come from the processes and being able to manage and respond to varying demand placed upon the production system. This is because current demand is actually rising from existing customers, with some new customers coming on line. These customers tend to be at the expensive end of the market with a large chunk of cheaper manufacturers excluded because of the price. Richardsons wish to stay in this expensive market due to the fact that the margin is favourable and the customers are high profile within the marketplace.

Therefore areas identified for strengthening, a **Link B** include:

Ramping up and down production capacity to suit demand, this equates to capability indicator **B1 Scale-ability**. Part orders are shipped which negatively effects Richardsons supplier ratings with its customers; this is capability **D2 Customer Delivery.** Workflow needs to be considered to aid in the flow of materials around the factory, this is to aid delivery time to the customer of completed orders. This relates to a capability of **B1 Scale-ability.** Workflows will also be an important area to look at because of the part order shipment. Whole orders must be able to move together, and quickly, in order to enable the shipment to contain the whole of the customer requirements. This will relate to **B5 Utilisation.**

Link A capabilities which are weakened by changes in the market include such factors which will effect cost, like a cheaper competitor entering the market, people skill level and utilisation within the company. The factors mentioned above will affect people agility, **C1 Employee Skill Level** and **C2 Replaceability** will be important issues here. **B6 Robustness** will be an important process agility metric here as deterioration in this will result in late deliveries and poor quality, which, Richardsons cannot afford to have in the particular market that they operate in.

Therefore the two important areas of capability for Richardsons are the areas of product agility and people agility.

The suggested tools for the company in the report are as follows:
SMED
5S
Multiskilling
Layout restructure
OEE
Poke Yoke

The case also suggested some sort of scheduling should be done within the production system.

To compare what the tools selector table suggests with what has been suggested on the report the following ACI's will be looked up and referenced:

B1 Scale-ability

B5 Utilisation

B6 Robustness

C1 Employee skills flexibility

C2 Employee skills replace-ability

D2 Customer delivery

The results from the table (tools and there suggested impact, high medium, low,) are as follows:

Results of Tool Selection for Richardsons Case study		
Tools	Section B	
5S (h)		
Benchmarking (m)		
BPR (h)		
BPR (m)		
Cellular mnfg (m)		
FMEA (h)		
FMEA (m)		
JIT (m) [two times]		
Kaizen (m)		
Layout restructure (m) [two times]		
Multiskilling (h)		
OEE (h) [two times]		
SMED (m) [two times]		
	Section C	
5S (m) [two times]		
Multiskilling (h) [two times]		
	Section D	
5S (h)		
BPR (h)		
FMEA (m)		
JIT (h)		
Kaizen (m)		
Kanban (l)		
Layout re-structure (h)		
MRP (h)		
Multiskilling (m)		
OEE (m)		
Six Sigma (h)		
TQM (m)		

Table 9: Tool selector results for Richardsons (Hetherington)

The next section of results shown here are the negative impacts these tools could have on other Agile Capabilities. This has been developed to show the user where other impacts may occur and what to watch out for. The tools suggested in the results above are used to look up the negative impacts on the ACI Vs Tools –ve table. The results have been tabulated and are as follows:

Results of Negative Impacts for Richardsons	
	Capabilities Effected and Magnitude (H,M,L)
Tools	
BPR	A4(M), C1(H)
JIT	A2(H), B1(H), B2(M), B6(H), C1(L)
OEE	A4(L), B1(M), C1(H), C2(H), D1(L)
Multiskiling	C2(L)
Cellular Mnfg	B5(L), C1(L), C2(L)
Layout Restructure	B1(M), B6(M)
SMED	B6(M)
FMEA	A1(L), A3(L), A5(L), A6(L)
5S	A1(L), A3(M), A4(M), A5(M), A6(M)
Kaizen	C2(L)
Benchmarking	
TQM	A3(M), A4(M), B2(M), B3(L), C1(L)
6 Sigma	A5(L), A6(L), C1(M)
BPR	A4(M), C1(H)
SPC	A4(L), B5(M), B6(H), D1(M)
Multiskilling	C2(L)

Table 10: Negative impact of tools on ACIs for Richardsons (Hetherington)

RS Clare & Co Ltd

The environmental analysis undertaken on RS Clare was focused on one area of the framework. It looked at Dynamic customer requirements and the sub section Product performance.

Once the turbulence effect analysis had been applied and a turbulence priority number generated, the area that required immediate focus was that of Number of Live sales Orders. This is mainly because of the companies drive to put to market new products to offer customers a greater choice and open up many new markets. This has had a major effect on the internal departments of the company and they are now finding it hard to manage the increased number of live orders that they are experiencing.

The senior management of the company feel that the operations are not robust enough to handle the number of products and orders coming through, and they need to be able to respond more quickly to the dynamics of the customer. Also each individual department has tackled the problem in its own way meaning members of staff have had a mismatch of information. It has created a feeling of disharmony and each department has not really thought about the effect of its actions further down the chain.

On top of the above there has also been a large percentage of orders cancelled due to price, which is due to the fact foreign customers are being serviced by home markets and R S Clare cannot compete on price.

The following areas of product agility have been identified as important to the company:

Product variation causing part proliferation

This relates to a mass customisation capability A1 in the capability indicators table.

Process agility is a large area of importance to the company. The key issues raised here are:

Capacity, Utilisation, Saleability, Replacing breakdowns, Changing from one product to the next.

These relate to agile capabilities in the B (Process) section as follows:

B1 Scale-ability
B2 Re-Configurability
B3 Usability
B4 Replace-ability
B5 Utilisation
B6 Robustness

People agility has been highlighted for training issues and here the capabilities are C1 Employee skills flexibility.

Therefore the capabilities highlighted for this case study are as follows:

A1 Mass Customisation
B1 Scale-ability
B2 Re-configurability
B3 Usability
B4 Replace-ability
B5 Utilisation
B6 Robustness
C1 Employee skills flexibility

The tools suggested for use in the case study are as follows:
Mass customisation techniques
5S
SMED
Multiskilling
MRP
Cellular manufacturing
Layout restructure

The next stage is to look up the ACI's from the tools selection table and the negative impact table and present the results here tabulated. The results from the tools selection table (tools and there suggested impact, high medium, low,) are as follows:

Result of Tool Selection for R S Clare Case Study	
Tools	Section A
Kanban (m)	
Mass Customisation (h)	
Cellular Manufacturing (m)	
FMEA (l)	
BPR (m)	
SMED (l)	
	Section B
BPR (m) [three times] (h) [two times]	
JIT (m) [two times]	
OEE (h) [two times] (m) [two times]	
Multiskilling (h)	
Cellular mnfg (m) [three times] (l)	
Layout Restructure (m) [three times]	
FMEA (h) [three times] (m)	
SMED (m) [two times] (h)	
Mass Cust (l)	
Benchmarking (m) [two times]	
Kanban (l)	
Kaizen (l) (m) (h)	
5S (h) [two times]	
TQM (h)	
Six Sigma (h)	
SPC (l)	
Poke Yoke (h)	
	Section C
BPR (m)	
Multiskilling(h)	

Table 11 Tool selector results for RS Clare (Hetherington)

The next section of results shown here are the negative impacts these tools could have on other Agile Capabilities. This has been developed to show the user where other impacts may occur and what to watch out for. The tools suggested in the results above are used to look up the negative impacts on the ACI Vs Tools –ve table.

The results have been tabulated and are as follows:

Results of Negative Impacts for R S Clare	
	Capabilities Effected and Magnitude (H,M,L)
Tools	
Kanban	B1(H), C1(L)
Mass Customisation	A2(L), B1(M), B2(H), B4(M), B6(M), C1(M)
Cellular Mnfg	B5(L), C2(L), C2(L)
FMEA	A1(L), A3(L), A5(L) A6(L)
BPR	A4(M), C1(H)
SMED	B6(M)
JIT	A2(H), B1(H), B2(M), B6(H),C1(L)
OEE	A4(L), B1(M), C1(H), C2(M),D1(L)
Multiskiling	C2(L)
Layout Restructure	B1(M), B6(M)
Benchmarking	
Kaizen	C1(L)
5S	A2,A3,A4,A5,A6, (M)
TQM	A3(M), A4(M), B2(M), B3(L), C1(L)
6 Sigma	A5(L), A6(L), C1(M)
SPC	A4(L), B5(M), B6(H), D1(M)
Poke Yoke	A2(H), A3(H), A6(H)

Table 12 Negative impacts of tools on ACI for RS Clare (Hetherington)

This concludes the three case studies for the framework of the tool selector table to be applied to and gives a good set of results for comparison. Each of the companies operates in different markets and has a different number of staff and turnover so this gives a good cross section of industry types.

The results will be analysed and discussed in the results section, which will look for where things worked well and where things need further examination or changing slightly to give better or more usable information. There will also be suggestion for ways to improve the results and possible further work to develop the system to the next stage.

The next chapter looks at how the whole process can be put into an automated system, which will allow users to access parts of the ASF and the ETI questionnaire remotely. It utilises some of the outputs from the tables section in making sure results generated automatically are robust and accurate enough to be used without the assistance of an experience operator of the ETI section of the ASF.

Following on from there the project moves to look at the strategic implementation of agility. The first part of the project has concentrated mainly on the operational aspects and ensuring that the ground work is in place. The second part of the project is to drive agility strategically through the company by pursuing a direction that actively seeks agility and aligns the companies resources to achieve this.

Chapter 8

Systematisation of BEA Using an IT System

This chapter will explore the specification for the automation of the BEA system and how this may benefit the systems implementation within a company. The aim of automation is to speed up the process of information gathering currently complied manually through the questionnaire process and in doing so:

Increase accuracy

Allow split sessions and multiple data entries

Provide expandability

Allow a database of completed projects to be created

The systemisation of the BEA is included here as it shows how the Manufacturing Tool Selection Automation can be continued and developed into an IT system. This will provide a basis for the automation of the strategy system proposed at the end of the project. It takes out the human element of the system and the time consuming part of the BEA which is gathering the data for analysis. By allowing this initial data gathering time to be reduced it means the focus of the BEA cab be given over to implementing the tools that make the processes more robust. It also allows more time for the strategy section to be bolted on in conjunction with the existing system. The IT system proposed here is referred to again at the end of the project when looking at the automation of the strategy tool developed. This covers some of the benefits of the IT system.

However, the main disadvantage of the IT system is that some of the tacit data gather through face to face discussions is lost. It may therefore be necessary to still utilise some form of manual results checking session whereby the answers to some of the questions can be investigated further. This will also be true with the strategy sessions that are proposed further on in this project.

The automation should make this process as easy for the company users as possible, allowing a less time intensive period needed to complete the questionnaire. From this information the analysis to generate TPN should be completed automatically. The system then picks up the work generated by the author for automatic selection of tools and techniques to be implemented.

The automation of the system does however have some limitations. One of which that is particularly hard to quantify, is the face to face consultation process of information gathering which makes the company 'feel' like it is getting a service. The second is the quality of the data is only as good as the input, and while an experienced operator may be able to get a participant to think more carefully about the answers they are providing, questionnaires being answered remotely to the BEA operator will not have this secondary check. There may also be an advantage of having all the information providers together in one room to discuss the levels of priority each user places onto a factor or question and the real business impact.

The system design has been specified throughout the work in this project and the implementation of a test system has been carried out as an undergraduate project.

The objectives of the project were broadly set as follows:

To design a database and user interface which deals with the ETI questionnaire and TPN calculation leading to a list of critical factors as the output. These should feed into the tool selector section of the BEA and produce the same results as the manual system

Build the database with extendibility being a key aim. The project and the BEA both need to be able to be extended.

Produce a project which fully incorporates a next-step approach with other elements of the BEA process being able to be implemented later. This will allow the inclusion at a later date of the strategy section.

The project should include a user interface which clearly shows how the system can be used my multiple operators to provide information at a central point. The following diagram shows a flow which represents the functionality of the BEA and how the automation should proceed.

System Spec:

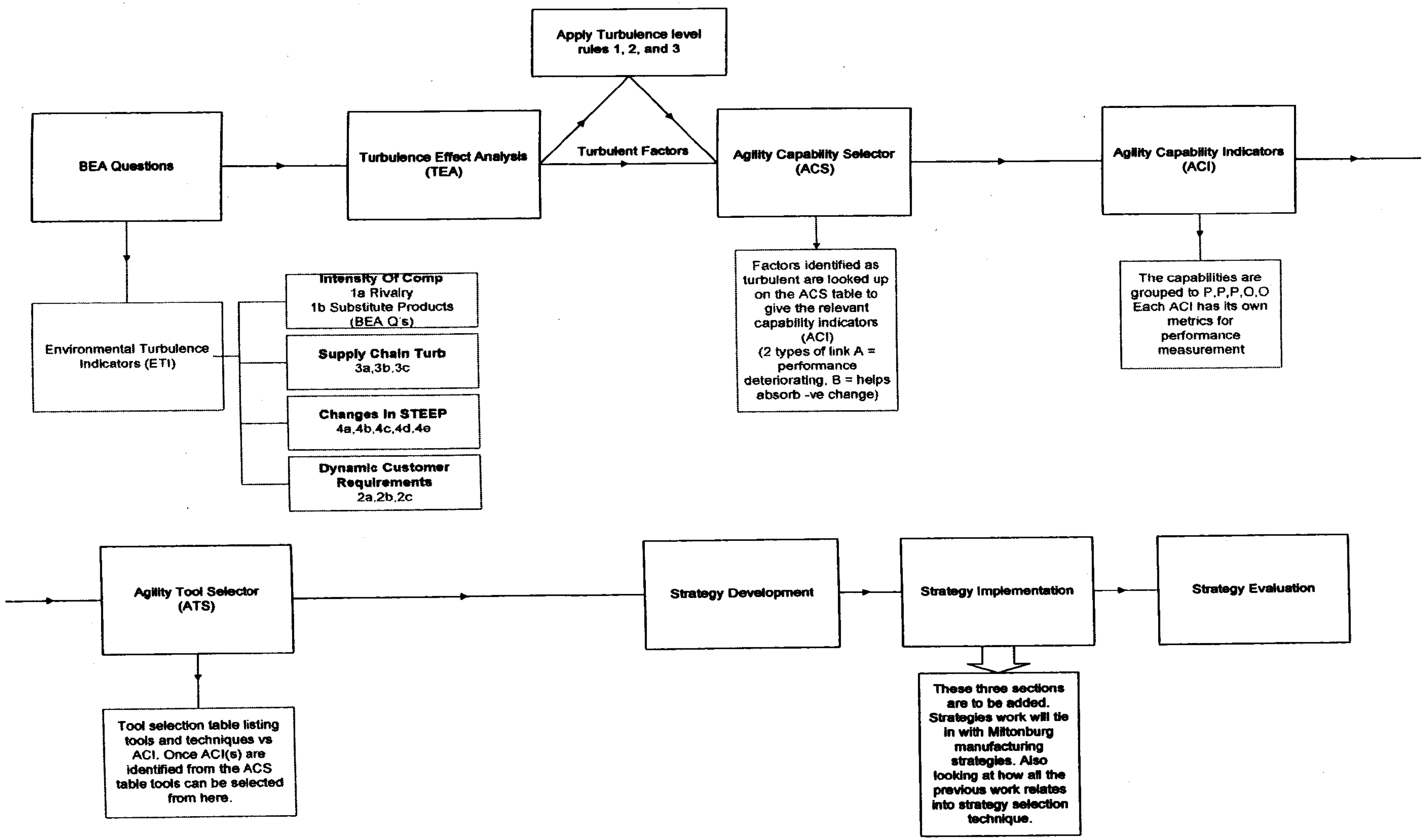


Figure 25: BEA system flow (Hetherington 2007)

The diagram above shows an overview of the process flow for the entire BEA system.

From the system overview the following requirements were defined for the automation of the BEA model using an IT system.

Easy to navigate user interface
Information gathering from multiple sources to collect a single location relating a particular company the project they are currently working on
Relational database system to record the information gathered
Processing of the turbulence effect analysis, turbulence level rules and agile capability selector calculations
Generate an overall TPN ranking for each factor
Generate ACI's to be used for measures and rankings
Use the above information to feed into a tool selector table which will show a ranking of tools to use to improve the ACI measures being used

Functionally:

The functionality of the system can be represented in diagrammatic form showing the relationships between system parts and the consultant and company users. This is shown over the page.

System Design:

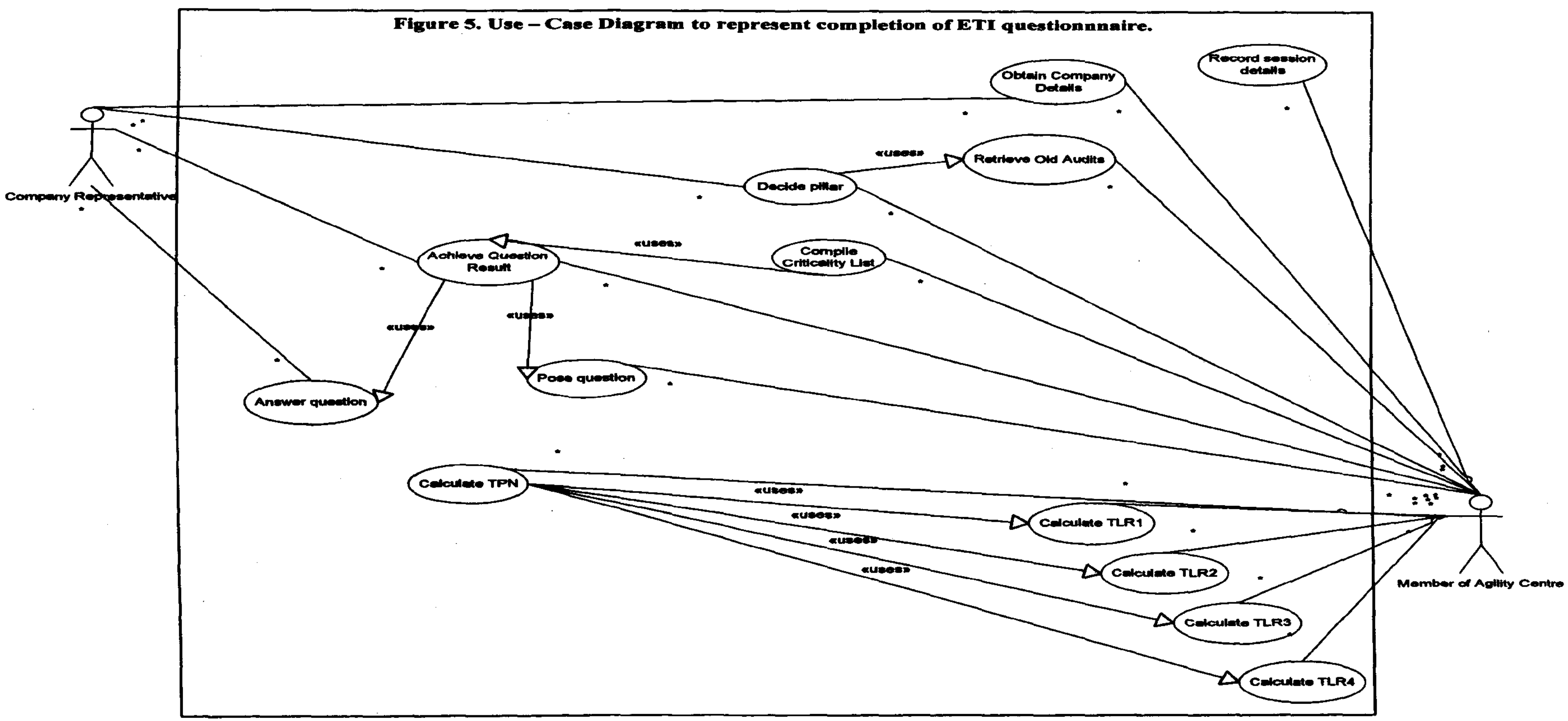


Figure 26: Use case of automated system (Hetherington)

The above diagram shows the use case for the system.. It represents how an ETI questionnaire is carried out. This is used to represent how the system works in real time. The system can also be thought of in terms of levels to show how ach section fits with each other, the user and the database. This is represented diagrammatically below.

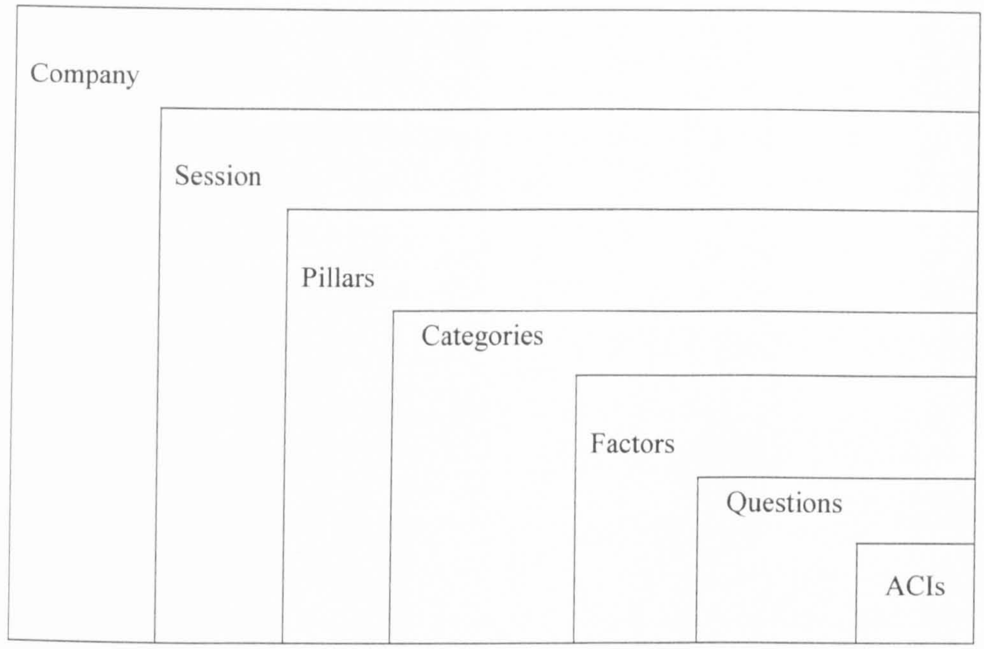


Figure 27: Levels diagram, where a company sits in relation to the system (Hetherington)

The levels diagram here illustrates where a company sits in relation to the rest of the system. It helps to visualise how each part of the BEA relates to the company, the system the session being completed and the questionnaire being worked on. The second diagram which was used to gain information on the overall system shows how each section is related to an organisation and to each other. Both these diagrams were used to help develop the relationships in the database.

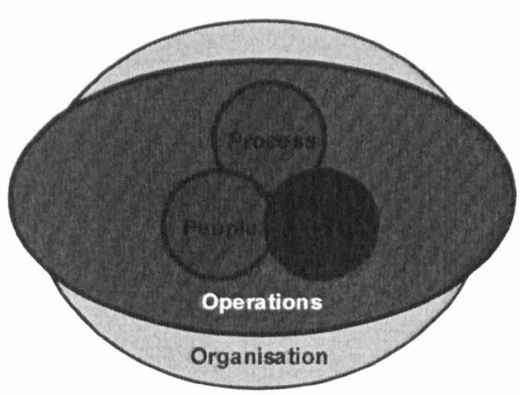


Figure 28: Overall system information (Ismail)

The tables implemented to support the database system include:

Company Table, Session Table, Pillars Categories and Factors, Questions Table.

The company table compiles information related to the contact sector and date account created, it stores general information about the company using the system.

The session table creates a store of information about the time, date and reason behind the particular use instance of the system.

The pillars, Categories and Factors tables store information relating to the factors and pillars in the BEA system. This is similar to the questions tables which holds information based on the questionnaire.

The next part of functionality to consider was the implementation of the TLRs into the database. TLR's 2,3 and 4 have been implemented as parameters into the database meaning they make up several options or combinations of options. For example TLR 3 makes up 27 parameters although only 9 would be used in one session. The TLR 1 is slightly more difficult to implement due to the large number of parameters that it would make up. Because the weighted score cannot be above 10 then applying a score to the different elements of the TLR could mean that they sum to greater than 10. Therefore every possible combination of the outcome of TLR 1 has been stored which makes up one hundred and two parameters, each stored with a value against them. This large number seams cumbersome but means that the TLR's function as per the original system design and therefore provide the correct scoring method to the turbulent factors.

The database is a relation structured database to enable data to be related to each other to to provide integrity, a key is used to identify which data pieces are effecting which areas of the system. A short summary of the relationships is provided below.

1. One company can have many sessions; one session relates to only one company.

(One-to-many: Company to Sessions).

2. Many sessions can involve many pillars.

(New table: Linktbl1with session_id, pillar_id, co_id).

(One to many Sessions to linktbl1, many to one linktbl1 to Pillars).

3. Many Pillars can have many categories.

(New table: Linktbl2 with pillar_id and session_id).

(One to many pillars to linktbl2, many to one linktbl2 to Categories).

4. Many Categories can have many factors.

(New table: Linktbl3 with cat_id and factor_id).

(One to many Categories to Linktbl3, many to one linktbl3 to Factors).

5. One factor can have many questions; many questions can have only one factor.

(One to Many: Factors to Questions

6. Many questions can be related to many ACIs.

(New table: qu_aci with qu_id and aci_id).

(One to many Questions to qu_aci, many to one qu_aci to ACITable.

The results table is the table which glues the system together; it is literally where the results shall be stored as data. It is therefore linked to a number of tables. Each result must be linked to: a company, a session, a parameter and a question. Each of the tables suggested has a one-to-many relationship with the results table. For instance, one company can have many results but one result is only linked to one company. The Parameters table has one-to-many relationship with the par_values table.

After the design of this system a prototype database has been built with a relational structure looking as follows:

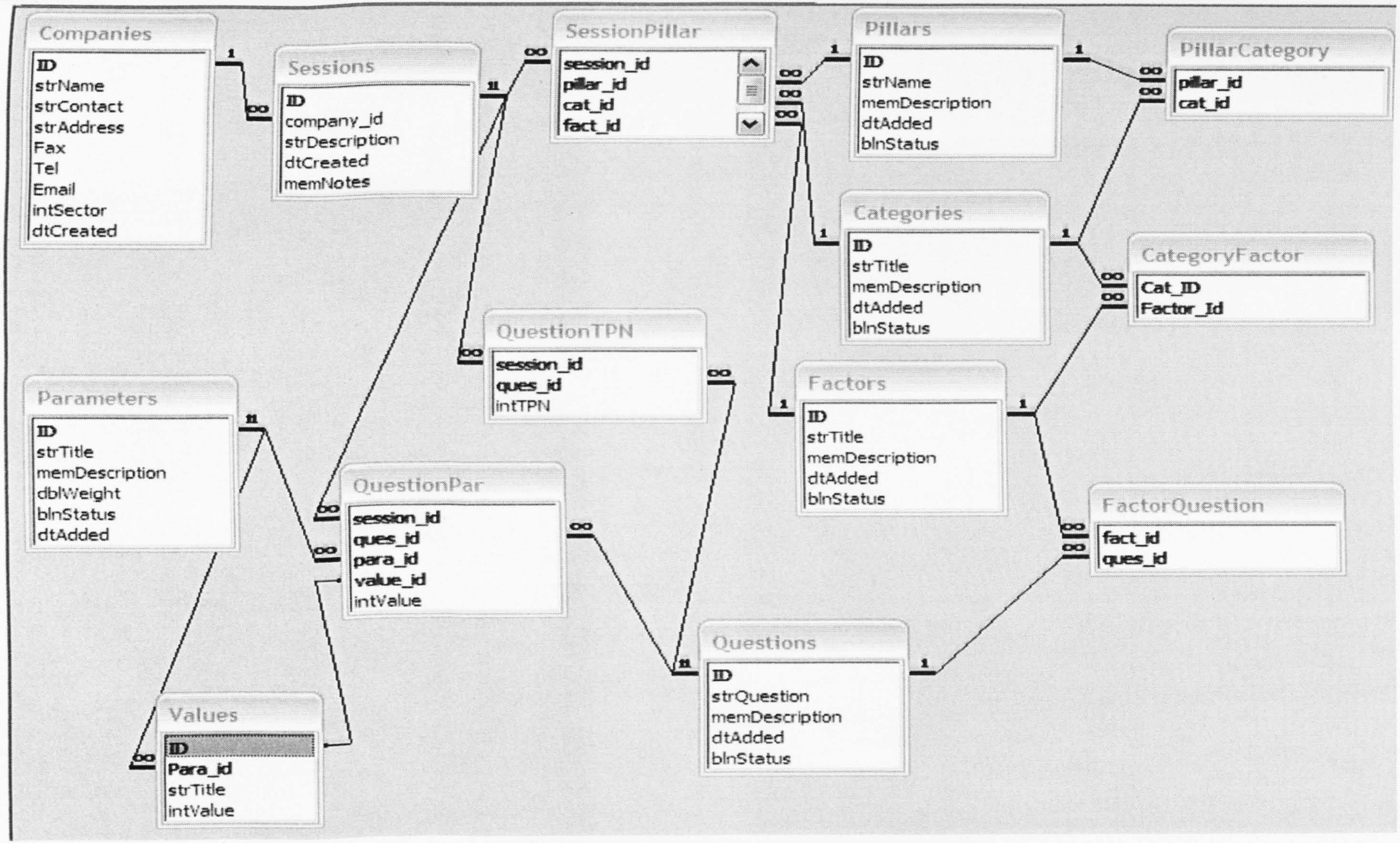


Figure 29: Relationship diagram of Database structure (Johnson 2006)

The above diagram represents the system in its most basic form and the electronic automation of the whole system should be possible. This gives the advantage of being able to implement the whole package through one database, and allow the user to be able to pick and choose which parts of the ASF should be applied to the company being examined.

The author proposes the following additions to the relationship diagram which would allow the implementation for the cross impact sections developed by the author. It would also allow other areas of the authors work to be implemented in the automated system such as a tool selection process, metrics or KPI (Key Performance Indicator) selection to monitor tool impact, and a strategy section linking through the ACS section of the system.

The modified relationship diagram is as follows:

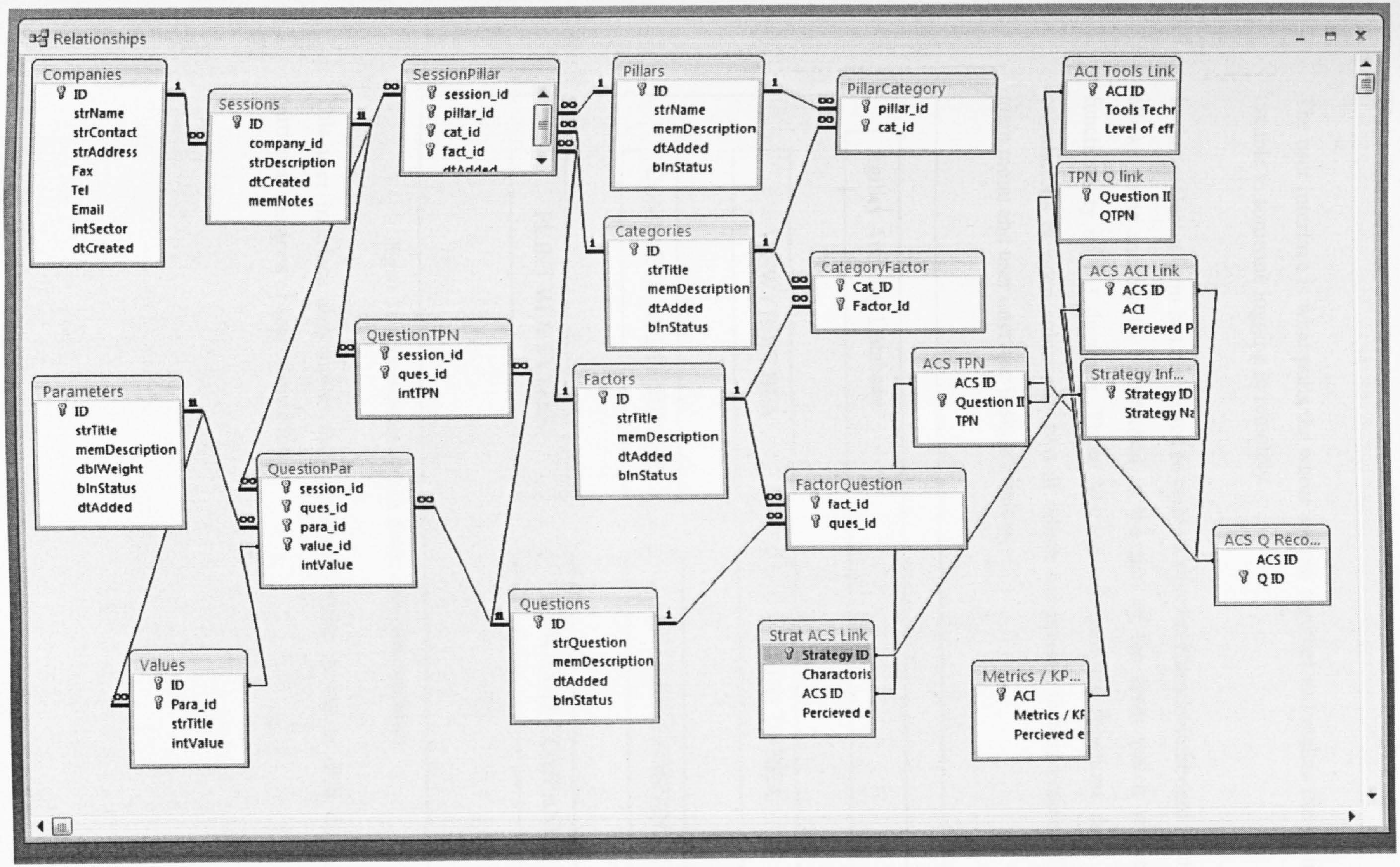


Figure 30: Modified relationship diagram to allow increased functionality of ASF automation (Johnson 2006)

User Interface:

The user interface is what pulls the whole system together and makes the system useable to someone logging in remotely.

In this project a form has been used to create a user interface switchboard as this allows some macros to be attached to the part of the form which will run functionality of the database. These Macros will perform functions such as calculations or open submenus, two of which are present in this project. The main menu and user interface is shown below.

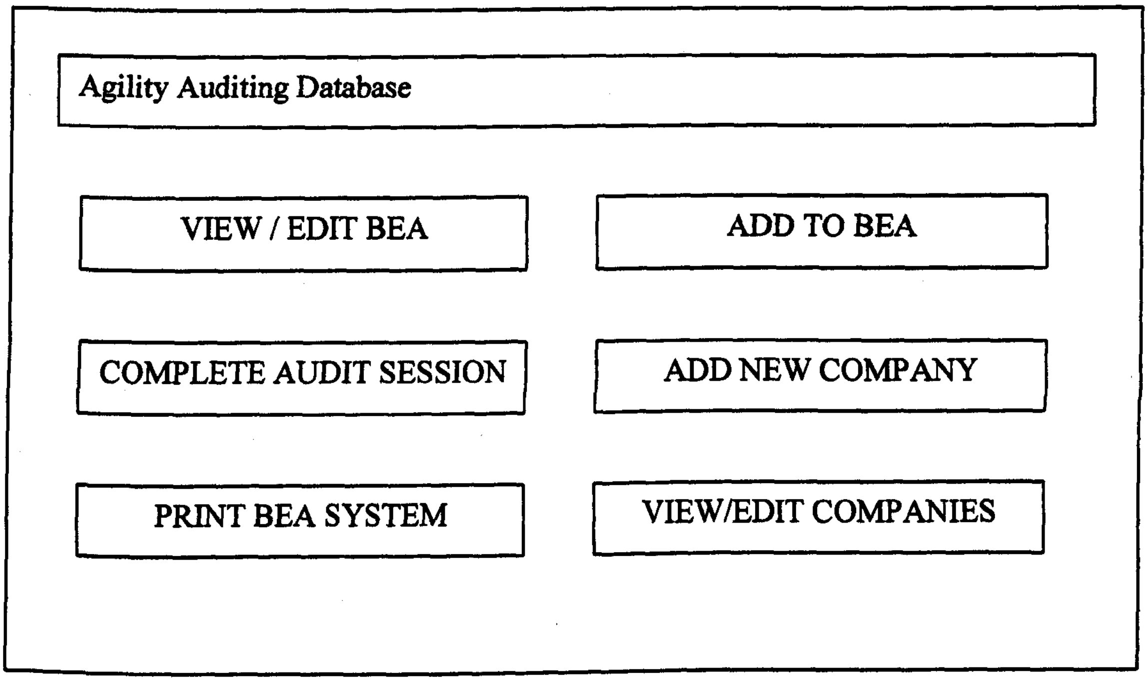


Figure 31: User interface of BEA Automation (Johnson 2006)

This user interface also moves through other similar menus to drill down to particular sessions or sets of questions.

From the second relationship diagram it can be seen that the structure and functionality of the database becomes much more interesting with the addition of the tool selection table and the selection of appropriate strategies. Each one is examined in turn here.

The addition of the tool selection table allows a robust list of tools to be generated which are suggested for use in a company's particular situation. What robust means in this situation is that the list generated will be repeatable, has been defined and validated through recognised research techniques and provides the electronic repeatability to the system.

For the strategy section of the database an element of implementing best practice strategies gives again robustness to the process. Strategy however is a complex part of the developed system and the full topic of this is covered in the next chapters.

Both sections here highlight in priority order the tools and strategies suggested through the system. There are however some interesting manifestations that arise as the relationships between turbulent factors and the tools and techniques as well as the strategic elements are examined.

The system is mechanistic by nature and the High Medium Low ratings that are assigned to the tool and strategy implementation are labels added through research work of previous impact shown by tool implementation. The author proposes that there is a more complex relationship between the HML ratings given to the tools than first becomes apparent. When many pillars of the questionnaire have been implemented the same tools and techniques may be arising a number of times, always suggested at Low or Medium rating. The author suggests that there is a tipping point where by Lows combine to a medium score, and mediums combine to a high.

To take a hypothetical example, Kan Ban, may be suggested as a Medium impact tool *n* number of times. Another stock replenishment or control technique may also be suggested, but only once as a High impact. At this point the operator of the ASF would have to make a judgement of whether ten iterations of a medium tool would have a greater good to the overall system (the company) that one iteration of a high impact. The tipping point here would be judged by the person using the ASF system.

This fuzzy type of logic continues when investigating the strategy implementation area of the database. ACI may lead to a certain type of strategy being suggested for a particular instance of the database use. However, the database use does not take into account the risk levels associated with each strategy, in a sense where they lie in the Ansof Matrix. Certain strategy types may be suggested as high impact, however this may be due to the fact they are also high risk in this particular instance. Risk averse companies will shy away from this implementation and will need to look for alternatives. Perhaps as in the previous suggestion with tool selection, medium level strategies suggested more frequently by the system are more suited to the situation than an infrequently suggested High strategy.

The author proposes that some of the relationships demonstrated in the database are not fixed and rigid like a database diagram but are in fact more fluid and fuzzy. The aim of the database is therefore not to provide a panacea to a problem by presenting tools, metrics, ACI and strategies for the situation at hand, rather the value of the system come from the paired down list to select from. There is then some judgement to be made on whether to implement what might be seen as high risk high impact solutions, or, to take the lower hanging fruit and implement the Medium suggestions which have appeared a number of times – perhaps to greater success in the combating of turbulence, and enabling agility to a further degree within the company.

Summary:

The database designed here includes all the elements set out in the original spec. It represents the ETI system at the point of development of the automated system. The database performs all the functionality of the BEA as stood at the time of developing the database. This has been achieved mainly through the use of VBA (Visual Basic for Applications) and macros and allowing a relationship structure to be created for the tables to maintain referential integrity.

This feature also allows expandability of the system as extra questions, pillars or turbulence rules can be added in using the addition of tables to provide functionality. The relationship structure of the database is also well documented which means any expansion on this structure would be possible by maintaining the relationships set out in the project.

The main continuation of this automation would centre around populating the data fields and testing fully the tool selector table and the TPN calculations against known case studies to allow direct comparison.

The automation of the system with the use of a referential database has also highlighted the interrelationship between the High Medium and Low rankings placed on both the tool implementation and the strategy selection. The author proposes that these High Medium and Low rankings will have a cumulative effect on the impact and suitability of each of the tools and strategies and a tipping point will be reached whereby a number of lows will form a medium impact, and a number of mediums will constitute a high impact. This tipping point is also not seen to be fixed at a set number, but will have a unique effect on each iteration of the ASF. Therefore some operator skill at recognising this tipping point and judging the fuzzy relationships is necessary. The operator becomes a form of risk manager and will implement on risk levels as well as impact levels.

Chapter 9

Framework for Agility Strategy

Why TRIZ

This chapter aims to explain the TRIZ framework, the next looks at how it may be relevant to a framework for agile strategic implementation.

The TRIZ system is examined here as the author suggests this as a way of putting into a framework some paradigms of agility. The framework is examined in detail here for ways in which strategy development for agility can be incorporated into this type of Framework.

TRIZ is a generic framework for problem solving engineering or product / process development type problems. TRIZ is a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas and solutions for problem solving. TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both 'as-is' and 'could be'). TRIZ, in contrast to techniques such as brainstorming (which is based on random idea generation), aims to create an algorithmic approach to the invention of new systems, and the refinement of old systems.

The sum total of paradigms or inventive principles that TRIZ has come up with to solve all problems is 40. The author proposes that is all the above type problems can be reduced to 40 methods or principles then a technique such as Agility must be able to be reduced to a set of principles or "Paradigms." Here Paradigms are defined as 'a philosophical or theoretical framework' (see page 9 for abbreviations and definitions of terms). The number of these finite or generic elements is not known but a number are investigated in the following chapter.

The TRIZ framework is also used as it gives a structure and approach that other tools do not. It aims to make the selection of a principle less of a random event and more of a structured approach to development. It fits well with the practical application of tools and in this case the practical applications of strategy. Here the author proposes that agile is a strategy and TRIZ type systems can be used to implement practical tools to generate agility. It enables all agility type problems to be put through the TRIZ model and helps to reduce the amount of work required to find an agile solution in one particular industry. This is because like in engineering problem solving the solution for agility may lie outside the company's area of expertise.

The paradigms of agility and the reasoning behind them will be examined in the next chapter in more detail. Here the TRIZ system is outlined so as to provide understanding of how it may be implemented for an agile type environment.

TRIZ: Systematic innovation and Inventive Problem solving

TRIZ is the Russian acronym for the theory of inventive problem solving. [Teoriya Resheniya Izobreatatelskikh Zadatch]. A Russian patent officer, who started examining patents for patterns in the physical effects and design techniques being used to solve problems, started it in the 1940's.

'Genrikh Altshuller is the man who started it all. As a patent officer in Baku in the Soviet Union during the 1940s he noticed that there were patterns in the way physical effects and design techniques were being used within applications. People in different industries were solving essentially the same problems,' (Hollingum J, 1998)

From the work it has been discovered that there are 40 Principles or design techniques used to solve any engineering challenge. These principles are simple facts that show techniques used to solve engineering problems in many different industries and situations.

'Up to 1977 thirty seven such principles had been discovered, and it is theoretically possible that more are waiting to be found, but the likelihood is growing less as the work continues.' (Hollingum J, 1998) .

It can be seen from this last excerpt that work continues on TRIZ today under the guise of The Invention Machine Corporation. There is still research going on into the principles but it becomes less likely that new ones will be discovered the more the system is used and tried in new circumstances. It is also interesting that there are such a low number of principles when considering the multitude of problems available for the application of the TRIZ system in the engineering world. This system has been used in some large companies and applied to many different problems.

As well as identifying the 40 principles the system also identifies 39 parameters that can describe the engineering problem. It has been shown through research that by describing the problem through one of these 39 parameters some of the most appropriate design techniques (or 40 principles) can be highlighted as the most probable solutions. It is also claimed that over 90% of all engineering problems have been solved before. This was one of the main drivers for the development of the system in the first place, that many people were all solving essentially the same problem, a huge waste of time and effort. The other main driver was the fact that engineers will only apply certain solutions to a problem, these usually being based upon their own experience.

'It was discovered, though, that an engineer's own knowledge base was limited to a fraction of those existing solutions and effects. For example, Edison filed 1,023 patents using 23 effects, and Tupolev 1,001 patents using 35 effects. A good engineering physics PhD might know 100 effects.' (Hollingum J, 1998).

This factor is called psychological inertia and leads to product being developed only in the range of knowledge of a specific engineer. It means solutions are not drawing from all the experience that mankind has in a vast array of engineering situations.

This psychological inertia separates problem solving into two distinct categories: those with known solutions and those with no known solutions. Those with known solutions can usually be solved through reading text books, technical journals or through consulting subject matter experts.

The solutions will follow the path of the general problem solving model shown below:

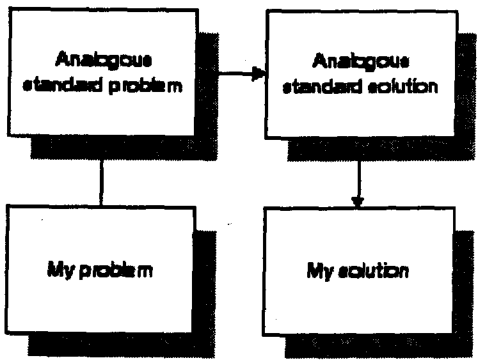


Fig 32: General problem solving model (Mazur G 1995)

In this cycle of problem solving, the current challenge is compared to a similar known problem, or past experience. A standard solution is then drawn from the available experience or material and implemented.

The second type of problem with no known solution is often called an inventive problem. These types of problems often contain some conflicts or contradictory requirements and are often complex in nature. Many methods have been suggested for solving these problems, brainstorming, heuristics, and trial and error are just some and all have advantages and disadvantages. 'Depending on the complexity of the problem, the number of trials will vary. If the solution lies within one's experience or field, such as mechanical engineering, than the number of trials will be fewer. If the solution is not forthcoming, then the inventor must look beyond his experience and knowledge to new fields such as chemistry or electronics. Then the number of trials will grow large depending on how well the inventor can master psychological tools like brainstorming, intuition, and creativity. A further problem is that psychological tools like experience and intuition are difficult to transfer to other people in the organization.' (Terninko J, et al 1998).

This leads to some psychological inertia especially within large organisations where previous problems solving techniques are often used even if they are not the most appropriate. It means that where a person or organisation has experience is likely to be the first place that they look for solutions. This means that by the trial and error method the ideal solution, if it lies in a different field from the experience of the problem solver, will take a large amount of time to find; and may be never discovered at all.

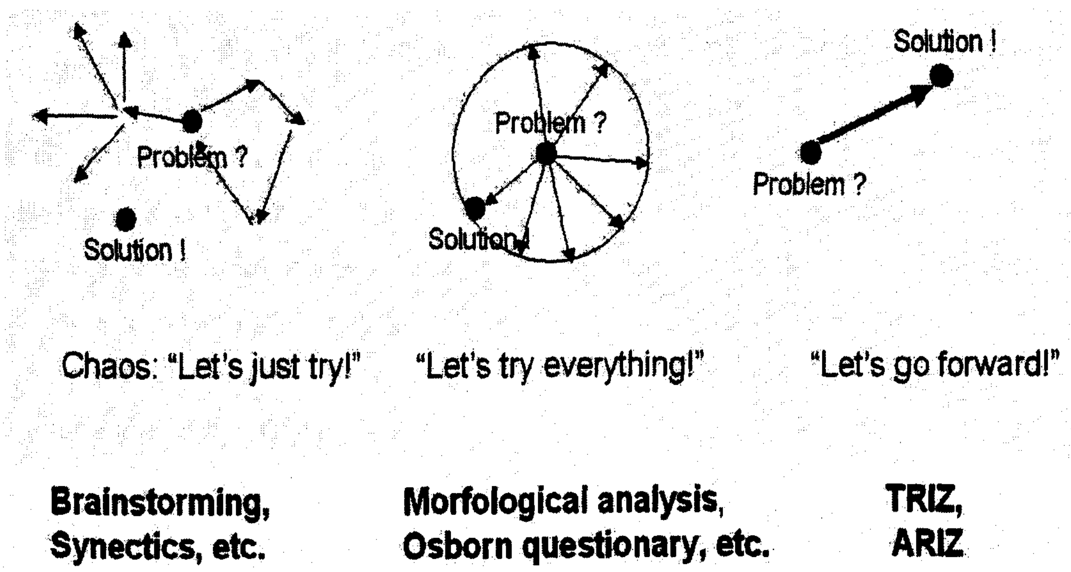


Fig 31: A diagrammatic form of the problem solving methodologies available (Mann D 2002)

The diagram above shows some common techniques used to create solutions to problems. It can be seen in the first diagram that the solution is a long way off with the trial and error method and may never be hit. It is all a mater of luck whether or not the solution target is achieved, more than likely is that some sort of trade off situation will be met with and this will be used as a best-fit scenario. The second systematically searches for a solution; again this may or may not work and has an increased chance of success when compared to the purely random method. But, the diagram does not take into account the solution finders moving into a field that they have no or little knowledge of. The psychological inertia mentioned before may channel the thought process (in a subconscious manner) away from areas which people have little or no knowledge. Therefore the solution may lie outside of existing knowledge and never be found. No matter how systematic and thorough a search may be the answer will never be found if the search is in the wrong place. With TRIZ, the system tries to remove al the barriers to areas of thought and industry sectors and allow ideas from many backgrounds to contribute.

The TRIZ process aims to overcome psychological barriers by satisfying the following conditions:

'be a systematic, step-by-step procedure
be a guide through a broad solution space direct to the ideal solution
be repeatable and reliable and not dependent on psychological tools
be able to access the body of inventive knowledge
be able to add to the body of inventive knowledge
be familiar enough to inventors by following the general approach to problem solving in figure 1.' (Mazur G 1995).

Further Altshuller went on to say that the solutions to inventive problems often cause other problems to appear, 'such as increasing the strength of a metal plate causing its weight to get heavier. Usually, inventors must resort to a trade-off and compromise between the features and thus do not achieve an ideal solution. In his study of patents, Altshuller found that many described a solution that eliminated or resolved the contradiction and required no trade-off.'(Mazur G 1995).

Because Altshuller recognised that some inventors were discovering solutions which eliminated the need for trade off he became very interested in how this may be categorised to enable more people to discover ways of avoiding trade offs. He found that many problems had been fundamentally solved again and again in different industries, so instead of producing a classification system by industry he removed the subject matter to uncover the problem solving process. This is where the forty principles came from, he found that each problem he examined had only been solved by using one of these forty principles over and over again. 'If only later inventors had knowledge of the work of earlier ones, solutions could have been discovered more quickly and efficiently.'(Mazur G 1995).

Altshuller goes on to say that most problems have been solved somewhere else before. The table below illustrates his finding on how many problems have been seen before. They are sorted into categories of varying levels.

'In the 1960s and 1970s, he categorized the solutions into five levels.
Level one. Routine design problems solved by methods well known within the specialty. No invention needed. About 32% of the solutions fell into this level.

Level two. Minor improvements to an existing system, by methods known within the industry. Usually with some compromise. About 45% of the solutions fell into this level.

Level three. Fundamental improvement to an existing system, by methods known outside the industry. Contradictions resolved. About 18% of the solutions fell into this category.

Level four. A new generation that uses a new principle to perform the primary functions of the system. Solution found more in science than in technology. About 4% of the solutions fell into this category.

Level five. A rare scientific discovery or pioneering invention of essentially a new system. About 1% of the solutions fell into this category.' (Mazur G 1995).

For each level Altshuller noted that the solution required broader and broader knowledge to find solutions and consider more ideas before an ideal solution can be found. The table below illustrates the level of solution compared to the degree of inventiveness and source of knowledge. It also shows how as a problem becomes more complex the greater the number of solutions to consider.

Level	Degree of inventiveness	% of solutions	Source of knowledge	Approximate # of solutions to consider
1	Apparent solution	32%	Personal knowledge	10
2	Minor improvement	45%	Knowledge within company	100
3	Major improvement	18%	Knowledge within the industry	1000
4	New concept	4%	Knowledge outside the industry	100,000
5	Discovery	1%	All that is knowable	1,000,000

Fig. 34: Levels of Inventiveness (Mazur G 1995).

As can be seen from the table only the level four and five problems require significant investment of time and knowledge as the other problems have often been solved within the company or industry and so consultation with other employees and or industry connections can bring results quickly. This is because if the phenomenon of 'problem solved before'.

Level four and five problems cannot be solved (or it will be very hard to solve) using you existing knowledge, trial and error cannot produce the results if new information is required. Unless a system like TRIZ is applied then new areas of knowledge will not be explored. Level five problems that generate true 'unique' solutions and or products are rare occurrences indeed and only occasionally will the principle of the solution have not been used elsewhere and in a similar manner.

Before the system of TRIZ is examined as a step by step process the law of ideality will be examined. This law shows how technical systems evolve towards ideality, where ideality is defined as the quotient of the sum of the systems useful effects, Ui, divided by the sum of its harmful effects, Hj.

$$Ideality = \frac{\sum U_i}{\sum H_j}$$

Figure 35: Ideality equation (Mazur)

'Useful effects include all the valuable results of the system's functioning. Harmful effects include undesired inputs such as cost, footprint, energy consumed, pollution, danger, etc. The ideal state is one where there are only benefits and no harmful effects. It is to this state that product systems will evolve. From a design point of view, engineers must continue to pursue greater benefits and reduce cost of labour, materials, energy, and harmful side effects. Normally, when improving a benefit results in increased harmful effects, a trade-off is made, but the Law of Ideality drives designs to eliminate or solve any trade-offs or design contradictions. The ideal final result will eventually be a product where the beneficial function exists but the machine itself does not. The evolution of the mechanical spring-driven watch into the electronic quartz crystal watch is an example of moving towards ideality.' (Mazur G 1995)

This is also shown neatly in diagrammatic form as follows:

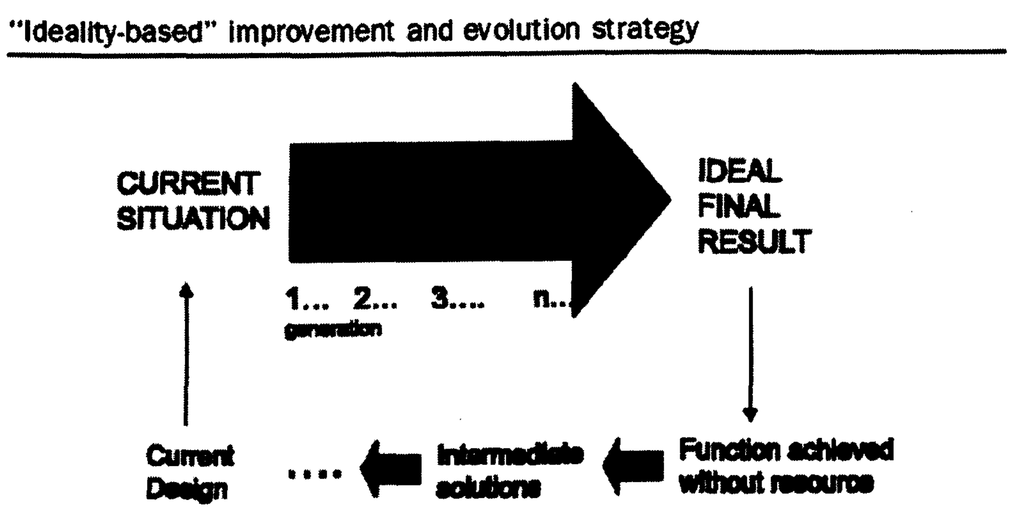


Fig 36: The ideality based law suggested in the TRIZ system (Mann D, 2002)

The step by Step TRIZ process: An Overview

1 – Identify Problem:

2 – Formulate the problem: The prism of TRIZ

3 – Search for previously well solved problem

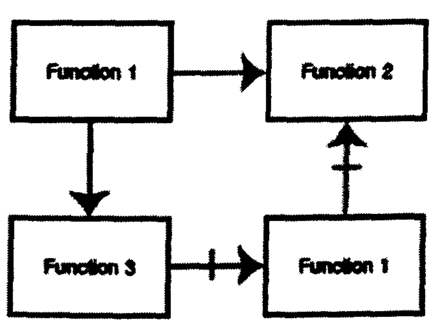
4 – Look for analogous solutions and adapt to my solution

5 – Formulate ideal solution

Step 1: Here the problem is simply written down in clear principles stating what the primary use or function is and what part of this function causes a problem and what needs to be solved. It specifies 'the resource requirements, primary useful function and harmful effects, and ideal result.'(Mazur G 1995). This can be done using the innovation situation questionnaire developed by Ideation company.

Step 2: A problem formulator has been developed to help formulate the problem into engineering principles and give insight to the problem solving team. The problem formulator states the problems in terms of physical contradictions. An example of this is shown.

'Problem



Formulator™ Diagram (Ideation Co Ltd)

With four types of links—

1. "Provides" something good (green solid)

2. "Eliminates" something bad (green w/cross line)

3. "Causes" something bad (red solid)

4. "Hinders" something good (red/w/cross line)

It is possible to diagram and analyse any type of problem, technical or non-technical.

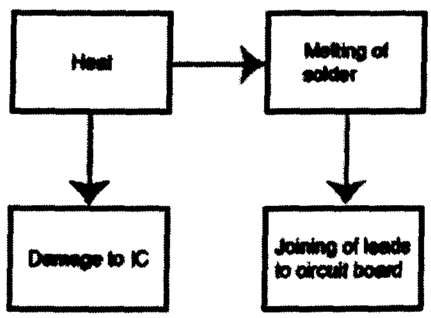


Figure 35: Problem formulator diagram (Mazur G 1996)

A Simple Example

This is a simple example of a diagram for the soldering of an integrated circuit. It shows the one primary contradiction (heating provides something good--melting of solder, as well as something bad--damage to the integrated circuit). Contradictions are easy to identify by seeing a box which has a green and red arrow exiting.' (JWH Consulting 2000-2006)

Step 3: From the examination of patents Altshuller extracted 39 engineering parameters that cause conflict. These 39 parameters are listed on the following page. They are then formed in to a contradiction table (a small segment of which is on the following page). The table is used to help identify solutions to problems, which are structured in the manner of: As feature A improves – Feature B worsens. If this cross impact is looked up on the contradiction table a list of solutions are suggested from the 40 principles list.

The principles list follows the contradiction table.

The 39 Engineering Parameters:

Weight of moving object
Weight of non-moving object
Length of moving object
Length of non-moving object
Area of moving object
Area of non-moving object
Volume of moving object
Volume of non-moving object
Speed
Force
Tension, pressure
Shape
Stability of object
Strength
Durability of moving object
Durability of non-moving object
Temperature
Brightness
Energy spent by moving object
Energy spent by non-moving object
Power
Waste of energy
Waste of substance
Loss of information

Waste of time

Amount of substance

Reliability

Accuracy of measurement

Accuracy of manufacturing

Harmful factors acting on object

Harmful side effects

Manufacturability

Convenience of use

Repair-ability

Adaptability

Complexity of device

Complexity of control

Level of automation

Productivity

Step 4: Use the standard technical conflict to look up the cross impact and find some suggested solutions.

A segment of the contradiction table:

Improving feature→	Worsening Feature→	Weight of moving object	Weight of stationary object	Length of moving object	Length of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object
		1	2	3	4	5	6	7	8
1	Weight of moving object	+	-	15, 8, 29,34	-	29, 17, 38, 34	-	29, 2, 40, 28	-
2	Weight of stationary object	-	+	-	10, 1, 29, 35	-	35, 30, 13, 2	-	5, 35, 14, 2
3	Length of moving object	8, 15, 29, 34	-	+	-	15, 17, 4	-	7, 17, 4, 35	-
4	Length of stationary object		35, 28, 40, 29	-	+	-	17, 7, 10, 40	-	35, 8, 2,14
5	Area of moving object	2, 17, 29, 4	-	14, 15, 18, 4	-	+	-	7, 14, 17, 4	
6	Area of stationary object	-	30, 2, 14, 18	-	26, 7, 9, 39	-	+	-	
7	Volume of moving object	2, 26, 29, 40	-	1, 7, 4, 35	-	1, 7, 4, 17	-	+	-
8	Volume of stationary object	-	35, 10, 19, 14	19, 14	35, 8, 2, 14	-		-	+

Figure 36: Segment of TRIZ contradiction table (Mann D, 2002)

Step 4:

The principles list was developed from examining numerous patents, these are principles that will help an engineer find a highly inventive solution to a problem. From the contradiction table the numbers generated in the cross impact section relate to the principles list. By looking up these numbers a simple principle will be suggested that could be incorporated into the design of the solution that should solve the problem.

Step 5:

Formulate the ideal solution from the shortlist of the useful inventive principles.

There are many software packages available which aid with this problem solving process and these are commercially available. They are used by many big corporations to help solve complicated problems and speed up the process through automation and generating suggestions to the problems specified through the step by step software. The programs help to generate the standard technical conflict and well and illustrate with diagrams the possible solutions to the problem.

Examples of the 40 Principles for solving problems

1. Segmentation
a. Divide an object into independent parts
b. Make an object sectional
c. Increase the degree of an object's segmentation
Examples:
Sectional furniture, modular computer components, folding wooden ruler
Garden hoses can be joined together to form any length needed

2. Extraction
a. Extract (remove or separate) a "disturbing" part or property from an object, or
b. Extract only the necessary part or property
Example:
To frighten birds away from the airport, use a tape recorder to reproduce the sound known to excite birds. (The sound is thus separated from the birds.)

3. Local Quality
a. Transition from a homogeneous structure of an object or outside environment/action to a heterogeneous structure
b. Have different parts of the object carry out different functions
c. Place each part of the object under conditions most favorable for its operation
Examples:
To combat dust in coal mines, a fine mist of water in a conical form is applied to working parts of the drilling and loading machinery. The smaller the droplets, the greater the effect in combating dust, but fine mist hinders the work. The solution is to develop a layer of coarse mist around the cone of fine mist.
A pencil and eraser in one unit.

4. Asymmetry
a. Replace a symmetrical form with an asymmetrical form.
b. If an object is already asymmetrical, increase the degree of asymmetry
Examples:
Make one side of a tire stronger than the other to withstand impact with the curb

While discharging wet sand through a symmetrical funnel, the sand forms an arch above the opening, causing irregular flow. A funnel of asymmetrical shape eliminates the arching effect.

5. Combining

a. Combine in space homogeneous objects or objects destined for contiguous operations

b. Combine in time homogeneous or contiguous operations

Example:

The working element of a rotary excavator has special steam nozzles to defrost and soften the frozen ground

6. Universality

Have the object perform multiple functions, thereby eliminating the need for some other object(s)

Examples:

Sofa which converts into a bed

Minivan seat which adjusts to accommodate seating, sleeping or carrying cargo

7. Nesting

a. Contain the object inside another which, in turn, is placed inside a third object

b. Pass an object through a cavity of another object

Examples:

Telescoping antenna

Chairs which stack on top of each other for storage

Mechanical pencil with lead stored inside

8. Counterweight

a. Compensate for the object's weight by joining with another object that has a lifting force

b. Compensate for the weight of an object by interaction with an environment providing aerodynamic or hydrodynamic forces

Examples:

Boat with hydrofoils

A rear wing in racing cars which increases pressure from the car to the ground

The system shown above can have many applications in many industries. Now that the system has been outlined there may be some parallels drawn from this type of work which can be implemented with agility problems. Some conclusions from the above are:

Majority of problems have been solved before
Knowledge frameworks can speed up problems solving
Knowledge frameworks can lead to unique solutions
Knowledge frameworks can provide a validation of problems and theories
Paradigms exist for problems solving which can be applied to numerous situations
Ideal solutions can be found without trade off by using areas of knowledge not yet explored in the situation specific problem

Agility must also have some paradigms which can be applied at a strategic level. These must be able to generate strategies, or validate strategies as agile or agile creating.

Some of the principles to apply are that the majority of organisation structures and issues surrounding getting product to market have been solved before in a different industry. Frameworks for organising agile strategy can greatly speed up the process of moving into action. Ideal solutions for agile strategies can be sought to avoid trade off.

The next chapter will examine how this is possible, what kind of strategic paradigms exist already and how they may be formulated into a system such as TRIZ to aid development, and ultimately share learning amongst many sectors and industries.

Chapter 10

Paradigms of Agility

Content Analysis and Grounded Theory

This chapter explains the authors theory around the paradigms of agility. Namely that paradigms must exist which are akin to the TRIZ type system of engineering problems. Agile paradigms must be finite in number and be applied in much the same way that the TRIZ system applies these paradigms, in order to move a situation or challenge forward and generate an outcome desirable to the investigating party. The author also suggests the following points:

The majority of problems have been solved before, the occasions when new solutions will be generated is rare, the solutions will appear outside the experience of the people seeking to solve the problem.

There will be situations where a trade off is sought, however and ideal solution will exist although it may be outside the experience or knowledge of the company.

$$Ideality = \frac{\sum U_i}{\sum H_j}$$

Figure 35: Ideality equation (Mazur)

The author suggests that there will be an ideality formula for agility problems where a systems useful effects will be balanced by it harmful effects in the same way as the above equation.

For Agility there are many definitions available and many more being developed every day in research articles and the like. Many definitions are a rework of existing ones, or have small additions and caveats. Here the research is focussed on the existing definitions both within the manufacturing context and the wider use of the word in general business terms.

Content analysis

The methodology behind the selection of material for content analysis is included in the Research Methodology Chapter. The literature Used for content analysis is included in the bibliography. It is not proposed to list them all here, however any paper used for content analysis is coded in the bibliography with a *(CA)* at the end of the reference to it. As stated in the methodology chapter 96 papers were used to get a research accuracy of 95% with a + or – 10% error factor.

The process followed during the content analysis is outlined below:
1) Theory and rationale: What content will be analysed and why.
In this project the content of published research papers will be examined to look for the paradigms of agility. Literature examined around agility and strategy in the literature review and the research questions posed fit in here.
2) Conceptualisations: What variables will be used in the study, There are many ways to define a given construct and this is dependent on the coders.
In this project the concepts defined were around agility, and the pillars identified in the BEA project. This is where the literature will be coded and placed under these pillars.
3) Operationalisations (measures): What unit of data collection will be used e.g. by utterance in spoken text.
Here the author has used by print method and where the defined words appear in text coding has been applied under the structure of the pillars of agility. Explained in more detail over the next pages.
4) Coding schemes: method of applying dictionaries.
The coding was applied through examination of the text and words defined as related to agility were coded under the pillars (PPPOO)
5) Sampling: In this project sampling has been by availability of research material on electronic databases. Databases used were Emerald Full Text, The IEEE Library and the British Library. Agility was search in the subject box. The restrictions on the method used here are discussed in the research methodology.
6) Coding: Apply dictionaries to sample text.
A time consuming task were the definitions and structure of the coding are applied through all the text collected.
7) Reporting: What the results of the content analysis exercise show.

It is planned to examine the use of the word Agility and its definitions to examine the context that most research places around the agile concept and to try find out where most research is being conducted with regards to agility. The context framework that is planned to be applied is that of the agility centres pillars of agility. These are Product, Process, People, Operational and Organisational. The aim is to hopefully find what emphasis is being placed on each of these pillars and to examine the way in which the most common contexts are covered with the existing Agility Centre work. This will link this work to that done previously in developing the BEA. The definition and application context of agility is important as it is proposed it can feed into the strategy selection and evaluation tools being developed and examined in this project.

To find out the most common definitions, content analysis will be used on available material. The content analysis will take in papers, web sites and books. This is to gain a good cross section of research material available. The analysis pooled these sources and examined them for common themes and solutions.

To summarise, the aims of the content analysis are:
Common terms in agility definition
Context of definition (manufacturing) in relation to the pillars of agility (PPPOO)
Context of definition from strategy work
Context of definition when examining business processes
Find common elements mentioned by research to find main focus of recent agility work
Produce a definition from the above work
Produce a definition from my own reading and research and use this to help direct the research into agile manufacturing strategy formulation and evaluation
Define agile manufacturing and identify the difference between agile facilities and production and agile strategies
Define agile processes and strategies separately
Define common terminology around agility

From the above develop paradigms of agility present in all cases of agile, agile implementation and agile definition

The content analysis will be carried out under the social science research technique of grounded theory. This is due to the similarities in content, context and semantics work carried out in the social sciences and the work being undertaken here.

Here a definition of grounded theory is provided:

What is grounded theory: 'theory that was derived from data, systematically gathered and analysed through the research process....theory derived from data is more likely to resemble the reality' [Bogden and Biklen 1992]

Because the theory being developed is through the immersion in data and the use of content analysis techniques it is expected to increase the accuracy of the output.

In this section the research focused on content of published material on the subject of Agility. Many different papers and journals have covered the subject and it is proposed that by studying content of these a theory could be borne about the paradigms of Agility. Therefore content analysis of all the above documentation was used to develop grounded theory on the principles of Agility.

As content analysis can be very time consuming and results difficult to record the software package NVIVO was used to develop the qualitative project. This meant electronic copies of papers were obtained and loaded into the NVIVO package for content analysis. The use of NVIVO comes into its own when examining the contents coded under a heading by allowing easy data manipulation around coded areas, creating interesting and easy comparisons of the data coded under a node. The formed project was structured around specific factors; those areas coded during the research were as follows:

What is Agility?
What is agile manufacturing?
What is agile strategy?
What are the paradigms or factors that are required for, or to generate Agility?

To further the research the pillars of Agility as defined by Ismail et al, were also evaluated to look at how they fit into the definition of Agility provided by the research. These pillars are:

Product
Process
People
Operations
Organisation

Wherever these pillars appeared in agility definitions they were coded and each pillar built its own database of coded material. This helps to show where agility is being derived from in most research definitions. It may also help to develop further pillar measures. Pillars which at the moment are generating large amounts of coded data may be highlighting areas lacking in research.

Once the above factors were coded throughout the material studies on Agility, a list of short paragraphs relating to that particular area was generated. The coded material was build into data trees and categories of data developed by looking at functions such as proximity searches and union searches trying to identify where data formed close relationships to each other. The proximity search is particularly interesting as it can highlight where two definitions of agility sit closely together.

It was not expected to find a ready list of paradigms assembled from many different researchers but some key facts appeared that helped shape the thoughts about these.

In all ninety six papers have been explored so far, and although this number is small some results have begun to emerge. The larger the number of papers explored and examined the more results and the more confident of those results the researcher can be. It is proposed that while a small number of paradigms have been developed in their initial stages, larger numbers will be generated from continued research. This is compared directly with the large number of man hours and years spent developing the TRIZ paradigm and contradiction systems.

During the review of literature, agile strategies and techniques classed as 'agile strategy' were identified and examined in various contexts of strategy work. This may include but not be limited to work from Miltenberg, which some of the areas of the BEA system have been based on and identified to, Terry Hill along with others such as Mintzburg, Porter, and Hayes and Wheelwright.

Core agility attributes are important as these are what strategies will be trying to achieve, maximise or utilise to develop the business / manufacturing system.

Paradigms of Agility:

The NVIVO project was carried out to gather and code data at the previously discussed nodes. After reviewing the content analysis work several common factors keep appearing in relation to what is Agility. These common factors are summarised in their most basic form as:

Decentralised decision making
Technical functions involved in marketing
Leveraging intellectual power and creativity
Niche markets
Eliminate departmentalisation
Freedom and availability of information
Forming partnerships and improving relationships with supply chain
Treating each customer as individual and provide an entire solution

So how do these relate to a TRIZ type system? If we examine the first three factors we can put these into principles rather than a statement about company workings.

Decentralised decision making: This relates to flat structured organisations where employees are empowered to make decisions on the job. Therefore there needs to be an amount of training and skilling of the workforce to enable this to happen. There also needs to be an information system that provides the right information and enables easy manipulation to make a decision at the right point in the product or service process. It could be that the principle would be
'Install live data systems at decision points'
A Strategy paradigm here might be to 'Empower employees to customise products to the required levels by the end user'.

Leveraging intellectual power and creativity: A company that utilises all of the brain power available to it must be intellectually superior to one which utilises only a small percentage. This is a typical problem where management think they should be the only people using creative or intellectual capacity. Again this relates back to the first point about people having the authority to make decisions and the information to make the right ones. The principle here could be stated as

Employees contribute to workplace design

Employees contribute to product / process design

Employees experience utilised in decision making

Strategy paradigms here could relate to the HR perspectives of the business in 'Recruiting and retaining talent and knowledge and to invest in training and development of the employees'.

Technical functions involved in marketing: This is really talking about what are the possibilities that technical areas can offer the customer in terms of enhanced products and choice. Rather than marketing coming up with all the ideas for new products there should be an input from technical functions to show the possibilities that can be created. To be truly agile this should have input from customer as well. The principles that may come from here are

Technical experts drive product development / marketing

Content analysis results discussion

The principles shown here are a first attempt and will need refining down through more research. It is proposed that validation could take place in the form of coding the paradigms through different published work on agility to see if other definition and context fit with the paradigms. This should be done with multiple coders using the same coding dictionary to produce a large database of material.

However from this first attempt it is also possible to place these principles under the pillars of Agility defined by The Agility Centre. For example the three principles under leveraging intellectual power and creativity fit into the People Pillar.

It is also interesting to note here that the initial results point to People and Process as having the most text coded to them. In total these two pillars have more than 75% of the available material coded to them. This warrants further research but points to these as being key aspects to agile strategy. This also seems to fit with definitions explored rat the start of this research project which centred around the reconfigure-ability of process and people to achieve new goals operations or tasks.

Something that has not been carried out on this research data is detailed statistical analysis. This would be helpful in furthering the research throu relationship proving and significance testing. There are many published articules and books on the subject of statistical analysis of results from content analysis, therefore it is not proposed to discuss them here. However the application of some of these techniques would also point the direction for further research.

TRIZ system for agile paradigms:

The paradigms from the NVIVO work are all well and good but how can they be put into a system where they can be utilised for agile strategy, agile formulation and agile implementation?

TRIZ generates parameters which are the generic solution to an engineering problem. It is proposed that the paradigms of Agility can be used to develop the current position of a company to a more strategically agile position. This development needs to come through a structured approach to what strategy is, where a company is on its lifecycle, what manufacturing it's outputs are and how it falls into schools of strategy development. A key part of the strategy implementation plan would be to answer how each or some of the paradigms will be utilised.

The first proposal is that there must be several paradigms which are common in agile corporations, and, that there must also be a finite number of these paradigms. In engineering problems TRIZ proposes 'a mere 40 inventive solutions or design techniques used to solve any engineering dichotomy' [Hollinghum J 1998]. And this surprisingly low number comes from masses of research into problem solving through the examination of patent applications, 'they devoted some 700 man years to analysing 1.5 million patents' [Terniko J 1998].

The second proposal is that these paradigms are the enablers of Agility in terms of strategy for a company. From research we have already identified the capability indicators of agile, and associated tools that help to build these capabilities, this has been put together and proposed under the BEA system. Therefore it is proposed, as in TRIZ, a set of paradigms exist to build up agile strategy, or a solution to an issue.

The third proposal is that there will be trade off questions when looking for solutions. The TRIZ type system for agility should help the company move towards Ideality, as in the ideality equations shown before. The system should pull solutions from industries outside the users experience and propose new 'paradigms' to aid strategic business decisions.

Thus far the BEA has concentrated on a bottom up approach to agility, putting in measures and capabilities. So from the top end of the process of becoming agile, (strategy), there must be a way of identifying capabilities that are required of a strategy for it to generate or drive Agility in a business. These are the paradigms of agility and can be used as strategy enablers or checkers. It is proposed that strategic schools of thought, company structure and type of industry or classification will impact on which paradigms are most appropriate.

The flow chart below represents the current flow of the TRIZ process for an engineering problem in a simplified format. This highlights the general structure of TRIZ.

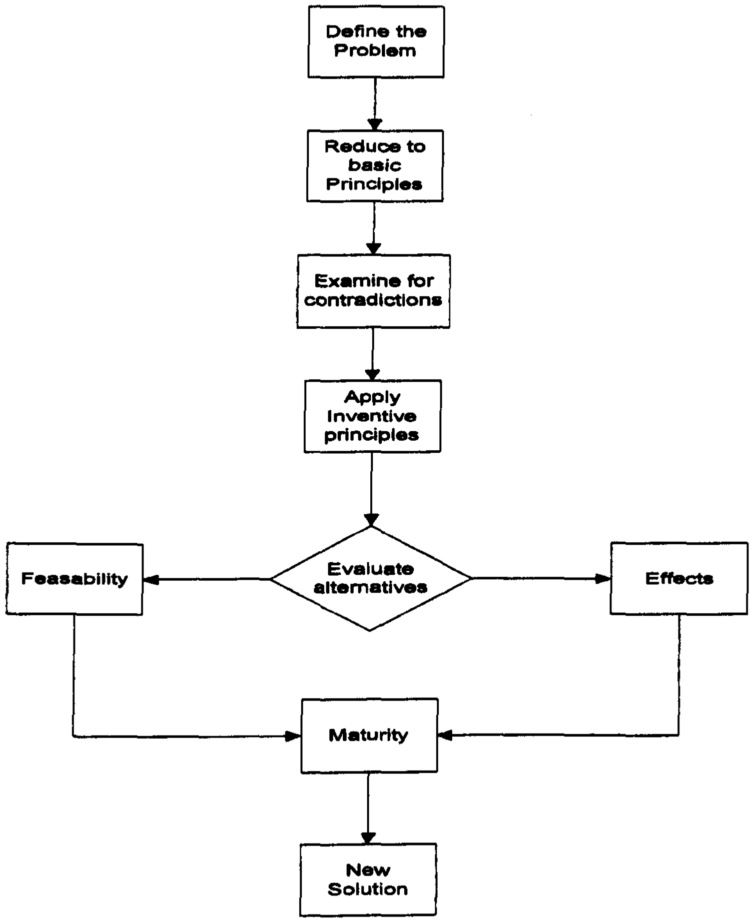


Fig 42: The basic TRIZ process (Hetherington)

As discussed in the previous section the output to TRIZ should be a new solution to an engineering problem. This new solution is drawing on the inventive principles (or paradigms of solution) created by the TRIZ process.

The next flow diagram shows a suggestion for business process agility, in a TRIZ type framework. A flow diagram is shown and at each stage an explanation of how it maps to the TRIZ diagram is given.

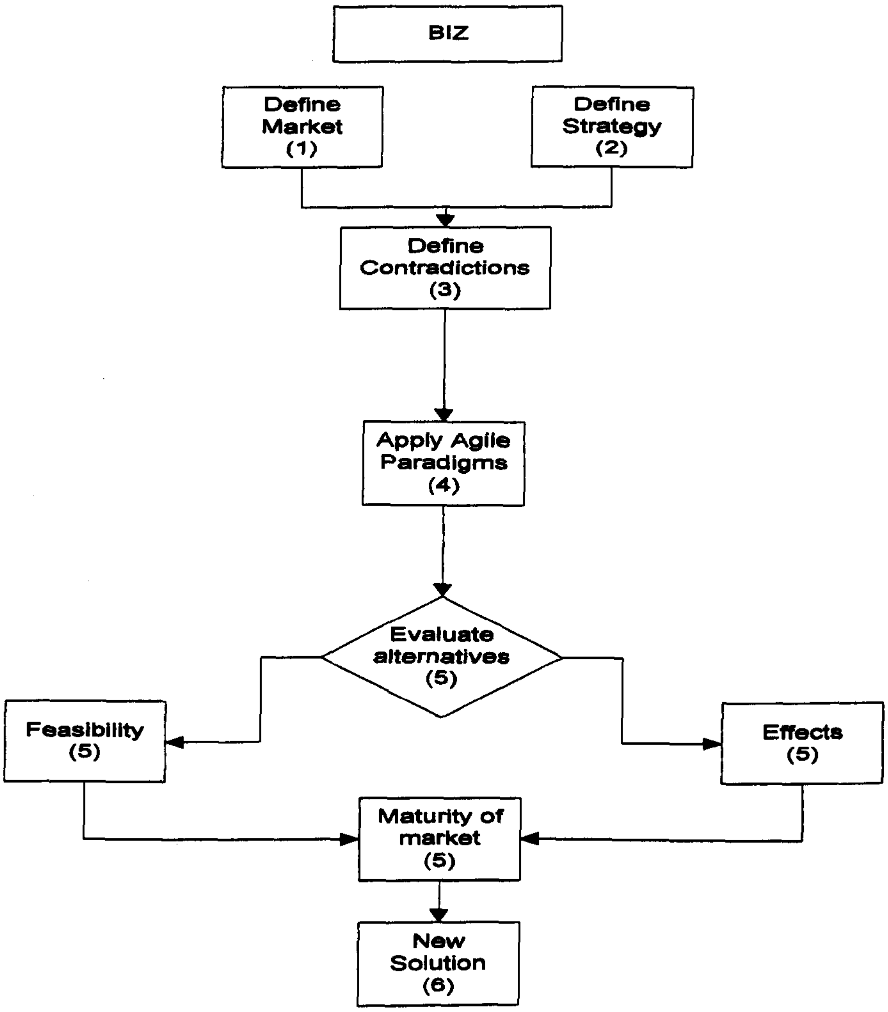


Fig 43: BIZ system process flow diagram (Hetherington 2007)

The above system is the Authors proposal of how the agile principles can be out into a framework. BIZ stands for Business agility Izobretatelskikh Zadatch, and roughly translates to Business Agility Inventive Problems Solving.

The steps for the application of the model are outline in detail below. However in summary the steps are as follows

Define the current type of organisation that the company is (from the list provided)

Define where the company wants to move to where is will create a segment in the market which will allow a niche to be carved and the company to provide unique solutions

Each individual market will have its own characteristics and by moving to a new classification there will be some contradictions in the way the company operates. These contradictions will need to be dealt with on an operational level to allow the product to operate in the manner of the new strategy.

Here the problems solving approach used in TRIZ is applied to the paradigms for agility. A a look up table from the contradictions is created which relates contradictions to agile paradigms. This requires the use of look up tables which are explained in the next chapter.

This section checks feasibility.

This presents a solution to the initial problem.

For the BIZ system a detailed description of how to operate each of the elements follows:

Step 1 of BIZ: Define the Market: (relates to defining the problem) For this system markets are defined as MTS, ATO, MTO, ETO (make to stock, assemble to order, manufacture to order and engineer to order), this is based on how the company supplies its market with the majority of its products. This is a very crude definition to start with but all businesses can fit into these definitions. Services, for example, can fit in with a little creative thought. An example might be airlines who schedule flights from A to B. This is a MTS product as the plane is scheduled to carry passengers and the airline company are selling seats from a stock. A different type of airline may charter airlines which operate in a different type of industry classification. These classifications may vary and become more complex but the aim of the system at this point is to provide simplicity. Financial companies too may fit different definition on this scale depending on whether they supply off the shelf type products or are created bespoke packages for individual customers.

Step 2 of BIZ: Define strategy: (relates to defining the problem) Strategy here is defined as moving from one market classification to another, or moving within the classification to create a market for the product. The process of moving forward and the type of strategy formulation is examined as part of this stage. A segregation of the market from traditional perspectives to a new way of servicing customers is one way of creating a niche and creating agility for the company. The process of strategy formulation has been examined in terms of traditional schools of thought on strategy. There are numerous ways of formulating strategy and each has its own advantages and disadvantages in terms of Agility. It is proposed that strategy formulation is often related to the type and size of the company and the structure that the company uses. This is examined in more detail later in the chapter.

Step 3 of BIZ Define Contradictions (examine for contradictions): Contradictions here may be put in terms of business strategy and current market or market position. This examines the differences in market type of MTO (Manufacture to Order), MTS (Manufacture to Stock), ATO (Assemble to Order) and how customer expectations and perspectives will be affected. For example the contradiction may be the market is an MTS type product. However for Agility reasons the company may want to fragment this market and use ATO or MTO giving customisation options. This however may have an adverse affect on the lead time of the product. Therefore the BIZ system needs to combat this and use tools and techniques which will help to reduce lead time. This is where ideality will be used and trade off (leading to sub-optimal solutions) need not occur.

From this we can say one of the contradiction principles in moving around the in market classification system is
lead-time expectations

Again for this section there will be many contradictions which the strategy must overcome. This area will grow and develop as the principles develop and can be used in much the same way as the TRIZ contradictions. As one factor improves (choice of options) one factor becomes worse (lead-time alters). TRIZ states that there will be an optimum solution for this and therefore the paradigms must help to combat these contradictions.

Another example might be a company operating ETO which wants to move to ATO. Some factors to consider may be that there is a loss of unique solutions, also a large number of parts and subassemblies need to be held (contradiction). The benefits being that customers' project will be ready in a shorter time. Therefore the contradictions here will be:
Loss of unique solutions (or a perception of)
Large Inventory

These types of contradiction can be dealt with both strategically and operationally, however the BIZ system will concentrate on strategic type elements as the BEA can be used for the bottom up approach.

4) Step 4 of BIZ: Paradigms of Agility (apply inventive principles): Put in paradigms here as explained in previous section, e.g. install data systems at decision points. Here practical solutions should be identified which allow data to be shared at the appropriate part in the product cycle to allow customisation to take place and reduce lead time. The table used here to apply these principles is the table developed by the author, called Mapping Strategy to agility Capability / Core Values. This table and its use and construction are explored in the next chapter. Essentially it is a look up table taking into account factors from strategy school through to manufacturing outputs and marrying this up to agile paradigms.

5) Step 5 of BIZ: Maturity of Market (maturity): This stage is a sense checking procedure where market research should be carried out on the strategy and path chosen to make sure that any unforeseen events or issues have been taken care of. Especially in relation to market / product maturity and the like to ensure that all costs factors and market requirements are fully understood by the business. There are many market research techniques available and other papers will better explore these type of techniques. Therefore for the time being this section is left up to the operator of the system to choose an appropriate method of market research. The process has however been mapped here to include looking at factors such as the maturity of the market and product, the feasibility and the effects on the market. The maturity model is included in the original TRIZ framework and is important here as product maturity and market maturity will guide in how far, how fast, and how successful strategies should be. Also feasibility is important in terms of cost Vs value to customer. Many products can have huge customisation and add lots of expensive process but does the customer value these and are they prepared to pay for the extra if it is expensive to add.

The case study later in the project which examines strategic formulation in a company gives examples of these action plans.

6) New Solution or Action: (new solution) This is a self explanatory phase. Get going with the new strategy. However, actions from strategic thinking need to be captured and issued to the appropriate people for follow up. It is suggested here that action sheets are produced in terms of operational deliverables which must be regularly reviewed, both to make sure that they are done and the jigsaw fits together, and that they are still relevant to the strategy and in the wider marketplace. The review process is particularly important to maintain Agility.