EXECUTIVE SUMMARY

THE DESIGN OF ORGANISATIONS, PRODUCTS AND PROCESSES FOR STRATEGIC FLEXIBILITY

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Abstract

Technological innovation and globalisation are driving profound economic, political and cultural changes. There is a widespread acknowledgement that organisations need to be more strategically flexible to cope with increased levels of competition and market change. The research reported here has two objectives. The first is that of identifying the causes of strategic flexibility in organisations, and the second being to implement methods of improving strategic flexibility.

A model of decision-making behaviour has been developed, which identifies the areas of individual and group decision-making behaviour that affect strategic flexibility. The model has general applicability. A significant cause of strategic inflexibility is a behavioural dysfunction in individuals that produces a much wider dysfunction in the organisation. The same model also provides the basis for the evaluation and improvement of such behaviours. This has led to the development of processes and tools to reduce the barriers to adopting high quality decision-making behaviour. However, individual behavioural change, while being an essential foundation, is insufficient on its own to achieve high rates of organisational and technological adaptation at low levels of disruption.

The second objective has been to implement a systematic process for integrating all players in a strategically flexible organisation. In the absence of a consistent, systematic process, particularly for organisational and technological innovation, a design model of the business has been originated and developed. This has been shown to be applicable to a wide range of organisational cultures and integrates recent trends in organisational thinking. Individual innovations in processes and tools, which have been central to the development and introduction of the design model, have been implemented in an organisation. These innovations are in the areas of innovation management, portfolio management, product targeting and target agreement, and are described to achieve wider application.

The concept of the brand has been shown to be a powerful 'attractor' to develop an organisation's fundamental relationship with its environment in the long, medium and short term. Because the values of a brand represent basic human motivational values, they provide stability for long term planning and can align internal decision-making values, innovation and core competencies to the benefit of the organisation and their workers, their customers and the wider environment.

The research work has shown that an organisation can meet the simultaneous requirements of design speed, knowledge reuse, semi-independent decision-making and creativity at the lowest possible level of the organisation. The concepts and tools are therefore valuable in supporting a step-change in the performance of conventional and virtual organisations. The modular partitioning of organisations, products and processes is compatible with the design model of the business, and the strategies are synergistic. While modularity in a traditional organisation could lead to decay and loss of strategic flexibility, its integration within the design model framework supports a dynamically unstable, but continuously innovative and long-lived organisation.

Acknowledgements

This research project was begun with the support of Joe Cullen, former Director of Operations Strategy, Rover Group, and completed with the encouragement and support of Paul Davies, Director of Product and Cycle Planning, Land Rover. Without their trust, and even protection in difficult times, this work could not have come to fruition. To them I offer my sincere thanks and appreciation. Organisations could not evolve without creative risk-takers such as these.

The scope of this work is wide, and touched most corners of the business. There are many that educated and helped me during the research, and these include current and former colleagues and collaborators who contributed to its development and implementation. They have also had to cope with the many difficulties, frustrations and upheavals involved with changing an organisation. My special thanks go to David Cove, Roger Pratt, Steve Thompson, Jim Shaw, Rana Ali, Ceirion Jones, Debbie Cornick, Paul Shenton, Dave Ovens and David Beadle.

Along the way, there have been a few special people that involved me in their own visions, and opened doors that led me to this place. I thank Stefan Shillington, Dr. David Kewley, Dr. Bill Rouse, Bob Hollier and Dr. Ian Priban for their support, encouragement and honest criticism.

I have had two academic tutors during the period of the research. My first tutor, Dr. Peter Davies, convinced me of the merit of my ideas and abilities enough to join the Engineering Doctorate scheme. It is thanks to Peter that I found a medium for this research at all. I am especially grateful to Dr. Kevin Neailey, my tutor over the last two years, for his unstinting time, good advice, insights and intercessions. Kevin has taught me much of the nature of academic rigour and the unique role of a good tutor. I much appreciate his candour, which tempered this work.

There are many people along the way who inspired and laid the foundations for this inquiry. My parents Vida and Janez, who provided an upbringing full of exceptional values and experiences that I wish I could provide more than a fraction of for my own children. Also thanks is due to my immediate and much extended family, who provided a richness of cultural and professional experience that motivated me to always connect different worlds, and who taught me so well that taking personal risk is the only way to get somewhere new.

My greatest thanks go to Stella who has personally shouldered much of the burden arising from this quest over the last six years, and to my children for their patience and understanding for the loss of a father over this time. I'm told that I have a lot of making up to do.

Declaration

I declare that the project work described in this report was produced by myself, and none of it was previously submitted for any academic degree. All sources of information herein are acknowledged by means of references.

CONTENTS

GLOSSARY OF TERMS

Architecture	The geometrical or other framework on which sub-systems are integrated
Attribute, value	A specific quality of value to a customer or other stakeholder, for example, safety
Benchmarking	The understanding of competitor's or other body's of interest performance
BPR	Business Process Reengineering
Capabilities	An organisations or product's abilities
CE	Concurrent Engineering
Centre of Competence	Expert functional area within engineering e.g. electronics
CEO	Chief Executive Officer of a business
Chassis	Functional engineering area covering suspension, steering, braking.
CO2	Carbon dioxide, tailpipe emission contributing to global warming
Codification	The assembly of information into a recognised format so that knowledge can be readily reused
Commonisation	The maximisation of component sharing across different products
Complexity	The science of complex behaviour.
Concept	Design solution for a product or a part of it, often used for the geometric design integrating the main components
Concurrent engineering	A type of design and development process based on parallel working
Core competence	The sets of knowledge, skills and abilities, technologies, services and products that add value for the customer of today and tomorrow
Cybernetics	The study of control and communications in complex electronic systems or animals, especially humans
Design	The process of creating solutions to meet customer needs. Used also as a title for the styling function
Design Model of the Business	The author's model for organisational innovation

Design tolerance	The range of values within which a solution is acceptable
Differentiation	The provision of distinct value giving competitive advantage
Dormancy interval	The time during which a risk or opportunity or is not being acted on
Dynamics	The driving quality and performance of a vehicle
Escalation	The raising of a problem to a more senior level
Escalation	The process of raising a problem from one hierarchical level to the next, usually because a resolution to the problem cannot be found at the lower level.
Fitness	The evolutionary probability of survival of an organisation
Function	Part of an Organisation
Fuzzy front end	The early phases of product development, prior to the decision to invest in product development
GA	Georgia
Gateway process	The previous BMW product development process, based on Cooper's stage-gate system
Gateway Zero – GW0	A milestone in the previous BMW product development process
Geba	A Japanese method of identifying problems and remedies for faults in a physical prototype
Governance	The method of decision-making in an organisation
Hierarchy	The levels of aggregation of a system, whether an organisation, vehicle or other complex entity.
Innovation	The harnessing of an idea to create competitive advantage
Interface	The explicitly-defined physical, geometric, data or other connection between two components or systems
Issue	In new product introduction, a design or other problem to be resolved
Kano Model	Diagram explaining delight, performance and basic features
KO	Kick-Off, the formal start of design for a product in Ford product development
Latency interval	The time during which a potential risk is not confirmed

Launch	Date of production of a new product
Make versus Buy	The choice on whether a business makes or purchases a commodity
Maturation	Full readiness for adoption in a product or process
Milestone	Formal decision point in the product development process
MIS	Management Information System
Modularity	The segmentation of a system into discrete and semi-independent entities
NPI	New product introduction process
Objective measure	A quantifiable quality
Open Door process	A concurrent strategic planning process developed within Rover Group
Parametrics	The science of estimating the characteristics of an unknown system by extrapolating from previous experience.
Phase	A section of time between two milestones in the product introduction process
Pilot process	The first introduction of a management or production process to test and improve its maturity
PL	Product Leader in the BMW organisation
Platform	A basis of shared technology and investment for a family of products
Powertrain	Powerplant and transmission, often used for the engineering function with this responsibility
Predevelopment	The maturation of technology and product concept prior to the project investment decision.
Product plan	The portfolio of products for an organisation
Programme	A project (or projects) to produce a new product or service
Prototype	A fabricated product produced for testing prior to manufacture.
QFD	Quality Function Deployment

R&D	Research and Development
Risk management	The practice of identifying likely problems and adopting precautions to prevent deviation against targets.
S&M	Sales and Marketing function
Scenario planning	The future-proofing of plans by testing them against possible future worlds
Standardisation	The implementation of a piloted process across project teams
System	A set of entities producing distinct qualities in their interaction e.g. chassis, product manufacturing system
Target pyramid	A diagram representing the important qualities of a product, and their relationships
Target Vision	The set of targets representing the required performance of a product and the project delivering it.
Time to market	Time a product spends in development
Trendline	Method of technological forecasting and target agreement developed by the author
Utility	The level of usefulness or value to a customer for a particular solution
Verification	The process of testing to confirm that components, systems and products have been correctly designed
Workflow	The sequence of tasks in a process

1. INTRODUCTION AND BACKGROUND

1.1 THE PRESSURES FOR GREATER STRATEGIC FLEXIBILITY IN ORGANISATIONS

Every generation believes it is going through great change, and ours is no exception. At the start of the twenty-first century, it is widely accepted that there is a power and momentum in the economic, political, and cultural change summed up by the term 'globalisation' (Economist 2000; Foust, 2000; Bettis and Hitt, 1995),. The main source of the change is ***"...the interaction of an extraordinary rate of technological innovation combined with the world wide reach driven by a global capitalism."*** (Hutton and Giddens, 2000).

A number of specific changes (discontinuities) will drive organisations (Prahalad, 1999). These include a high volatility of demand for products, a global specialisation of competencies, and a growing convergence in new technologies affecting many traditional products. The distance between producers and end-users is shrinking continually through the e-revolution (disintermediation), requiring producers to change their business models. Ecological sensitivity will also become a basis for business opportunities rather than just requiring legislative compliance (Coates, Mahaffie and Hines 1997; Hammond 1998; Hart and Milstein 1999). To cope with these changes, successful enterprises will have to become flexible, globally minded, fast in learning new competencies and knowledge transfer, capable with, and open to temporary alliances. Most firms are not adept at such a scale of change (Christensen 1977; Henderson and Clark 1990), and historically, few organisations have survived against newer entrepreneurial businesses more capable of capitalising on new combinations of factors (Schumpeter 1934, 1942; DeGeus 1997).

Yet, large established organisations have in-built advantages against new market entrants, often being leaders in the new technologies and with budgets, resources and capital assets well beyond the means of new competitors. What is lacking are the models of internal governance that allow the new situations to be seen and responded to (Prahalad and Oosterveld 1999). However, better governance alone is insufficient to be agile against new technologies and volatile markets. Flexibility in product structures (Sanchez 1996) and organisations (Nadler, Tushman 1997) to change products radically but economically is also identified. This allows changes to deep core competencies and the gaining of knowledge necessary to make these products successful (Leonard-Barton 1992; Lei, Hitt and Bettis 1996). It is this quality of Strategic Flexibility that organisations will need to achieve to survive in these circumstances (Sanchez 1995; Hitt et. al, 1998).

Some of the moves towards strategic flexibility have been made in the 1990's. Restructuring has made firms flexible, but no more capable of acquiring and deploying the skills and knowledge necessary to compete (Pfeffer 1994). The rate of product innovation and quality of innovation has increased hugely (Brown and Eisenhardt 1995; Eisenhardt and Tabrizi 1996; Stimpert and Duhaime 1997), but this alone does not make a firm more flexible in building needed competencies or strategic partnerships. As an example, the automotive industry has seen a large reduction in the length of product development processes and lifecycles, and has seen significant industry restructuring to meet competitive pressures (Womack et. al 1991; Haslam and Johal 1995). However, despite success in pursuing new product and faster development times, many alliances, mergers and new strategic initiatives have failed to produce the strategic benefits required of them both in the motor industry (Lutz 1995; Burt 2000; Bowe 2000) and across a range of industries (Prahalad and Oosterveld 1999).

Wider still, the way that firms and institutions are designed and governed for this globalised era will affect not only the well-being of these organisations, but that of their workers, customers and the wider environment. The research carried out by the author is aimed at examining the governance of organisations, their weaknesses in recognising the needs for fundamental change, and in making beneficial changes through organisations, processes and products. There is a need for a 'Design Model of the Business', which provides a 'template' and processes for an organisation to steer by to help it innovate continuously, and successfully.

1.2 OBJECTIVES

The overall objectives of this research have been two-fold. The first has been to identify the causes of organisational inflexibility that were preventing rapid innovation, and the second, to provide solutions to address these problems. A third set of objectives have been developed for this executive summary to allow the innovations and insights developed to be more widely communicated.

Objective 1: Identify the causes of organisational inflexibility preventing rapid innovation.

The sub-objectives were addressed in the order given below:

- Identify the measures of success and assessment of the barriers to successful technology creation and implementation.
- Provide a hypothesis for the barriers identified.
- Provide an understanding of technology issues, and their morphology.
- Examine a company's response to technology issues, and develop a general understanding of how best to address the management of these issues.
- Identify whether the company's response to technology issues supports the hypothesis identified for barriers to innovation.
- Recommend further areas of exploration where company innovation performance could be improved.

The research initially identified why an organisation could not respond adequately and rapidly to opportunities and future strategic threats. The hypothesis drawn was that of a flawed decision-making process preventing the organisation from focusing on the right needs and co-ordinating appropriate actions and resources. Technology issues are the external challenges to an organisation's survival. From the development of an organisational response to one of these issues, a general principle for responding to external challenges was originated. This was further developed into a 'design model of the business' in later research.

Objective 2: Provide solutions to address organisational inflexibility preventing rapid innovation

The sub-objectives were the following:

- Understand good practice in identifying and instituting change against external environmental needs in a large company.
- Develop a model of the design process that integrates a company at the business, product and engineering levels.
- Gain confidence in the principles of the designed model by examining external practice.
- Identify routes for taking appropriate learning into practice. These were the following:
    - Introduce a company-wide process of strategic planning.
    - Introduce a holistic methodology for managing company and product needs.
    - Introduce a process for aligning the goals of those that deliver technology (researchers and technology developers) and those that deliver products (product teams).
    - Introduce a practice for understanding and converting the subjective area of automotive brands into targets.
    - Identify tools and techniques for innovation and apply them effectively in the design process.

The objective of identifying tools and techniques for innovation and applying them effectively in the design process was divided into two objectives. These were:

- To recognise the competencies and deficiencies of the business objectively, and then to identify tools and techniques for innovation, and a programme to stimulate innovation within the company.
- To permanently instil the innovations developed over the course of the research, and place them in the operational processes of the business.

The objectives for the Executive Summary

For the Executive Summary, the following objectives were identified from considerations developed from the foregoing research: -

1 Explain the design model of the business that allows understanding and application in a wider context.

2 Describe the model of decision-making culture identified, the possibilities for its dysfunction, and the approaches available to correct these.

3 Describe rules developed for target-setting and target agreement and their benefits. Include the use of process innovation and IT tools in this context.

4 Describe the benefits of the brand concept for organisational integration, and generally applicable methodologies.

5 Describe the effect of product structure on organisation and knowledge management. The relevance of the model to concepts of modularity should be considered.

6 Show that the design model of the business can be applied to a wider context than the automotive domain.

1.3 METHODOLOGY USED IN THE RESEARCH

The starting point for this area of study has been to understand and respond to a dysfunction in the decision-making culture of a business. It has been found particularly important to provide an objective basis for the studies and developments and so ensure a high level of confidence in the findings and recommendations. Two disciplines were adopted which together formed an intellectually rigorous approach for the project, and also guided the engineering doctorate over an extended number of projects. The first of these is the scientific discipline, which relies on the use of empirical data to support the construction and building of confidence in a rational theory. Two qualities are needed to successfully apply the scientific discipline: -

- confidence and repeatability in the data used.

- the applicability of a hypothesis to a more general situation than that from which the data was derived.

However, complex decision-making processes and human systems in businesses do not fall into a physical area of knowledge that lends itself easily to quantitative experimentation. Instead, a social system (a system being a set of interacting bodies forming a unified whole) is studied through the observation of systematic (affecting the whole system) problems. Figure 1 shows the second approach taken in the research.

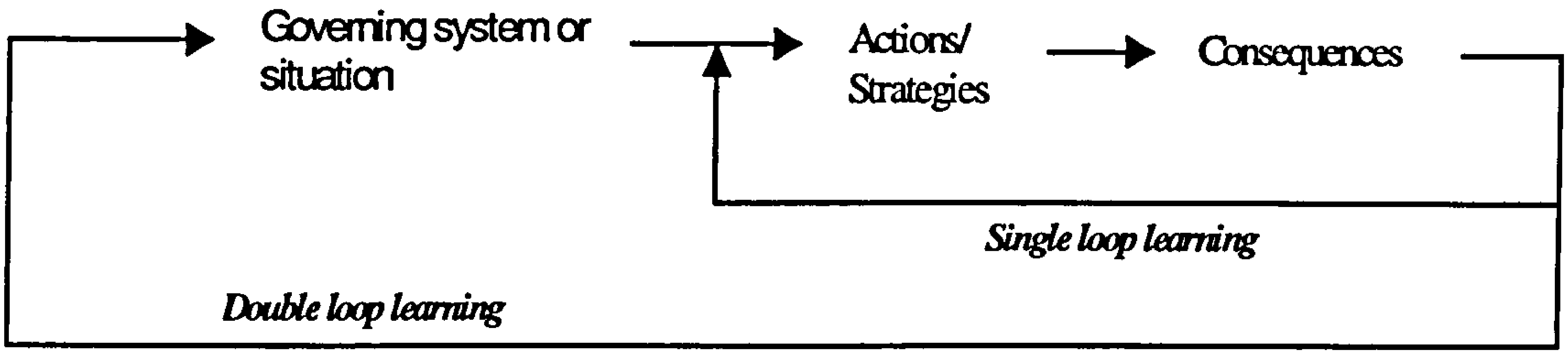

Figure 1 The concepts of single loop and double-loop learning. The governing system or situation is examined through the actions it affects.

This discipline adopted is the combination of single loop and double-loop learning, developed by (Argyris 1993) and popularised by Senge's work (1990) 'The Fifth Discipline', a book seminal to current developments in organisational learning. Single loop learning is gained from making tactical adjustments to correct deviations from the desired results of an activity. This leads to an understanding of what actions produce a certain effect. Double loop learning relates the results of single loop learning experiences back to the system as a whole, leading to the understanding of how a system works and why actions have certain effects. Using this approach can lead to more optimal and creative management of complex systems.

1.3.1 The structure of the portfolio

The research work was broken up into a number of submissions, some containing a several individual projects. Projects 1 to 4 are individual submissions to the doctorate portfolio, and contain the work of formulating the problem and defining the ideal model of the design process. Projects 5 to 11 on the right hand side of figure 2 are contained in one submission and its annexes. These projects develop the tools and processes to implement the design model into the organisation.

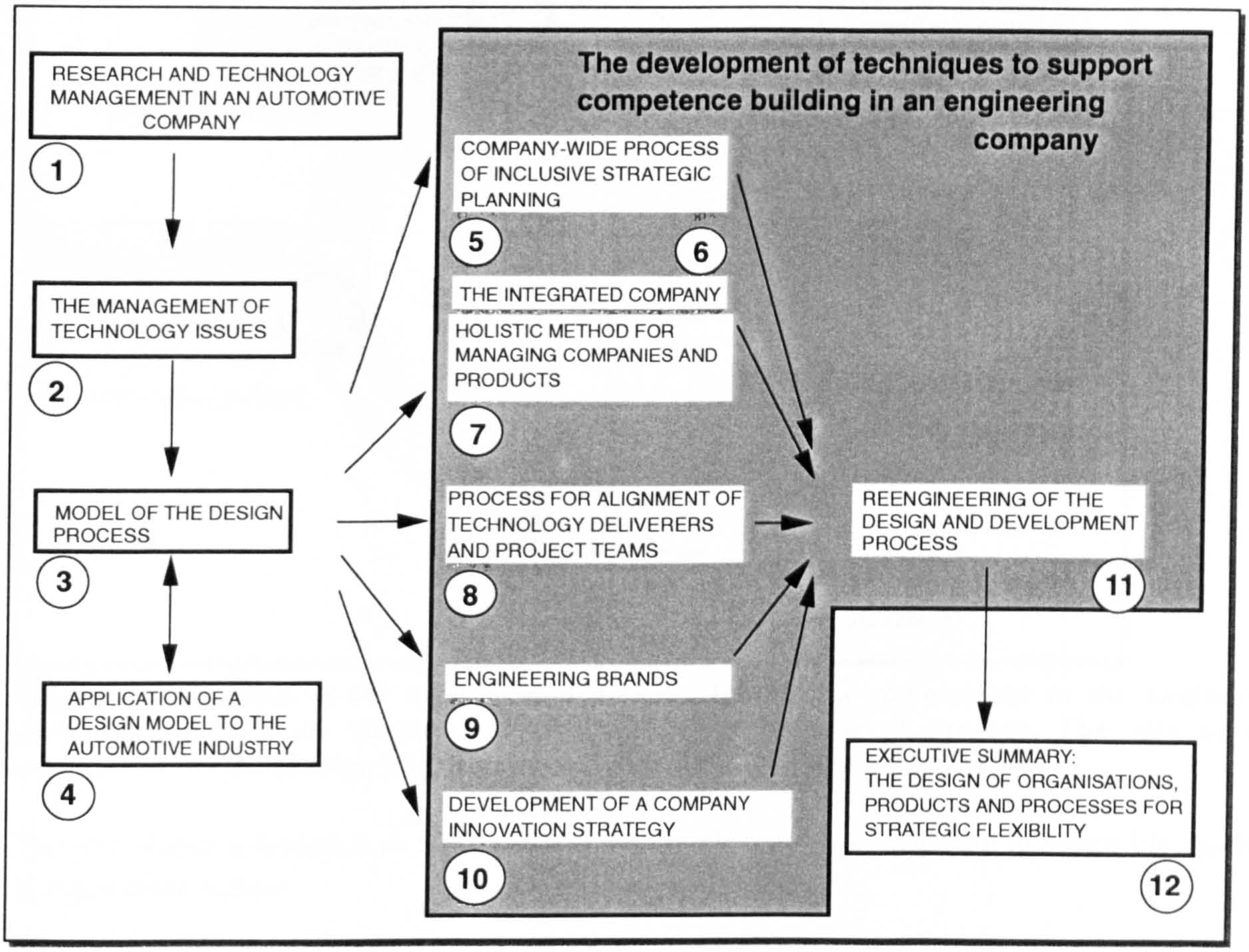

Figure 2 The individual projects making up the portfolio, and their relationships. Projects 1 to 4 represent individual submissions, while projects 5 to 11 are contained in one submission.

While the submissions provided individual 'single loop' innovations to the business, they also had a 'double loop' effect by providing information on the wider system, or by affecting the performance of the wider system. Figure 3 summarises how the submissions to the engineering doctorate take part in a double-loop process for changing the business.

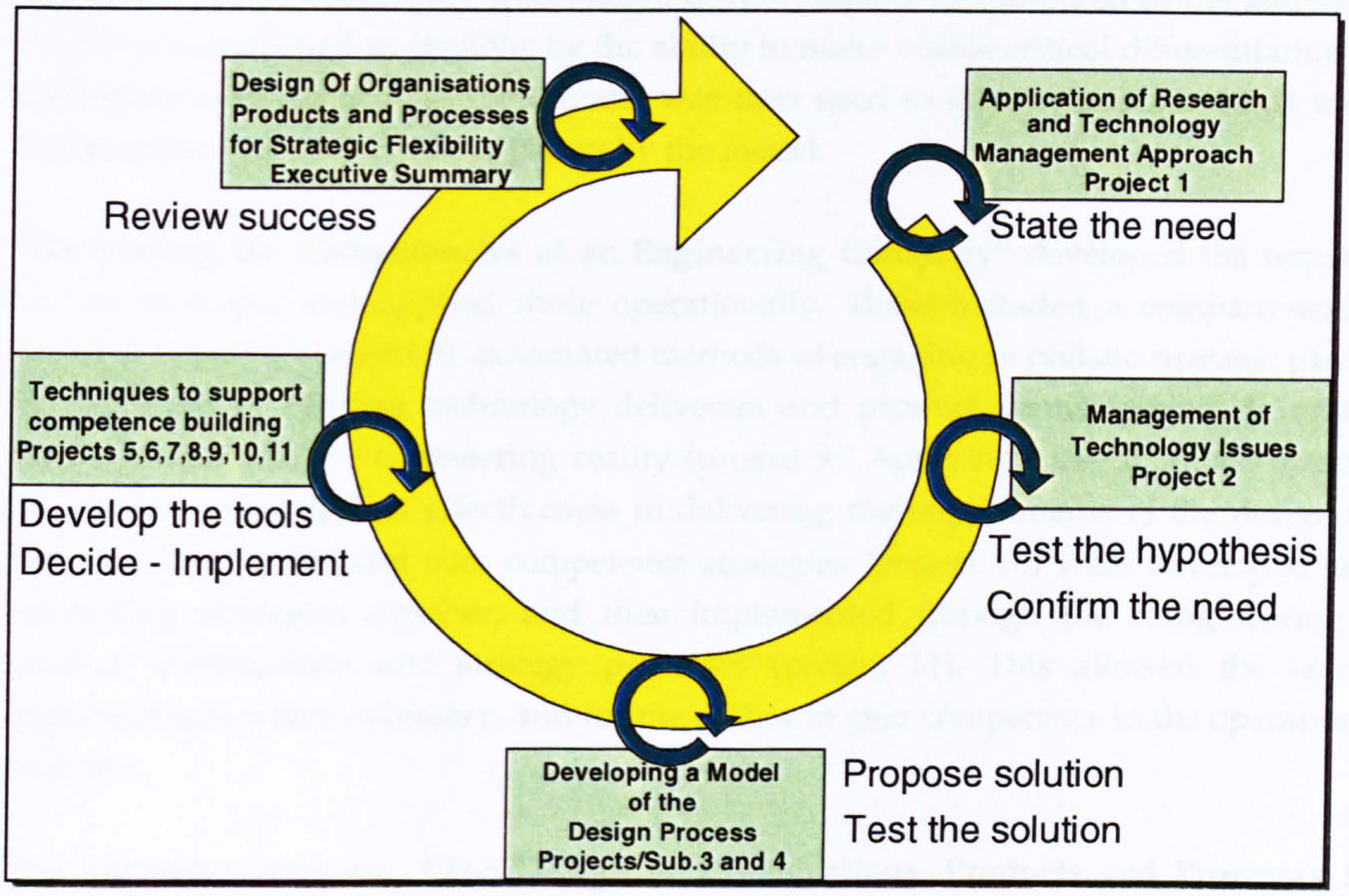

Figure 3 A diagram of the double loop process. Individual submissions to the engineering doctorate portfolio are shown in boxes with their constituent projects. The role of each submission in the redesign of the organisation is described alongside the box.

The role of each submission as an element of the double loop process shown in figure 3 is described in more detail below:

"The Application of a Research and Technology Management approach" (project 1) implemented a new Research and Technology Management process, and used the outcomes of many research projects to identify problems with the wider system. This was achieved by observing where similar failures to innovate occurred repeatedly in different projects. The cause of the problem was hypothesised to be a dysfunctional decision-making process.

"The Management of Technology Issues" (project 2) observed the successes and failures in managing complex strategic issues that the organisation had to deal with to assure its long-term survival. This work identified the difficulties the organisation had in responding to strategic needs, and provided a check of the hypothesis produced in the first submission. The findings supported the hypothesis and a dysfunctional decision-making process was diagnosed. To overcome this strategic inflexibility, a systematic approach to decision-making was proposed based on observations of a how an organisation should respond to an external complex challenge .

"Developing a Model of the Design Process" (project 3) showed how a model of the design process was originated, and how this was essentially equivalent to the practice of product design. However, the design model embraced the strategic decision-making process, which product design did not. Existing design frameworks were used to support the development of the design model but were found insufficiently informative or comprehensive compared to the author's model. The model was confirmed as feasible, by the ability to make visible critical differentiating elements in a competitor's design process. The model was then used to identify specific needs for the author's organisation that were made apparent by the model.

"Developing the Competencies of an Engineering Company" developed the required processes for the business, and applied these operationally. These included a company-wide process of strategic planning (project 5), automated methods of engaging in holistic strategic planning (project 7), a process of aligning technology deliverers and product teams (project 8), and a means of engineering brands to engineering reality (project 9). Applying these methods operationally was essential to gauging their effectiveness in delivering the requirements of the design model to the business. Innovation and core competence strategies (project 10) were developed as a means of integrating strategies together, and then implemented through the reengineering of the new product development and strategy processes (project 11). This allowed the identification of improvements where necessary, and for the author to gain competence in the operations of the new business.

The Executive Summary, **"The Design of Organisations, Products and Processes for Strategic Flexibility"** is now used to confirm and report the new knowledge gained in the design loop represented by figure 3. There are two objectives for this submission. The first is to report the innovation achieved within the author's business, and the second is to disclose aspects of the research to show that it is innovative in a wider context. These objectives in detail are stated in section 1.2 and are developed through the following chapters: -

- *Chapter 2: Innovation achieved during the research project*

This summarises the research work carried out by the author, and the innovations achieved.

- *Chapter 3: An overview of the Design Model of the Business*

The design model developed by the author is explained in overview, to allow a more detailed examination of some of its features in later chapters. To place the innovation in context, the model is examined against the level of knowledge available when it was originated, and against wider and more recent academic fields that are now known to be related to the model. This provides a framework against which to show the major aspects of the innovation and its potential for wider applicability.

- *Chapter 4: The general application and implications of the design model of the business*

The following sections form this chapter: -

    - *The importance of the decision-making culture and its improvement*

This section examines the core requirement to enable strategic flexibility, that of the behaviour of the individual and groups in the decision-making process. Approaches to introduce and encourage the correct working of decision-making are introduced.

- *The process of target setting and target agreement*
  The benefits of applying rigorous processes for target setting and target agreement are examined, and a set of rules and processes introduced. The strong relationship between targets and the innovation process is shown. The application of an innovation model to support such a process is described.

- *The use of the brand for organisational integration*
  The value of the brand and its role in guiding and integrating an organisation's products, technologies and core competencies is described. Generally applicable techniques and insights developed by the author are shown.

- *The structure of the product and its influence on organisational structure and knowledge management*
  A central part of the design model of the business is the breakdown of the innovation process into hierarchies. These are closely linked to the structure of the products produced by the organisation. The benefits are shown as the rapid improvement of the organisation, better knowledge management and shorter development times. The implications of growing trends in modularization and how these affect the organisation are discussed in the context of the design model of the business.

- *Chapter 5 :The application of the design model to a non-automotive domain*

The aim of the work that is reported in this section is to demonstrate in principle that the model is applicable in principle to a wider set of domains. The example used is that of a healthcare organisation, with responsibilities ranging from national epidemiological incidence reduction and healthcare performance through to the performance of multidisciplinary teams in healthcare units.

- *Chapter 6: Conclusions*

This chapter evaluates the impact of the research work in the light of the objective set.

- *Chapter 7. Further Work*

Directions are set for the further application and evolution of the innovations.

2 INNOVATION ACHIEVED DURING THE RESEARCH PROJECT

The objective in this chapter is to summarise the research work carried out by the author mainly within the automotive industry, and the innovations achieved. The role of these projects in relation to understanding and changing the wider organisational system has been described in chapter 1. This chapter now looks at each project in more detail, and describes the main innovations developed from each.

Figure 4 shows the individual projects covered by the research, and their relationship to each other.

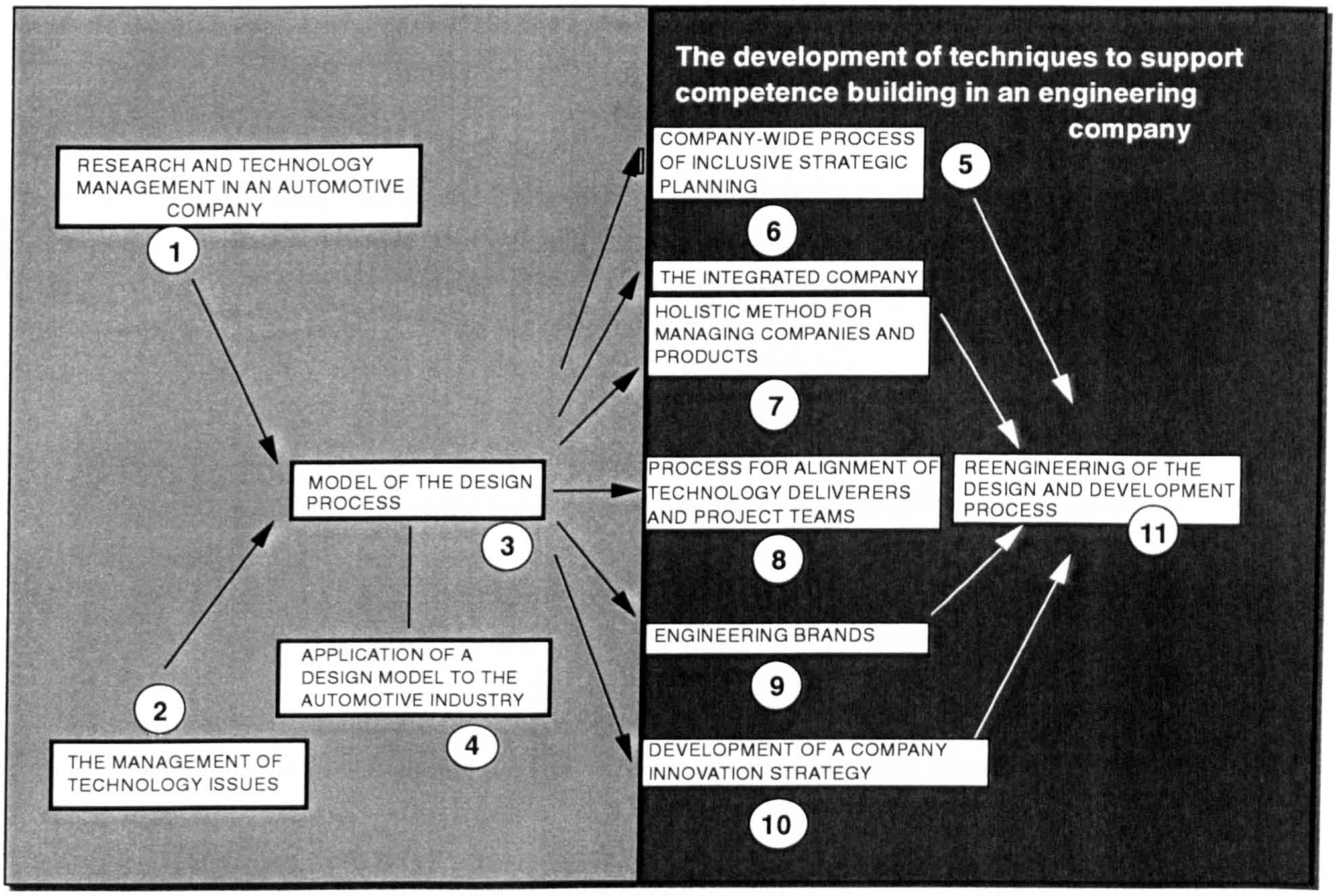

Figure 4. The relationships between projects in the Engineering Doctorate portfolio

The projects shown began with project 1 and developed in approximately chronological order as part of a unified whole in the double loop process described in chapter 1. However, each of the projects also has an individual value, as the innovations that were developed in each of the projects have merit in their own right. The distinction between the role of each project as a part of the double loop process and their individual contributions are described below:

Project 1 described the author's introduction of a new research and technology process into the organisation. As stated in chapter 1, a flaw was discovered in the organisation's decision-making process from an examination of the outputs of this process. However, the individual innovations arising from the research and technology management process are in themselves valuable and worthy of wider communication.

Project 2, the management of technology issues, had a role to play in the double loop process by confirming the hypothesis arising from project 1. As with project 1, the project represented substantial work in its own right, as a means of comparing and managing external challenges to the survival of the organisation.

Projects 3 and 4 formed and tested a design model of the business to provide a framework for strategic flexibility. In double loop learning, these originated as a response to the requirements outlined in projects 1 and 2, and were used to identify the processes and tools that were necessary for the business to become strategically flexible. As an independent innovation the design model is also more widely applicable as an innovative tool.

Projects 5 to 10 similarly had a role in the double loop process to provide capabilities that the organisation needed to become strategically flexible. Individually, they provide innovation and findings relevant both to the internal business and to the external world. The individual innovations delivered through these projects were –

- A means of representing a whole organisation in strategic planning.
- Introducing the potential benefits of automating the planning process to integrate an organisation, and revealing the barriers that need to be removed to allow their wider introduction.
- A trendline method for gaining agreement to radical change requirements for a product.
- A methodology for quantifying and implementing brand attributes for the engineering of products.
- Models showing how risk and opportunity interact throughout innovation, and a 'checklist' of the conditions necessary to successfully deliver an organisational capability to the marketplace.

Project 11, the reengineering of the design and development process, describes the implementation of the tools and processes developed, or their close analogues originally developed in other cultures. In terms of double loop learning, the objective was the operational implementation of the design model of the business. As an individual project, practical methods of overcoming behavioural barriers to target agreement and speeding the agreement process were developed and shown to be capable of operating in different cultures.

The innovation and changes achieved by the author are reported below for each of the projects. Further details are given in the relevant submissions.

2.1 PROJECT 1 – RESEARCH AND TECHNOLOGY MANAGEMENT IN AN AUTOMOTIVE COMPANY

This research was originally undertaken to improve the innovation performance of a product engineering company. 'State of the art' techniques of technology management, based on third generation R&D principles (Rousell, Saad & Erikson 1991) were applied and rapidly improved in an automotive business. From the position of a small central functional group remaining after the formation of powerful business units, the author succeeded in integrating research efforts to achieve the following innovations: -

Generally-applicable innovations

- A novel Quality Function Deployment-type tool (figure 5) was created and implemented by the author for selecting, managing and integrating research projects in portfolios of research projects.
- A confidence-based process (the R-process shown in figure 6) for the efficient maturation of research projects, and an efficient system of project control was developed and adapted by the author for the management of a research and technology programme.

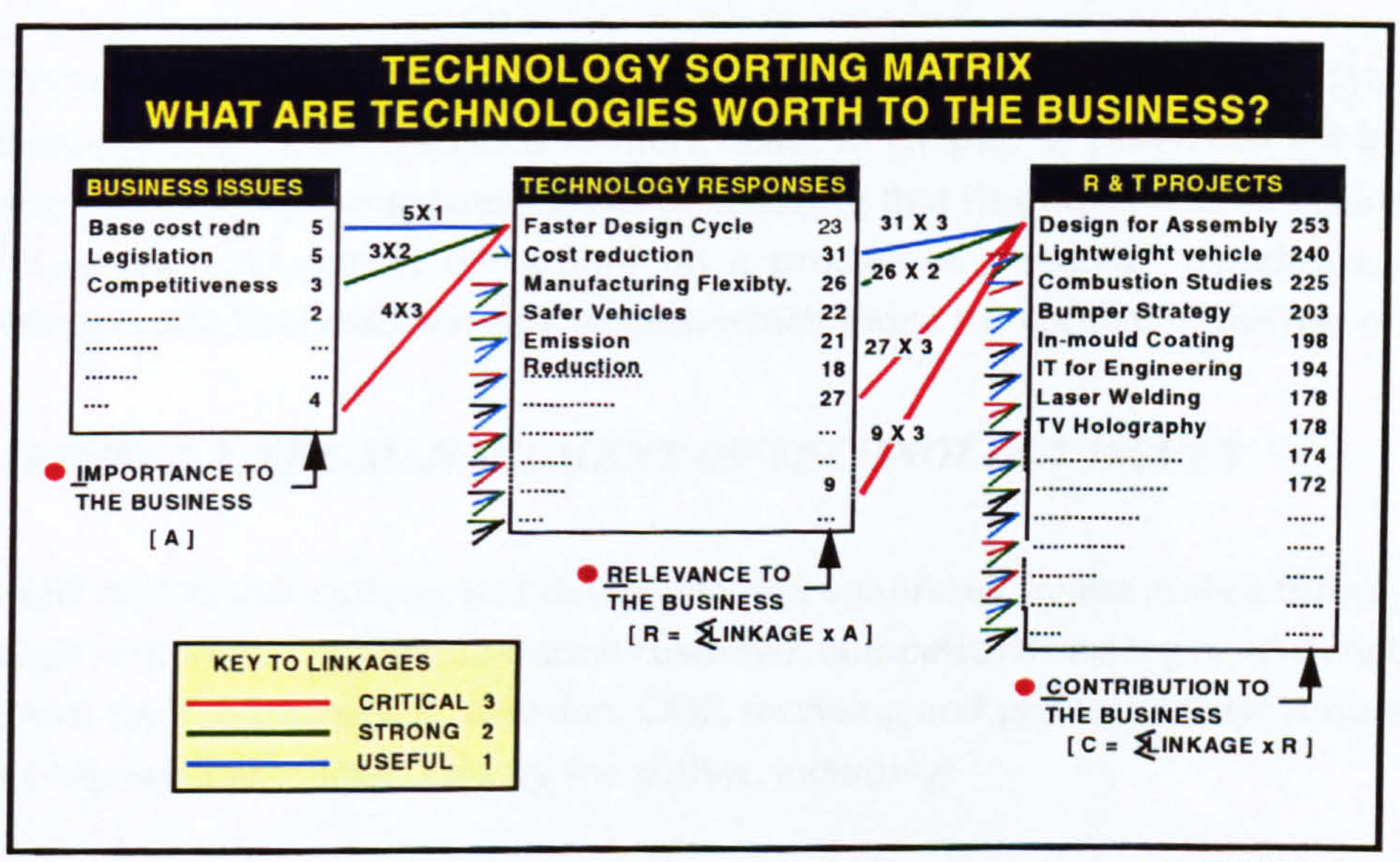

Figure 5 Overview of QFD-based tool, a basis for quantifying the strategic value of research and its management through portfolios. The values of the organisation are to the left, the strategies to achieve them are in the middle, and projects to serve the strategies are on the right.

Both of the above innovations have been disseminated by the author by means of external lectures and by teaching modules for MSc and Doctorate level courses at Warwick University.

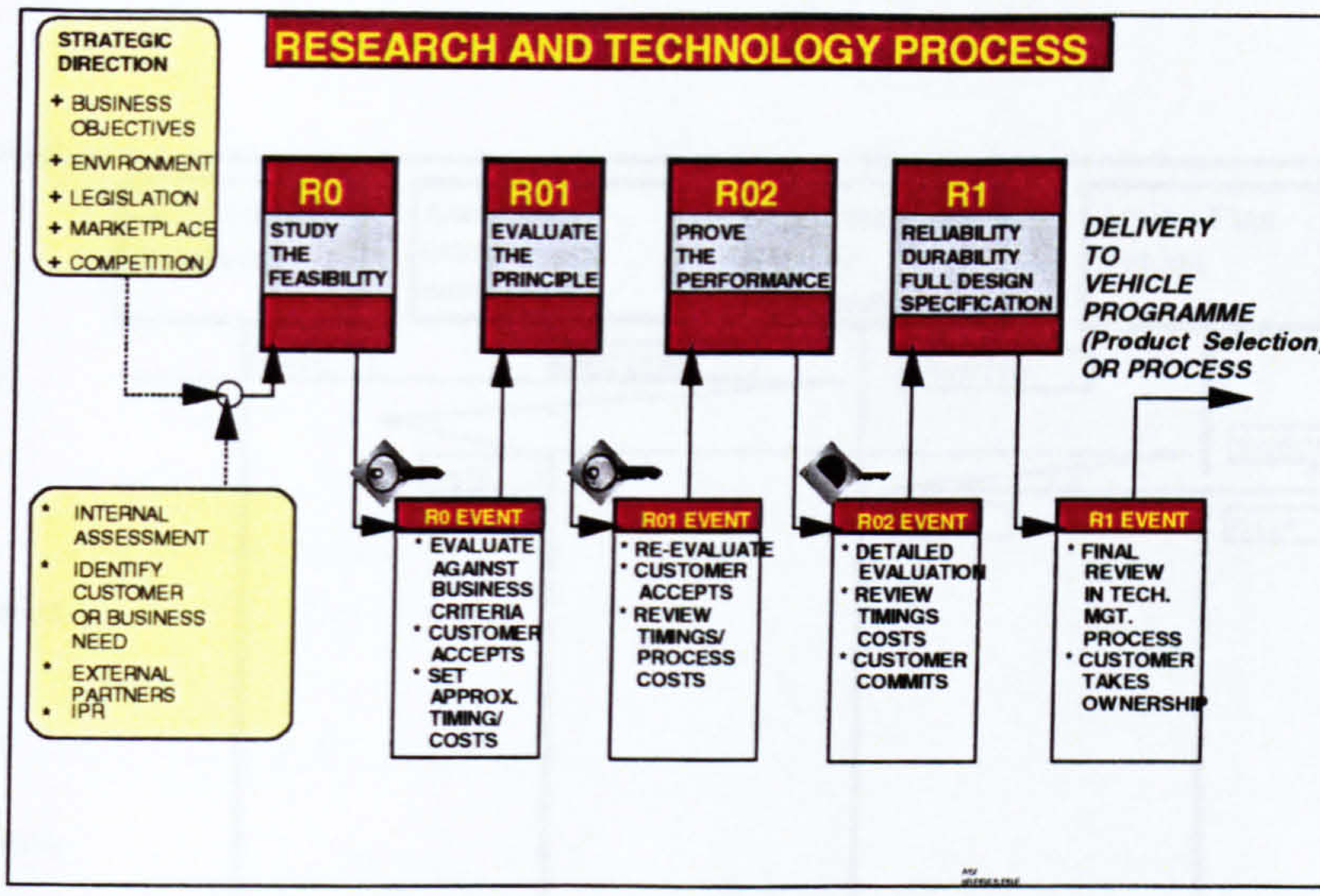

Figure 6 The R zero to R-one technology management process

Internal Innovations

- Effective communication processes between researchers and product, marketing and manufacturing areas to test and mature technology plans.
- The substantial increase in the strategic value and financial benefit of the businesses research and technology effort.

However, an assessment of the results of research projects showed that systematic obstacles in decision-making (to be described in more detail in chapter 4) prevented the business from setting appropriate research programme goals or ensuring that its output was co-ordinated with the rest of the business. This started the author on a process of research, hypothesis, action, review and implementation to correct the deficiencies, which forms the content of the rest of the research.

2.2 PROJECT 2. THE MANAGEMENT OF TECHNOLOGY ISSUES

A model of decision-making was developed and confirmed by the author through the study of strategic responses to various external customer, competitive and legislative challenges to the business, such as emissions, corrosion, CO_2, recycling and product safety. A number of innovations were originated and developed by the author, including: -

Generally and internally applicable innovation

- The origination and development of a method of comparing the progress and systematic problems in developing strategic responses to external issues, and the development of a method of managing these issues in the short, medium and long term.

Figure 7 shows a wall chart of the type originated by the author used for comparing the progress of strategies.

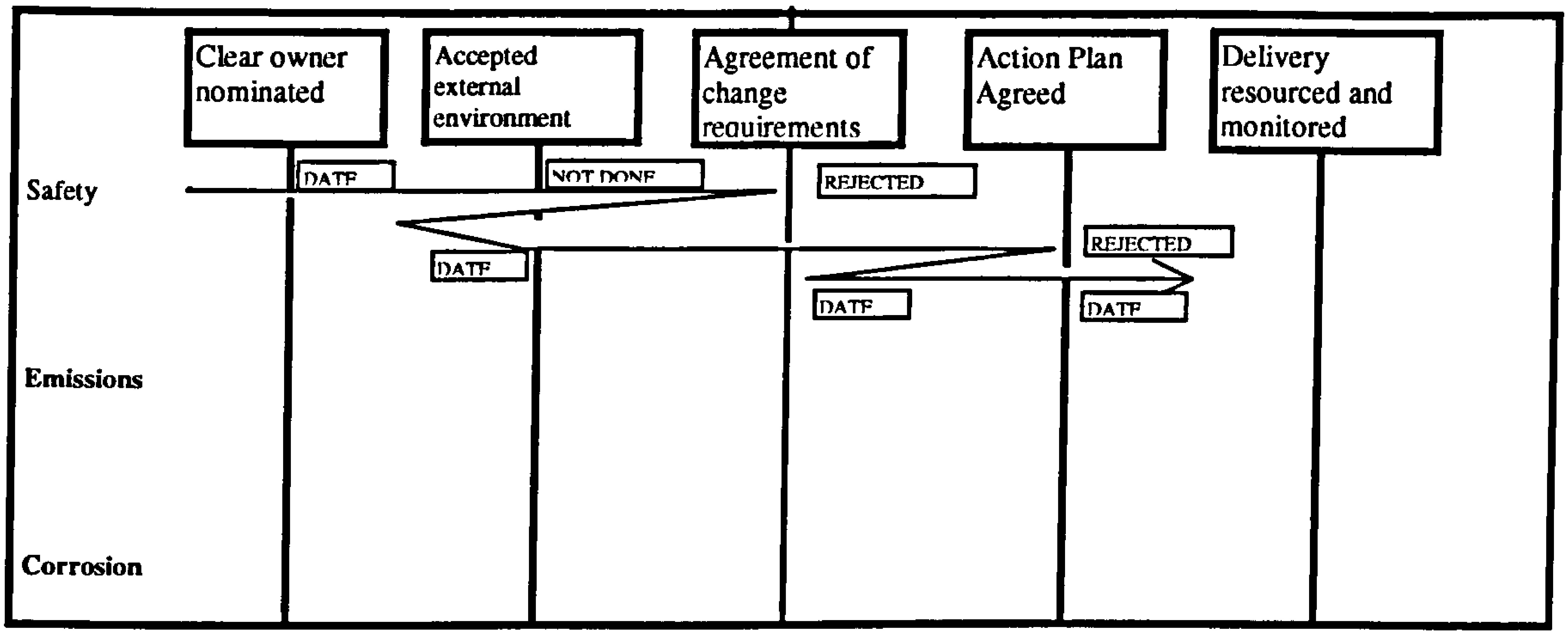

Figure 7 Wallchart of the type used to compare learning between strategies and improve the strategy management process. Practitioners mapped experiences against a maturation framework so that common points of difficulty and good practice could be shared.

- The origination and application of the use of the 'working assumptions' process by the author to solidify as the basis of planning the most likely outcome for highly volatile external events and legislation. This maps the course of future events as agreed by a cross-functional group of experts, marketing specialists and technical implementers.

Internal innovations

- The introduction of a successful emissions legislation and incentive process that has provided consistently trusted and acted-on future assumptions.

- The development and use of a strategy management process and maturity measures.

The rule-set developed by the author to respond to potential CO2 emission legislation provided the basis for a faster, more effective and rigorous business and product design process. The critical factors were the setting of demands at all levels of the business necessary to meet external needs, and the second factor was the co-ordination of responses against these requirements to formulate achievable plans. This process was developed further in project 3.

2.3. PROJECT 3 - A DESIGN MODEL OF THE BUSINESS

Literature methodologies covering the business strategy process and the early phases of product design and development, generally lacked a systematic process, based on sound principles that could integrate all players in the organisation. In the absence of a single, consistent approach, the author developed the ideas from project 2 further.

The resulting 'design model of the business' integrated the needs of three types of requirement. These were:

- the need to respond to new market and competitive challenges
- the need to meet customer and business requirements
- the need to provide technologists with clear requirements, stated early enough to allow timely, effective and efficient innovation.

Generally Applicable Innovation

- The author has originated a new model for the co-ordination of players in the business strategy and design phases of a product, with a hierarchical target-setting and decision process at its core. The model integrates external market and customer needs, internal and external creativity, codified and tacit knowledge and constraints in the organisation. The model has applications in benchmarking competitor design processes, identifying weaknesses or missing capabilities in an organisation, and being the basis for a fast and responsive new product introduction process.

Internal innovations

- An internal, more detailed design model has been developed as the basis for a more responsive strategy, design and development process. This has been used to identify missing processes, information and tools necessary to introduce the design process.

The philosophy of the model of the design process at this point in its development is described below:

Figure 8 shows the progress of an individual product (in this case a vehicle) from its conceptual inclusion into a product portfolio, through to it being fully designed in detail, and planned with all aspects agreed for development to market. Two funnels, one tapering in and the other tapering out, respectively represent the breadth of vision reducing and the design focus increasing from the business level to the component level. A nested hierarchy of decision levels, based on a systematic product structure, ensures that decisions made at the business level affect every aspect of the product at a lower level.

The lower levels in the hierarchy must respect the requirements and constraints of levels above them in the hierarchy. The technology of the solution (that is, the product, the processes that design develop, produce and deliver it to the customer, and the resources necessary to do so) must fulfil all the requirements necessary to simultaneously delight the customer and meet the needs of the business at each decision point.

Only those decisions that are necessary to achieve stated goals should be made at each stage. This allows other aspects to be left until later, which allows better focusing of resources, and allows more flexibility to respond to a changing marketplace. Also, if each decision made is to be correct (that is, that every project will be successful) then good evidence needs to be gathered efficiently by working at only the level of detail and accuracy necessary to make good decisions.

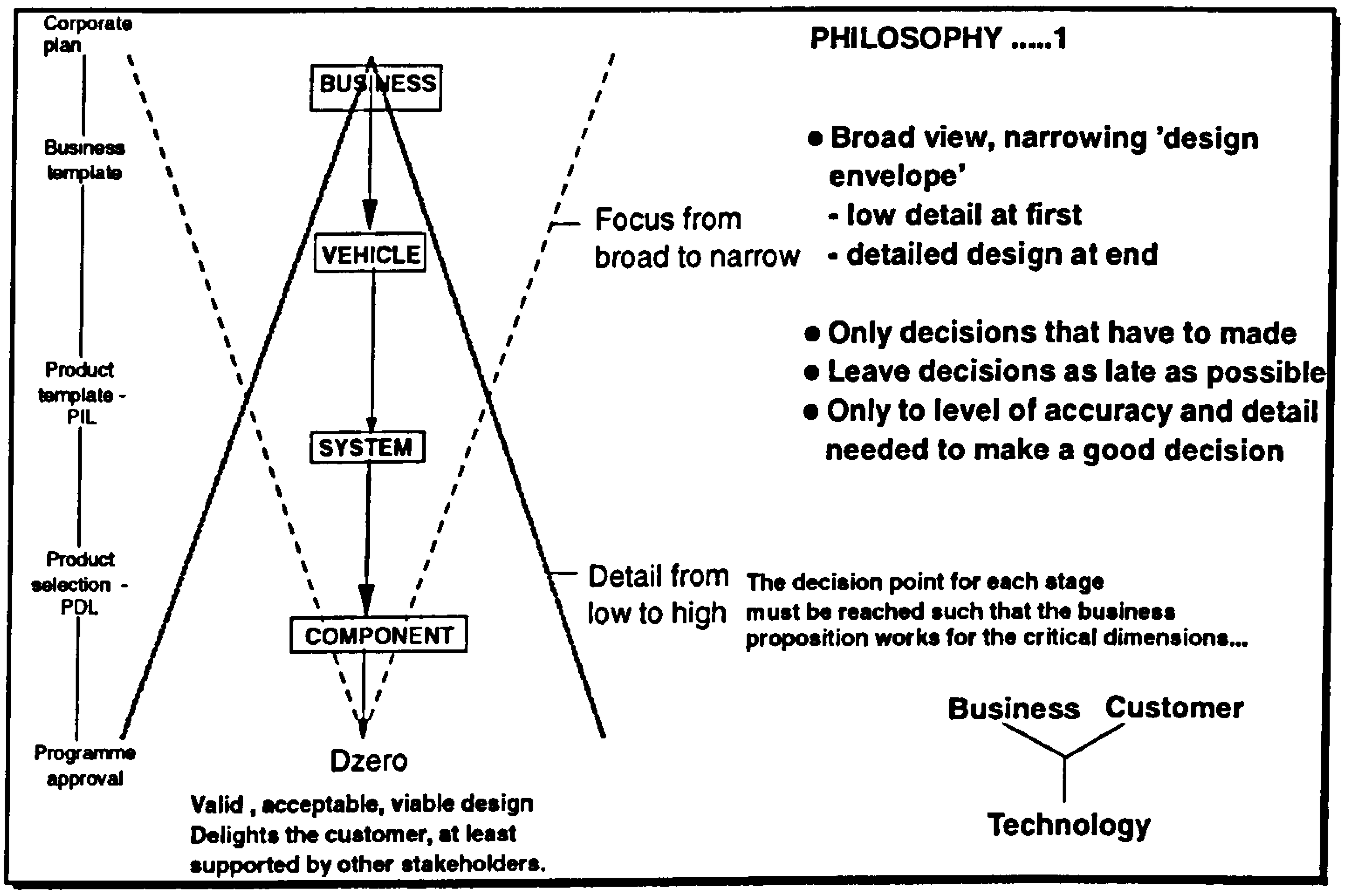

Figure 8 Early explanation of the design model – breadth, detail and decisions.

Figure 9 shows that the strategy and product design process is really a support framework to make good decisions. Each level will have a specific process, tools and techniques to deal with the information relevant to that level, to gather evidence, process it, and come to a decision. Each level has a question to answer, which it does by making a decision that fixes a set of targets. Again, each decision must be self-consistent and work on the business, customer and technical level. For the decisions to be valid, there must be enough measures, targets and values to guide the next phase of the process to deliver the best solution. The set of decisions and control documents in an automotive product development process is shown on the left of the diagram.

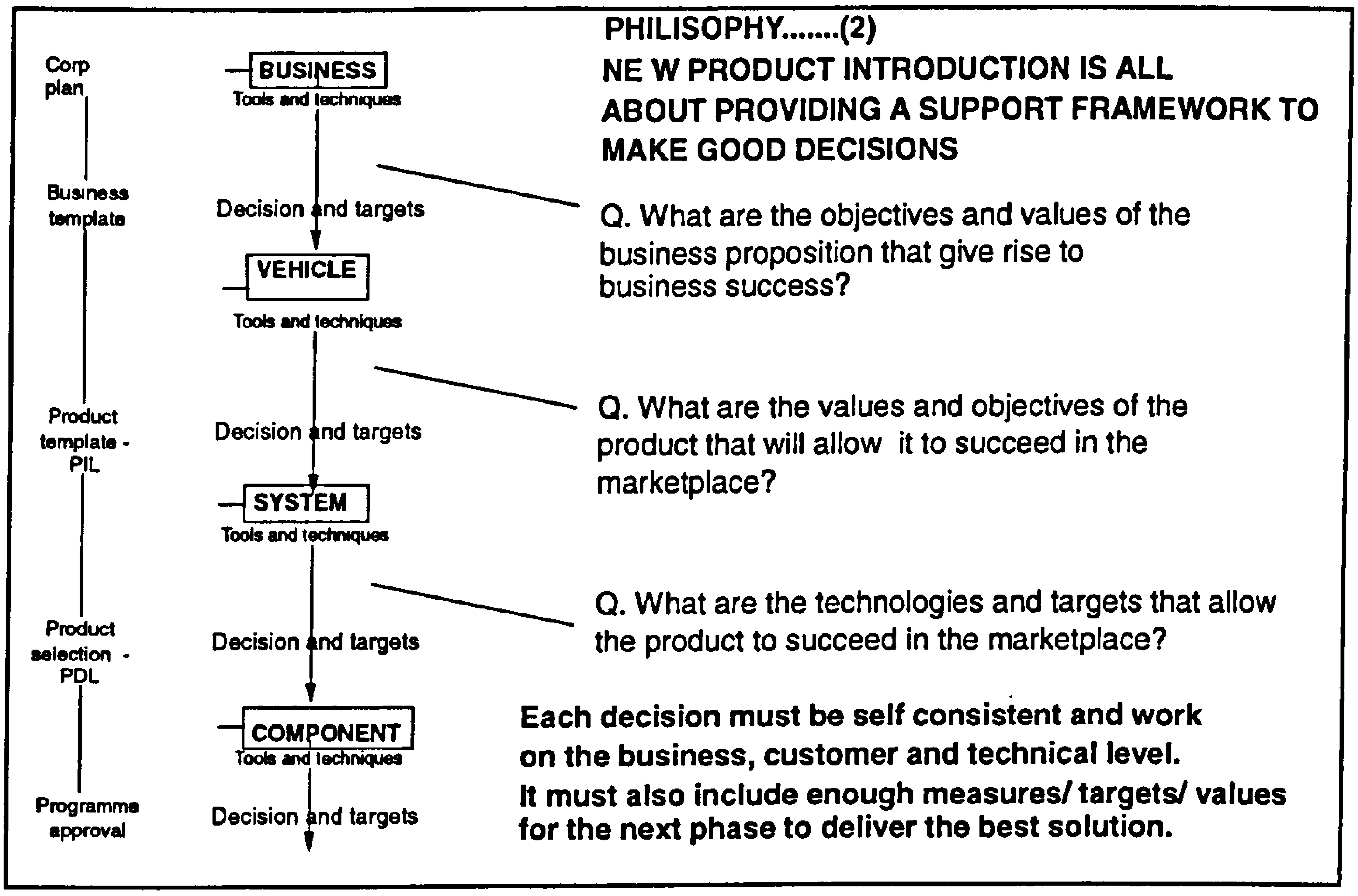

Figure 9 Early explanation of the design model - questions the decisions and targets must answer.

Figure 10 then takes this on a step. The best decisions that can be made are those that allow the next phase of the process to deliver to its full potential and within its capabilities. As each level has its own unique internal and external knowledge, threats and opportunities, it must be involved in the decision to positively add value to the business proposition.

The type of information that is used for decision-making must be in the right form and relevant at each level. For a lower level of the hierarchy to provide relevant information, it must be capable of integrating the information at its level to be understood and meaningful in making decisions higher in the hierarchy. Conversely, information at the higher level must be decomposed to make it relevant to subordinate levels in the hierarchy.

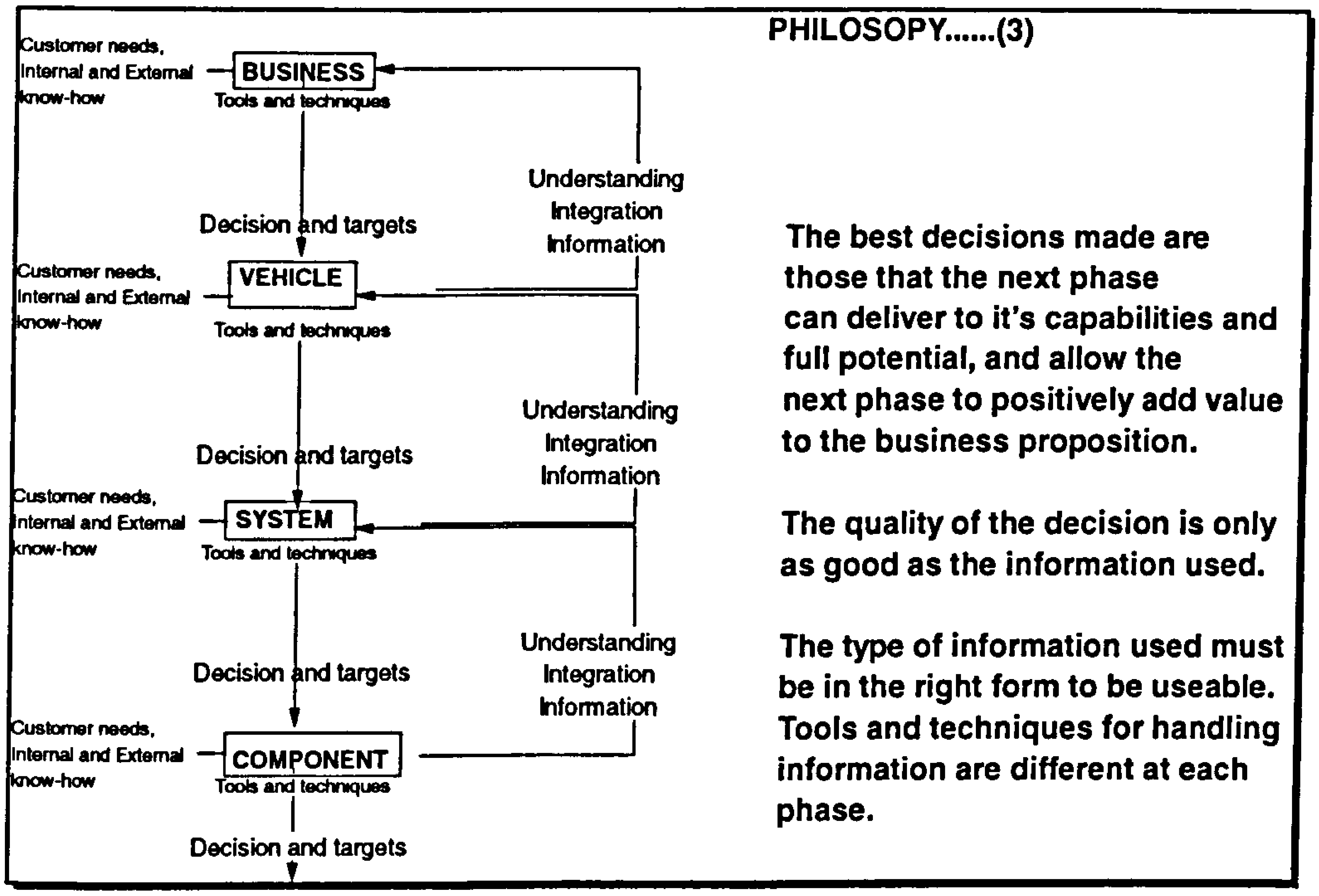

Figure 10 Early explanation of the design model – quality and form needed for information to make good decisions.

Figure 11 then shows the other factor present in unique form at each level of the hierarchy, both internally and externally to the business – that of creativity. In this context, creativity is the potential to apply something new to benefit an organisation, and it is a product of the knowledge and experiences of the individuals and the stimulus they are exposed to. In the author's words, the best conditions for creativity are 'head in the problem, and feet in the solutions', a result found from internal and external studies. The opportunities that arise from this creativity occur at all levels of the organisation and should be harnessed by the organisation. However, in many product development processes, the needs (targets) are not developed nor signalled well enough in advance to stimulate lower levels of the hierarchy. Neither is sufficient resource at the right level engaged early enough ahead of a product programme so that it begins to take the risk out of a new idea. In figure 11, the author's business did not properly engage the systems level of the hierarchy until the detailed design of a product started at the 'Product Template' milestone shown in figure 9. At this point there is no time left to make mistakes, and hence to take on risk. This leads to a dichotomy where new ideas are developed too late to apply to the product programme. Here, either the product would need to be redesigned, with loss of time, or the technology would be taken on at risk – with potentially large penalties in the poor quality of the product. But without taking on the market and technological risks presented by the new ideas, there is little likelihood of producing a product that is exciting to the customer or gives competitive advantage in the marketplace.

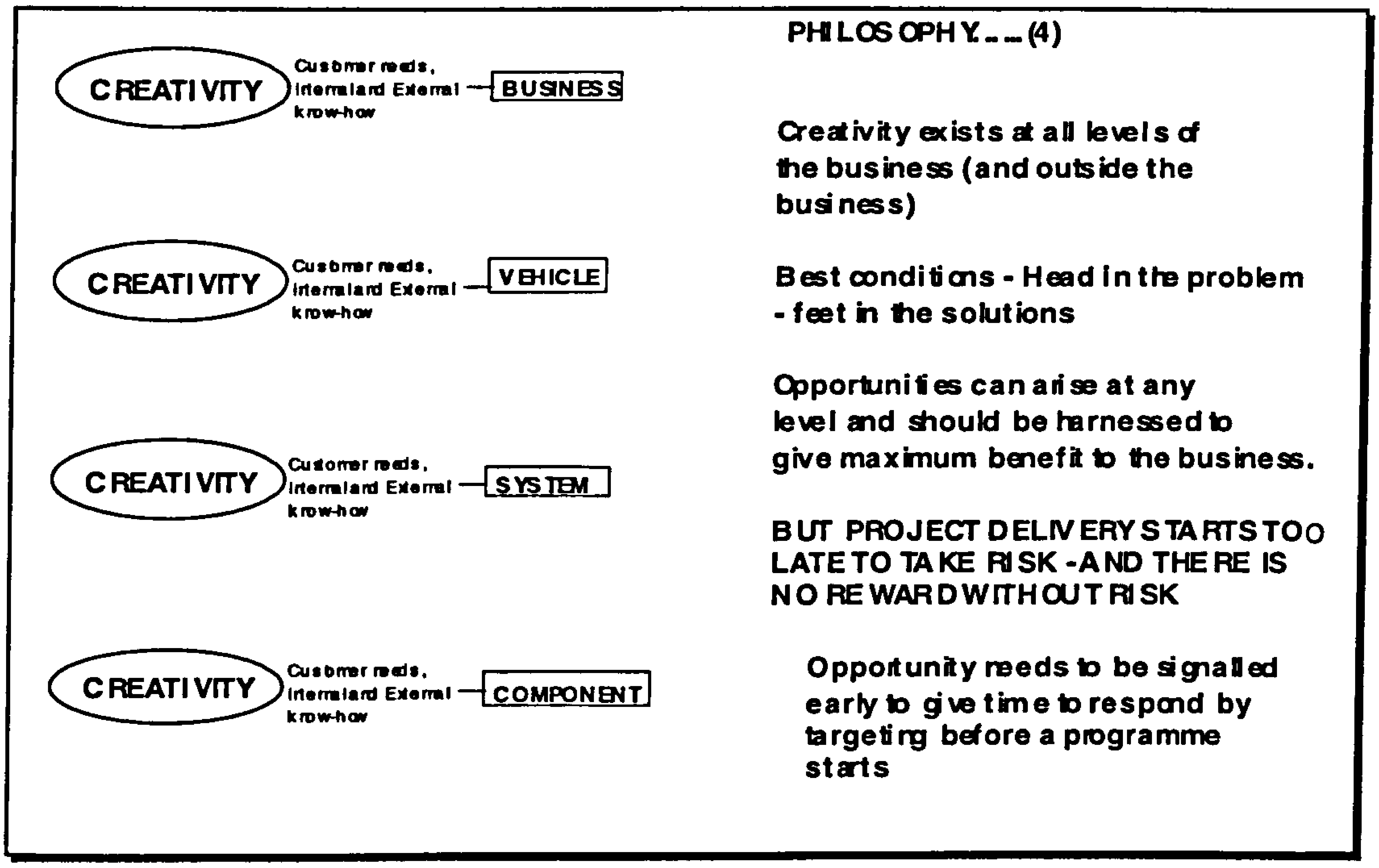

Figure 11 Early explanation of the design model – the conditions needed to apply creativity, and the fundamental conflict in top-down hierarchical organisations.

While the people in the organisation may be creative in the traditional scheme of product introduction, most do not have sight of the critical problems of the business nor of the customer's needs in a way that allows them to develop a timely response. For a product to 'sell in droves at a price that makes a profit' also requires: -

- A product vision and objectives that drive the work at all levels
- The visibility of legislation and competition
- The 'seeing' of the physical and psychological problems of the customer, the solutions to which provide delight in the product.

All of the above need to be visible in appropriate forms early enough in the process so that valuable new ideas can be understood and risks removed before development is committed.

The differences between the model and the author's organisation have formed the basis for targeting further research, developed through reports 6 to 11.

2.4. PROJECT 4 - THE APPLICATION OF A DESIGN MODEL TO THE AUTOMOTIVE INDUSTRY

To gain confidence in the model required some proof that it could be applied operationally. One of the most efficient design and development processes in the automotive industry is that of Toyota. In contrast to their much-copied Toyota production process (Ohno, 1988), this uses principles which are not formally described even within Toyota, and the differences to both Western and Japanese practice are the subject of much research (Sobek et al, 1995, 1998, 1999). The design model was used as the basis of comparison between the processes of Toyota and an advanced Western manufacturer, Chrysler, to see if the published differences could be discriminated using the model, and whether additional learning could be gained by applying the model's integrated framework.

The model was not only able to distinguish the set-based targeting approach identified by the researchers, but also reinforced the principles of the model and showed some practical solutions for how the author's model could be realised in practice. The main points of learning were: -

- The early commitment to change targets from as much as eight years before launch of the product, with internal functions and business partners starting work when they need to, not when directed.
- Functions that co-ordinate their own work with interfacing areas to meet hard output 'deadlines'. This was facilitated by the use of highly competent engineers who were skilled in the co-ordination of their work with internal and external players. External suppliers who were similarly competent at co-ordination were allowed to be less closely-coupled to the Toyota's design and development process.
- The use of set-based design to keep open a range of targets and solutions across the extended business until these are formally reduced at points through the design process.
- The use of 'living' design standards and capability data that was reused and updated by practical application to each new product programme.

Partnerships with suppliers were organised according to their competence in the targeting process and their fit with the core competencies of Toyota. Where partners were highly skilled in set-based targeting, but their components capable of being largely separated from internal design, these were loosely coupled to the business through targets and less frequent interaction. Less capable suppliers, and those with more dependent components, were more strongly supported by the core targeting process, and involved later in the design process.

Generally applicable innovation

- The author has shown a design model of the business that is feasible to apply because the essential elements are successfully, though rarely, applied in industry.
- A framework has been developed that can be used to analyse the structure of a practical example of the design and development process.
- A framework has been developed by the author that can help to identify potential gaps in process or performance for a real-world design and development process, and helps to specify the properties of those gaps.

Internal innovation

- A better understanding of target setting and target control has been developed by the author, which has been applied into the business through later projects.
- The identification of potentially useful ways of shortening the time of product development and increasing the efficiency and effectiveness of the design and development process.

2.5. PROJECT 5 - A COMPANY-WIDE PROCESS OF INCLUSIVE STRATEGIC PLANNING

The model of the design process was used to apply methods for correcting the first strategic shortfall in the author's business, that of the strategic targeting of technology. The opportunity for exploring this area occurred with the author's assistance in the development and implementation of an inclusive strategic planning process. The process gained acceptance and supported the business in making a decision to explore a radical departure from conventional automotive solutions.

Following the sale of the author's company to BMW, the resulting radical innovation programme was eventually extinguished. The design model was able to show how a difference in the decision values between the holding company and the business unit was one of the factors in the extinction of the resulting programme.

Externally-applicable innovation

- An episodic planning process capable of bringing about radical innovation, that is likely to be adaptable to other organisations. The author's part in the innovation was involving the creativity and knowledge of lower levels of the business hierarchy in the process to support radical innovation.
- Improvements to the design model of the business for the strategic process have been proposed by the author, which include further principles recognising:-
    - The need to continually manage the whole range of possible futures (scenarios) and options against the values and needs of the business. Owning businesses must explicitly recognise these values, needs and options as a system, without which a subsidiary will be sub-optimised.
    - That a radical option for a business must be included in the set of scenarios and options as a business develops, and not bypassed as a separate opportunity. Without this inclusion, a radical alternative will become increasingly marginal to the needs of the business, and the business will lose connection with a strategic opportunity.
    - That options for a future scenario must be managed on the basis that the resulting product <u>will</u> meet future market and customer needs. This allows work to be defined against the need to rigorously control technical and commercial risk. Allowing options to develop without this discipline prevents rigorous decision-making in the project and the appropriate resource decisions in the business.

- That market and competitive signals are part of the management process to make clear decisions on the performance requirements of solutions. These must be managed towards deployment as a coherent, integrated, set of targets.
- That it is the decision process that balances between the vision of a strategic option, and the focused competence and resources necessary to deliver this.
- That a principle of minimal waste should be adopted, enacted by combining and choosing between options and possible solutions to reduce the effort needed to deliver robust solutions. Figure 12 describes the principles.

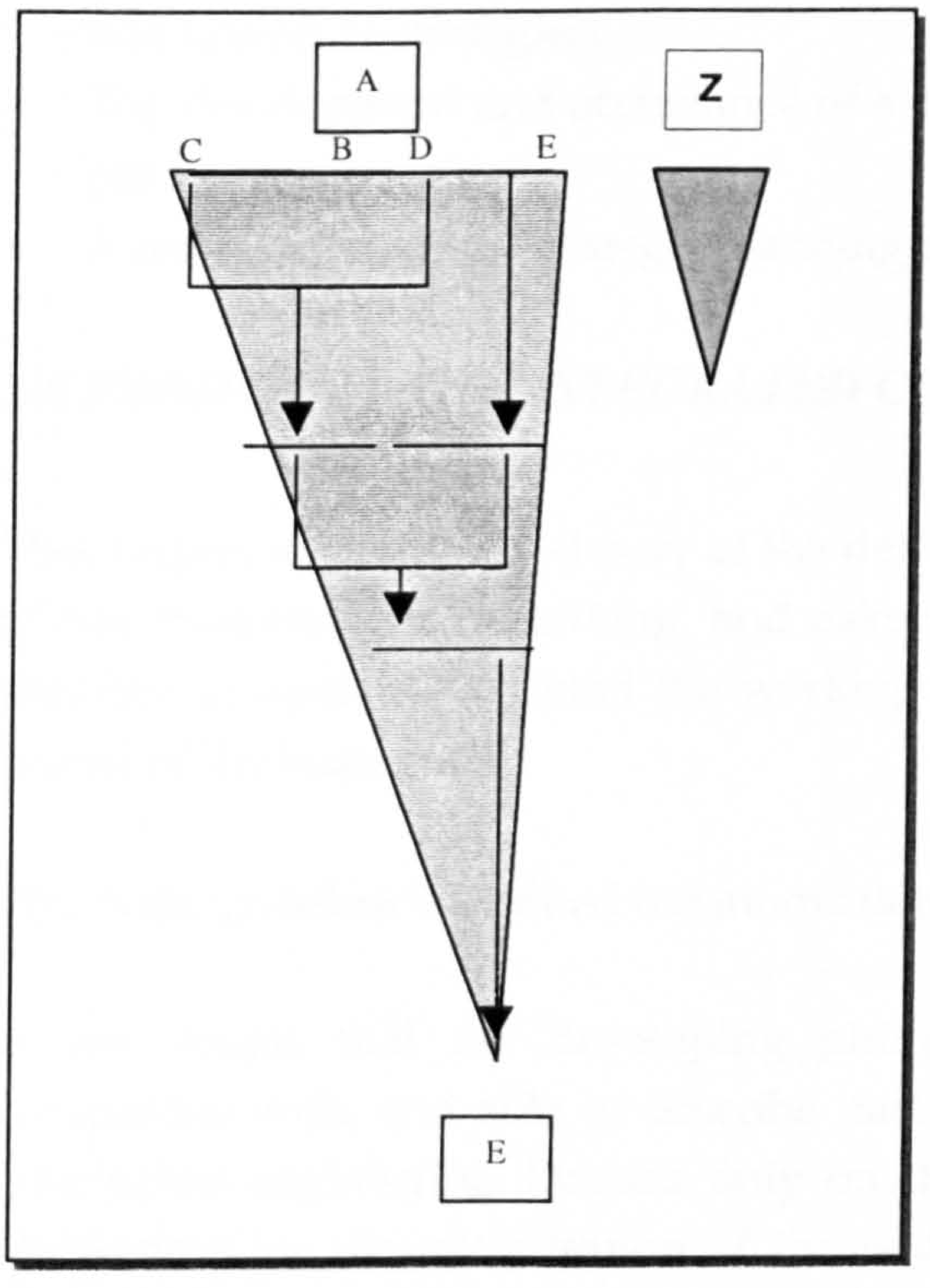

Figure 12 Shows the simultaneous development of future market scenarios for a business (large shaded triangle), and a range of options to respond to these (C, B, D and E) with time. The top of the triangle could be 10 years from launch, and the bottom is the start of development. The range of possible future worlds reduces with time, and the options are hybridised and selected against this as technical knowledge in them develops. Ideally, the result is a flexible, single solution to a wide range of possible scenarios to cope with market changes during the life of the product. Triangle Z shows the likely fate of a strategic innovation that does not respond to part of the range of perceived needs for the organisation – it gradually loses the resource and support of the business until it becomes unsuitable for the marketplace, and undeliverable.

The only factors that the organisation has control of in a strategic option are the availability and quality of resource, the spread of alternative futures that it decides to cover and the speed of development. This latter factor gives more time to reduce market and commercial risks. There are also independent variables that the organisation cannot affect: the rigour needed to remove the risk from a successful solution, and that of the date when a solution achieves a given business and market impact. This shows the importance of recognising the external environment, and of having effective, rapid co-ordination processes that engage participants in managing risk against requirements.

Internal innovation

The author has produced the following innovations for the business:

- A significant contribution to the development and implementation of a strategic planning process, and in particular, the innovative engagement of lower hierarchies in the formulation and testing of strategies.
- The development and acceptance of a radical strategic option for the business, progressed as a pilot programme.
- A better understood strategic planning process that can be used in future.

2.6 PROJECT 6 – THE INTEGRATED COMPANY

This project looked more closely at the definition of an integrated company that the Design Model of the Business was describing, and asked the question, "Are there other models available that describe in operational detail the working of an integrated company, consistent with the design model of the business?"

The findings below identified the innovation represented by the design model of the business.

It was found that the developing philosophy and practice of concurrent engineering was compatible with, and able to describe part of the requirements of the author's model. However, concurrent engineering focused only on the individual lifecycle of the product, while making allowances for the optimisation of the wider enterprise. In comparison, the design model is 'a design process that integrates to achieve the best results over the enterprise and across the product plan' –

$$\text{Model} \equiv \text{Maximise or minimise} \quad \int_{0}^{\text{Enterprise}} [F] \, d \text{ product plan}$$

where 'product plan' is the integration of all life-cycles, and

F includes time, quality, cost and company equity

The model aims also to maximise company equity, which is related to the value of the company brand(s), and not only the optimisation of time, quality and cost.

The design model of the business can also be expressed as

Model $= \cup$ [requirements CE + additional requirements Optimisation across Product plan + additional requirements Optimisation Brand Equity]

Where CE represents concurrent engineering.

The market and business success of a manufacturing company is delivered almost exclusively through its products or services and the activities in support of them. Therefore, business success can be defined as the sum of the success of its products and services, where success is defined as meeting the needs of the enterprise: -

$$\text{Business success} = \sum \text{Success (products, services)}$$

By incorporating the needs of the product plan and that of brand equity into a concurrent design and development process, it should be possible to drive a better optimum across the enterprise, through the following mechanisms: -

- A higher rate of successful innovation through anticipating the needs of the customer, and better alignment of planned business capabilities with the requirements of future vehicle programmes.

- Strategic planning that uses the deep understanding of competitors, technology and the capacity for change available at every level of the enterprise – including suppliers. This leads to more effective and efficient responsiveness to the business and market environment.

The examination of concurrent engineering philosophies showed that ***phases earlier than the inception of an individual product*** were not covered within the umbrella of concurrent engineering systems, methods and tools. The areas that must be covered are the direction of a business, the strategic planning of an enterprise and its brands, the early phases of innovation management, and commonality management. The motivation that drives the strategic planning and innovation of the enterprise, the element missing from all the other models reviewed, was proposed as being the brand. This is discussed further in chapter 3.

2.7. PROJECT 7 - A HOLISTIC METHODOLOGY FOR MANAGING COMPANY AND PRODUCT NEEDS

Two shortfalls in the business process that were recognised by the author using the design model of the business were those of: -

- systematically setting targets for the customer and
- producing an integrated set of targets to drive products and businesses.

To reduce the expert support and additional time needed to introduce such processes completely internally, a computer-based framework using embedded concepts of customer recognition and targeting was chosen for piloting in the business.

To gain operational experience in this area, the author developed an internal research project in collaboration with an external expert in human-centred design processes (Rouse 1991). Team-based computer tools for defining products (Design for Success/ Product Planning Advisor, Enterprise Support Systems Norcross, GA, USA) and for planning a business (Strategies for Innovation/ Business Planning Advisor, Enterprise Support Systems Norcross, GA, USA) were piloted in the company through the author's direct facilitation and co-ordination of trained facilitators. The pilot projects covered new product definition, product and research project management, research project selection, supplier selection and technology innovation. The product design tool proved valuable and popular in teams with well-understood decision criteria but lacked the conceptual frameworks for quantifying the brand for a complex product, a vital aspect of the author's business. The business planning tool had embedded many new and useful integrating and decision advice concepts that were accepted as missing or in need of development in the organisation. However, it was found that the organisation's basic business decision and work process would need to change markedly to accept and introduce this tool. This would require rigorous management of the flow and quality of evidence and use of risk management to make lasting strategic decisions through the use of the tool. While the use of such tools was found to affect the speed of customer understanding and product design markedly, the business needed to operate a compatible business decision process to allow the tools integration.

Externally applicable innovations

The following innovations were achieved by the author, and by the team working under his direction.

- Improvements to the Product Planning Advisor and Business Planning Tools available commercially.
- The confirmation that tools such as the ones piloted could support the design model of the business

Internal Innovations

The author and the extended team under his direction developed and applied team-based computer tools that:

- Supported the quantitative understanding of user groups in advance of any previous technique.
- Supported the effective setting of targets for customer groups and other stakeholders.

- Were found useful and acceptable with cross-functional teams that included product concept, engineering, and sales and service.

Against Quality Function Deployment, the best-known tool in this field, Product Planning Advisor was found to:

- Model a wider range of stakeholders
- Allow rapid evaluation between different concepts
- Allow better optimisation of targets against capabilities
- Take into account future markets, competitors and concepts
- Gain greater acceptance and enthusiasm from users
- Generate a strong environment for innovative ideas
- Improve user's internal models of the marketplace

To generate a business environment where such tools could be used to improve the speed of innovation, the improvement of the business decision process was needed, and a means of quantifying the brand. The move towards a computer-aided process needed to develop from the existing process, as a revolutionary approach was unlikely to gain the confidence of the business in a sufficiently short time to be adopted effectively. Efforts were then turned in the interim on understanding human behaviour and improving co-ordinated decision making through more internally acceptable processes. The techniques and lessons learned from the collaborative tools could then be reintroduced once basic decision-making had been sufficiently matured. Projects 8 and 9 introduced some of the targeting and agreement techniques learned in team-focused procedures that could later allow the introduction of automated processes. In project 11, the author re-engineered the early phases of product development with subsequent application of automated co-ordinating tools in mind.

2.8 PROJECT NUMBER 8 - A PROCESS FOR ALIGNING THE GOALS OF TECHNOLOGY DELIVERERS AND PRODUCT TEAMS

One of the identified needs from report number one was for a means of driving the product targets sufficiently into the future to allow an effective research and technology response. The author needed to apply a method for the effective integration of researched technologies into vehicle programmes. The method jointly originated and then implemented under the direction of the author for a number of product programmes is shown in figure 13. The format of a trendline is a chart that traces with time the expected development of a market or legislative requirement, for example the cornering performance of a type of car, or the competitive safety expectation for a product in a sector of the marketplace. It is important before the start of the exercise to decide which attributes (performance values or qualities of the product and project) are most important to its success. This then allows potential trade-offs in performance delivery to be measured against the success of the product.

Step 1 in figure 13 is for a person to be made responsible for the development of the trendline, usually the technical expert in conjunction with marketing. Firstly, the quantitative measures, or algorithm that captures the competitive need are researched and decided. In the case of safety, this may be the cumulative value of weighted safety features to the customer. Evidence is gathered and valid assumptions made for a range of competitors or the market across the lifetime of the product, which gives rise to a band representing the likely development of the marketplace through time. An important activity is to confer with the product team and marketing so that mutual confidence in the trendline is developed.

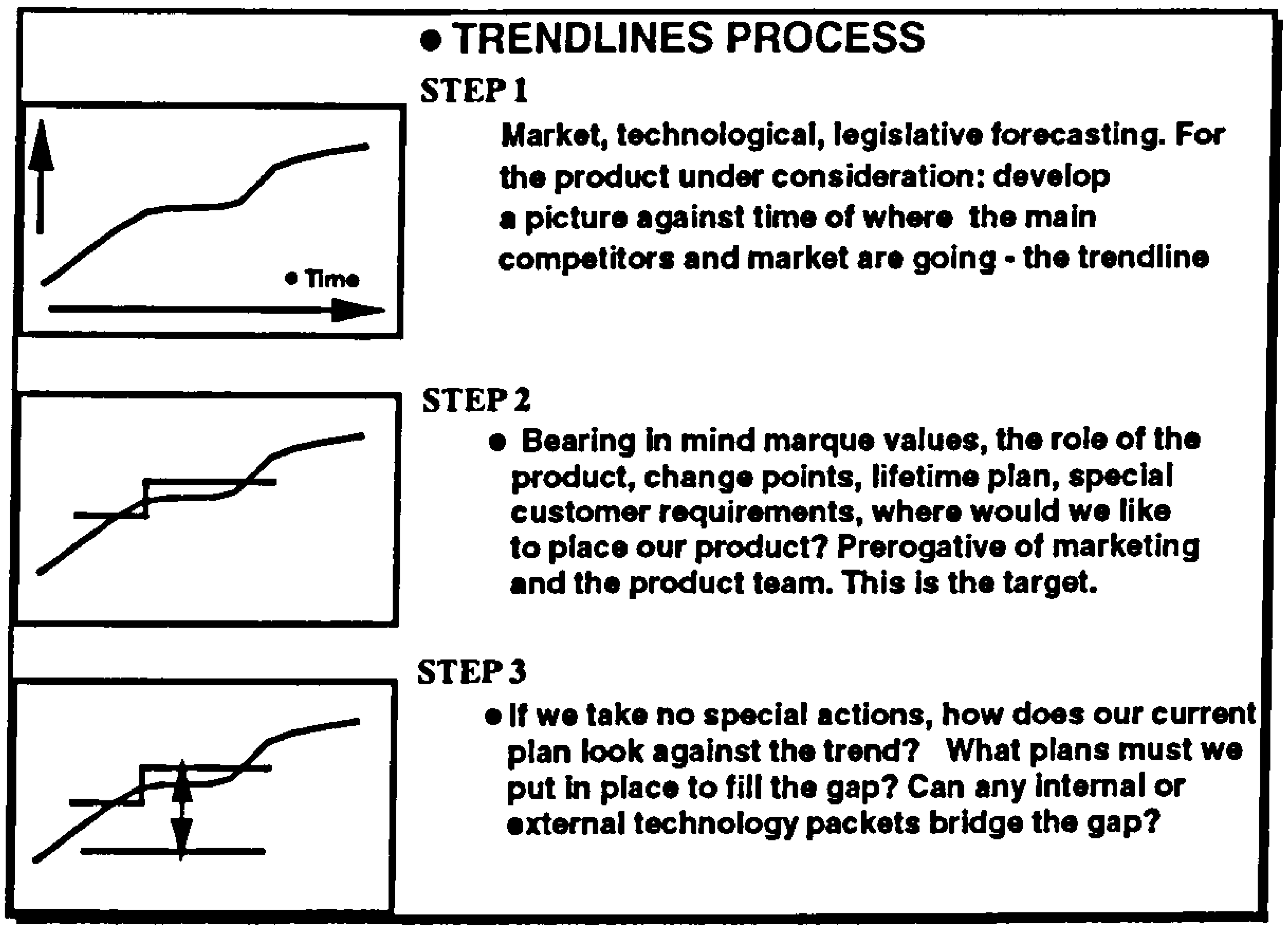

Figure 13 Trendlines process developed to form the basis of target agreements between product programmes and technology providers

Step 2 is then the role of the market and product team to consider the competitive position over the lifetime of the product. In relation to the trendline, they must plot the competitive position required (e.g. best in class, amongst the leaders or average), and how this should change through time with planned upgrading.

Step 3 then requires the functional expert to draw a line for the performance delivered by currently confirmed and planned actions. This shows the size of the gap between current capabilities and the required performance of the product. The gap generates the need for technology solutions to provide the performance necessary. The availability of technology or product options, their performance capabilities, cost, investment and other characteristics allows options to be earmarked for further development.

The initial trendlines are normally developed off-line and may take from several days to a month or more to identify measures, gather evidence, and develop confidence of trends in the marketplace. It is also advisable to prepare currently-planned performance lines ahead of the exercise, and the performance of product and technology options together with their costs and other characteristics.

The rest of the steps from the agreement of trends through to the identification of gaps can take place in one workshop, and has been carried out for two vehicle teams and eight trendlines concurrently in one day. However, trendlines can also be used on an ad-hoc basis to set targets for products outside of formal workshops.

Generally applicable and internal innovations

- The author, together with D. Beadle, originated a process for target setting. This was then developed and led by the author in detailed form to a process suitable for forecasting market place trends and agreeing the development of appropriate responses in larger teams.

Internal innovation

- The trendlines process was jointly originated, then developed and implemented on vehicle programmes. This has resulted in a more competitive product in terms of ride and handling, noise and safety performance.
- The trendlines process instituted and used within the business.

2.9 PROJECT 9. A PRACTICE FOR UNDERSTANDING AND CONVERTING THE SUBJECTIVE AREA OF BRANDS INTO TARGETS

A shortfall in the targeting process to drive the business and product teams for brand values was made visible in project 6. Without quantification, it was found that the subjective needs for the brand were lost against the more quantitative and rational financial decision-making process in the business. In addition, the engineering of a brand requirement cannot be delivered without eventually making specific decisions through quantitation. Without a conversion process relating to the brand and the customer, decisions affecting the brand are made on an arbitrary and subjective basis in the engineering process. This view was supported at a senior level in the business, and the author was made responsible for developing and applying an appropriate methodology.

There was little literature available to support the author in this task when the work started. The concept of automotive brands is relatively recent compared to those in fast moving consumer goods (FMCG) sector (Ward et al 1999). However, it was accepted that concepts developed in this area are often relevant to the automotive sector too. The concept of the brand has been defined as **"the promise of the bundles of attributes that someone buys and that provides satisfaction... The attributes that make up a brand maybe real or illusory, rational or emotional, tangible or invisible" (Ambler 1992).**

The bundle of attributes that is associated with the brand has the nature of an implicit contract between the organisation and the customer, as shown in figure 14 (Bernthon et al. 1999). The concept of brand equity is believed to provide higher profit potential due to brand loyalty, where customers have a preference to buy a single brand name in a product class, giving rise to higher sales, lower costs and higher prices, (Chaudhuri 1995; Aaker 1991). Equities for a brand may be positive or negative, in that once an organisation is recognisable by its brand, the customer has a perception of the brand's qualities and worth. Where the brand has high equity this provides a premium or willingness to buy. However, the converse is also true, in that an organisation having a poor reputation is likely to attract a negative willingness to buy from customers, in contrast to a brand 'neutral' competitor (Chaudhuri 1995).

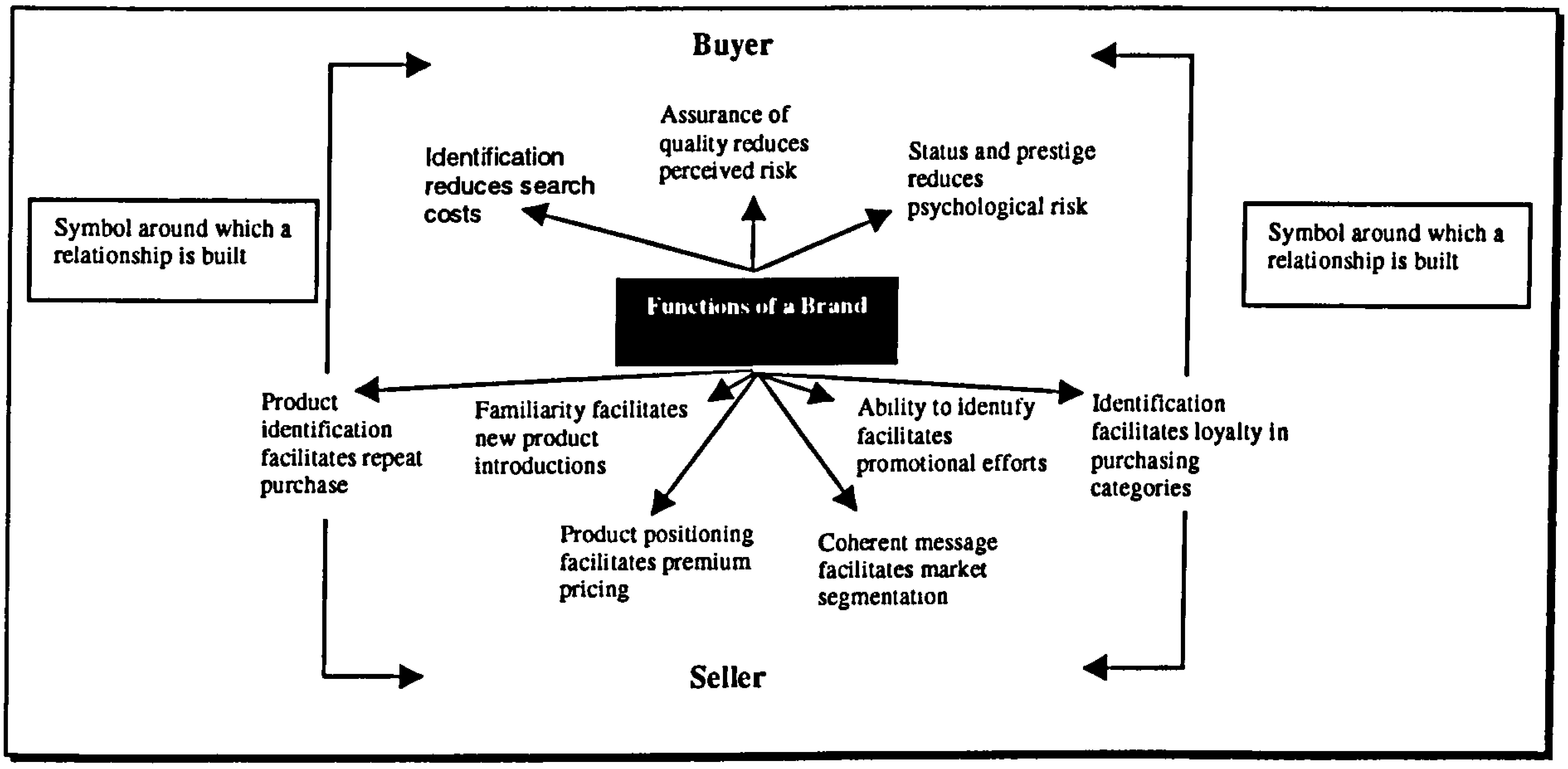

Figure 14 Functions of the brand for buyer and seller (Berthon et al., 1999)

Despite automobile brands movements being widely reported in brand and marketing literature, the conversion of brand values into engineering measures is little reported. This is possibly because of the complexity of the product, the general reliance on style to communicate the brand, and the relatively late application of formal conversion methods such as Quality Function Deployment into automotive businesses. According to Ambler and Styles (1996), the traditional route to product development has been the commitment of a product before brand values have been applied, with the subsequent loss of value. However, the growing capabilities of engineering systems such as noise and chassis to be tuned gave far more scope to support the brand more completely for the customer. Before the author's work, the attempted translations to technical features and values were found to lack repeatability and a basis for testing in the marketplace.

A number of basic approaches were developed by the author to be consistent with brand literature and the internal understanding of the stronger brands owned by the business, namely Land Rover, Rover, Mini and MG. The first principle is that a brand promises a set of values that form an unspoken contract between the customer and the organisation. This perception needs to be upheld in the perception of the customer by what is communicated through the senses, as shown by figure 15.

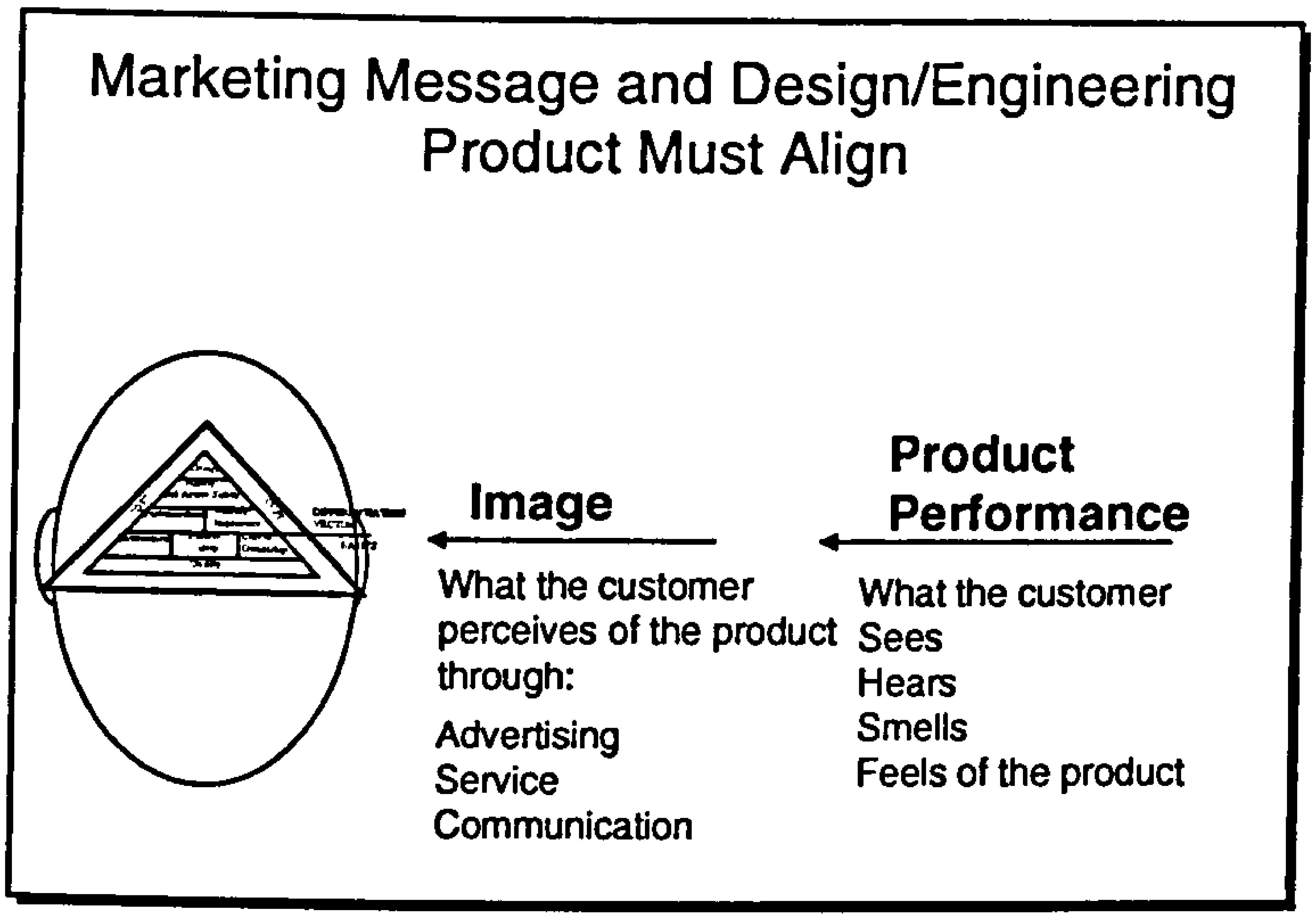

Figure 15 The need for consistency in the product's performance, services and the messages communicated to the to provide a consistent and valuable perception of the branded product.

It was understood internally that the product must retain integrity against the customer's expectation, or else confidence would be lost. The attributes important to the brand needed to be identified so that these could be delivered in the product. A useful tool was the Kano model (Kano 1984), shown in figure 16, which provides a definition of three types of attributes, or values that are important to customers. The first is that of the basics, those attributes that must be delivered for a customer not to be dissatisfied, such as brakes and doors that do not leak on a car. The next category is that of the *performance* attributes, the attributes that are commonly those on which products compete. The brand must meet the level of performance expected of the particular brand.

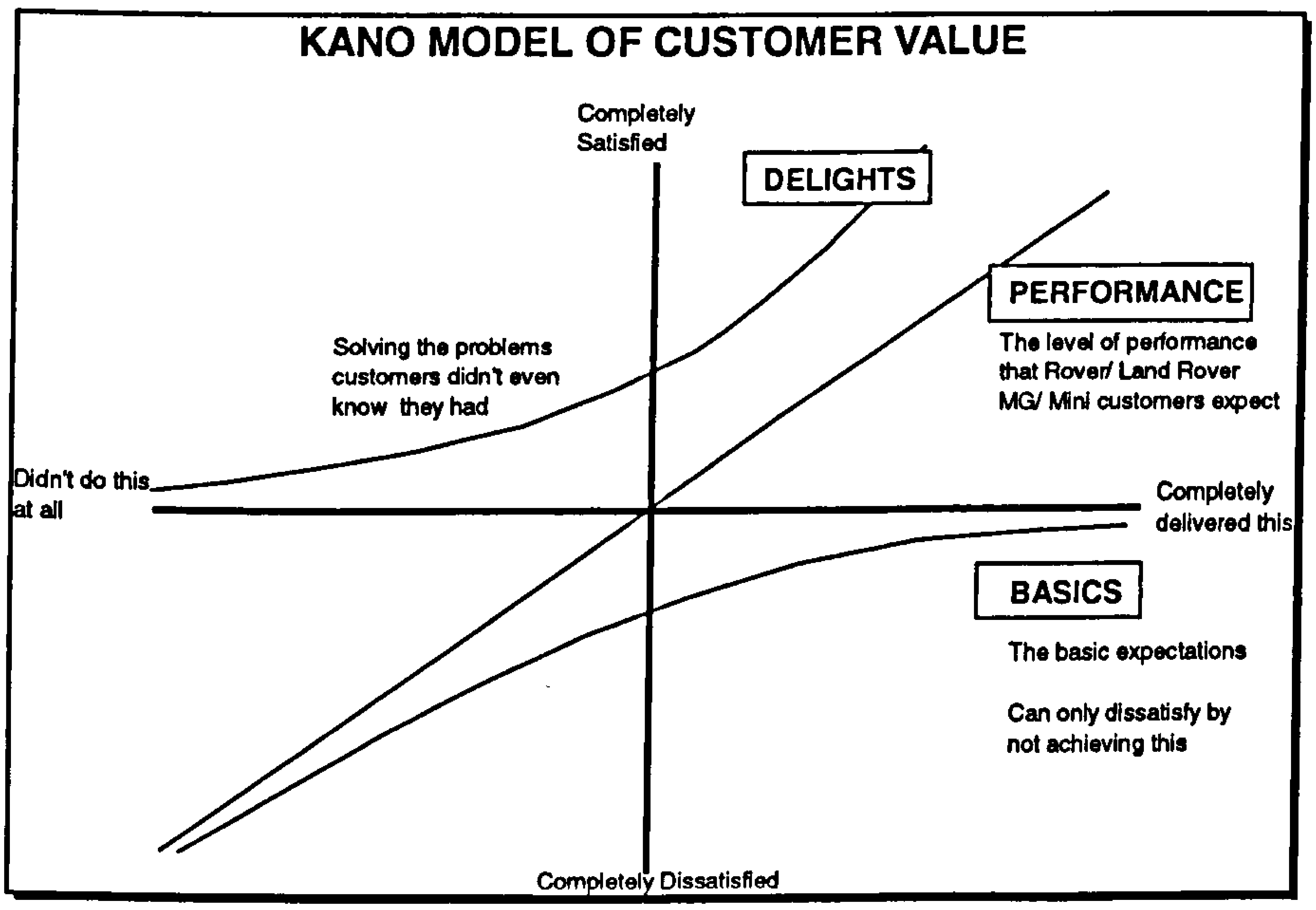

Figure 16 The Kano model (Kano 1984) of customer basics, performance attributes and delight attributes.

The delights are those factors which 'customers don't even know they have' and are unexpectedly solved. A strong brand will have customers that associate a brand with a group of attributes that have high performance, and those that have delightful solutions. Others will not have the same expectation, as the customer either does not expect these attributes, or will be happy to trade these for increased performance or delight in another area. For example, BMW cars are known and valued for their dynamic qualities, but the expectation and delivery of luggage space is lower than competitors. This is the basis of the tacit understanding between the brand and the customer. For the retention of customers, it is important that the basic qualities are delivered. For a product with even high desirability, the non-delivery of basic qualities can infuriate the customer and lead to a loss of customers and the long-lived reputation for poor basic quality

A key tool in engineering the brand has been the target pyramid. A model of the Mini car product target pyramid is shown in figure 17. The higher sections of the pyramid represent differentiators for the brand that the customer pays a premium for, and lower down are the competitive values where the brand must achieve the expectation of the customer. Around the outside of the pyramid is a cost constraint – for each product there will be a level of acceptable price that it will reach in the customer's mind.

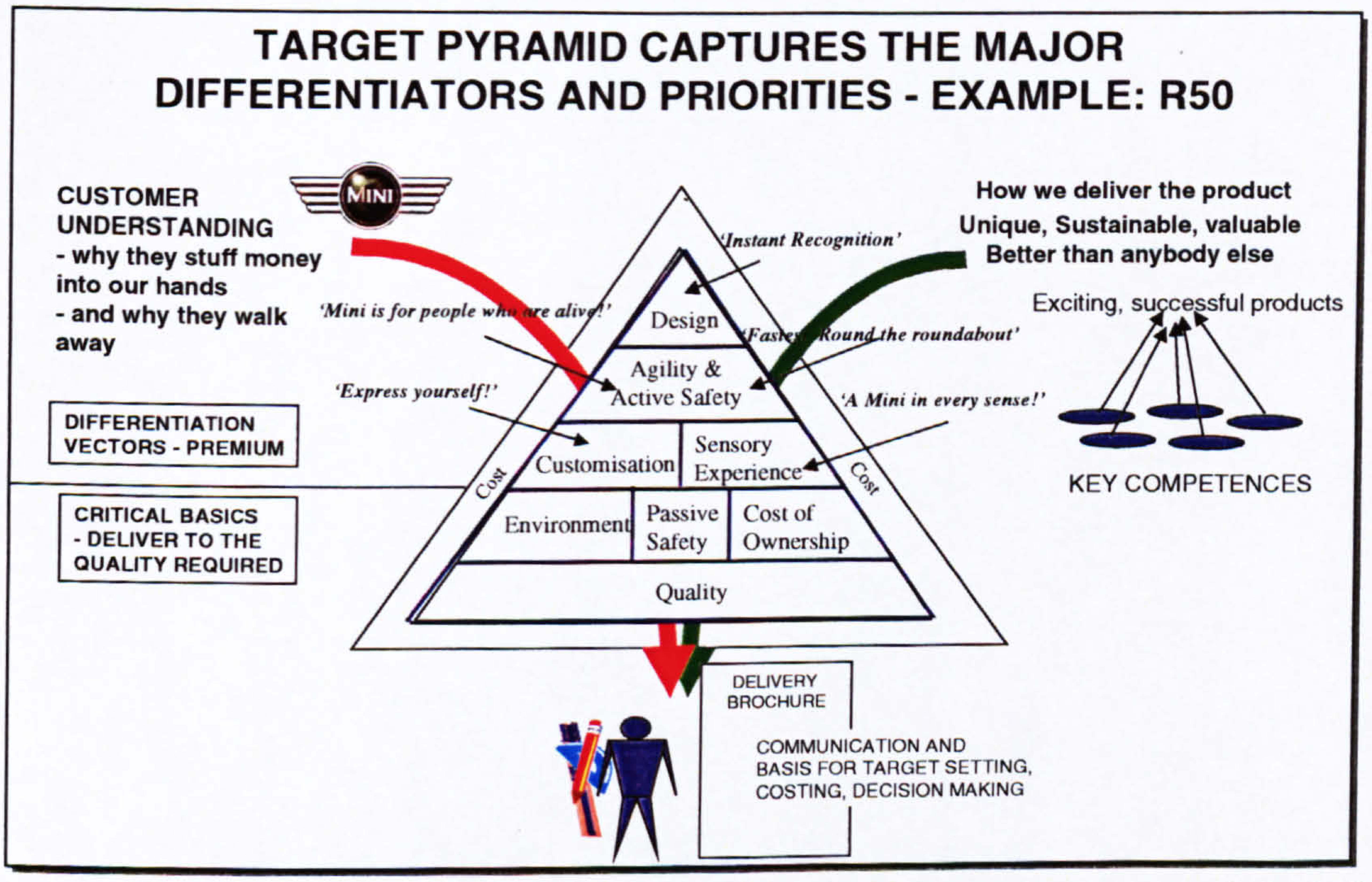

Figure 17 Target pyramid for the new Mini, showing the connection between psychological and functional needs, and the delivery of differentiators through the core competencies of the business

On the right of the diagram are the key competencies of the company. To achieve the differentiating values sustainably and better than competitors requires that the business has particular knowledge and advantages in this area. By concentrating the company's research and core competencies around brand differentiators, it can achieve a high level of profitability – but only through a successful brand, with products delivered at a cost that allows a profit to be made.

Figure 17 indicates some of the methodologies developed and implemented by the author. These include the conversion of brand and customer understanding into target pyramid form, the alignment of core competencies with differentiators and (at the bottom of the diagram) the breakdown and communication of these emotional values into quantitative engineering measures communicated. Beyond this were the tools for communicating brand needs at lower levels into product development, and the methods to ensure that appropriate engineering and cost targets are set and the targets delivered. The innovations of the author directing an extended team were:

Internal and externally applicable Innovation

- A methodology for identifying and quantifying the subjective qualities of a product so that they can be converted to meaningful targets for the wider enterprise.

- The author has developed, adapted and implemented techniques for
  - surfacing the brand from organisational knowledge,
  - visualising the values of a branded product in a target pyramid
  - verifying the understanding of the brand through the use of customer techniques.
  - decomposing the values into measurable attributes
  - decomposing these to the modules of a product and process
  - finding acceptable areas of commonality between branded products

- A number of principles have been developed by the author which have been found necessary to manage the integration and delivery of a branded complex product: -
  - The business needs to make decisions on the same visible set of project goals and targets at all levels, including the board level. Otherwise the integrity of the vision is destroyed on individual or political whims.
  - Customer understanding needs to be rigorous, and must drive the product system. Otherwise confidence is lost, and customer information becomes optional to the delivery of the product.
  - Cost targets need to be influenced by where differentiation is required.
  - Strategic targets need to be set from outside the development team by responsible customer, functional and legislative experts. The development team's main role is that of product integration and delivery. The holding of both roles compromises the customer's needs as here is a strong pressure on the individual or team to compromise targets under their own control if they become difficult to achieve within time, quality or cost constraints.
  - The mechanism for setting targets needs to be effective in controlling the product, and the targets must be used as the basis for identifying risks and resolving programme conflicts.
  - Product benchmarking needs to be carried out on the basis of important attributes, based on customer understanding, and not the personal preferences of the benchmarker.
  - Differentiation targets must be considered at the highest level in the business, in addition to normal business measures. What isn't seen is seldom delivered.
  - The business's understanding of a brand and its performance needs to be verified by objective testing in the marketplace, or it is subject to potentially fatal flaws in its decision-making.

Internal innovation

- The Engineering the Brand methodology succeeded in developing a differentiated target vision for a range of branded products, and converted the vision into a set of objective deliverable targets, and a control mechanism to ensure their delivery. The outputs of the process results are still the basis for these products and the research programmes to support them.

- A set of principles derived from the operation of Engineering the Brand formed the basis of target setting for the reengineered product development process within Rover Group. The principles showed the organisational and process gaps that needed to be addressed.

Two aspects are important to the further development of the overall research:

- The brand engineering process has been found significant to the whole design and development process. Figure 18 shows that the brand targets form a fundamental control mechanism for the business in the marketplace. The cycle starts with the brand and product definition for the marketplace, its verification against the market, and then their decomposition into engineering and other values for the supply chain. These values are set and then controlled through development and manufacture. Once the product is released to the marketplace, the perceptions of the customer can be monitored to verify that the 'hypothesis' of the brand pyramid has been successfully delivered. Any deviations between the targeted effect and that actually achieved provide learning for the evolution of the brand and the methods of targeting.

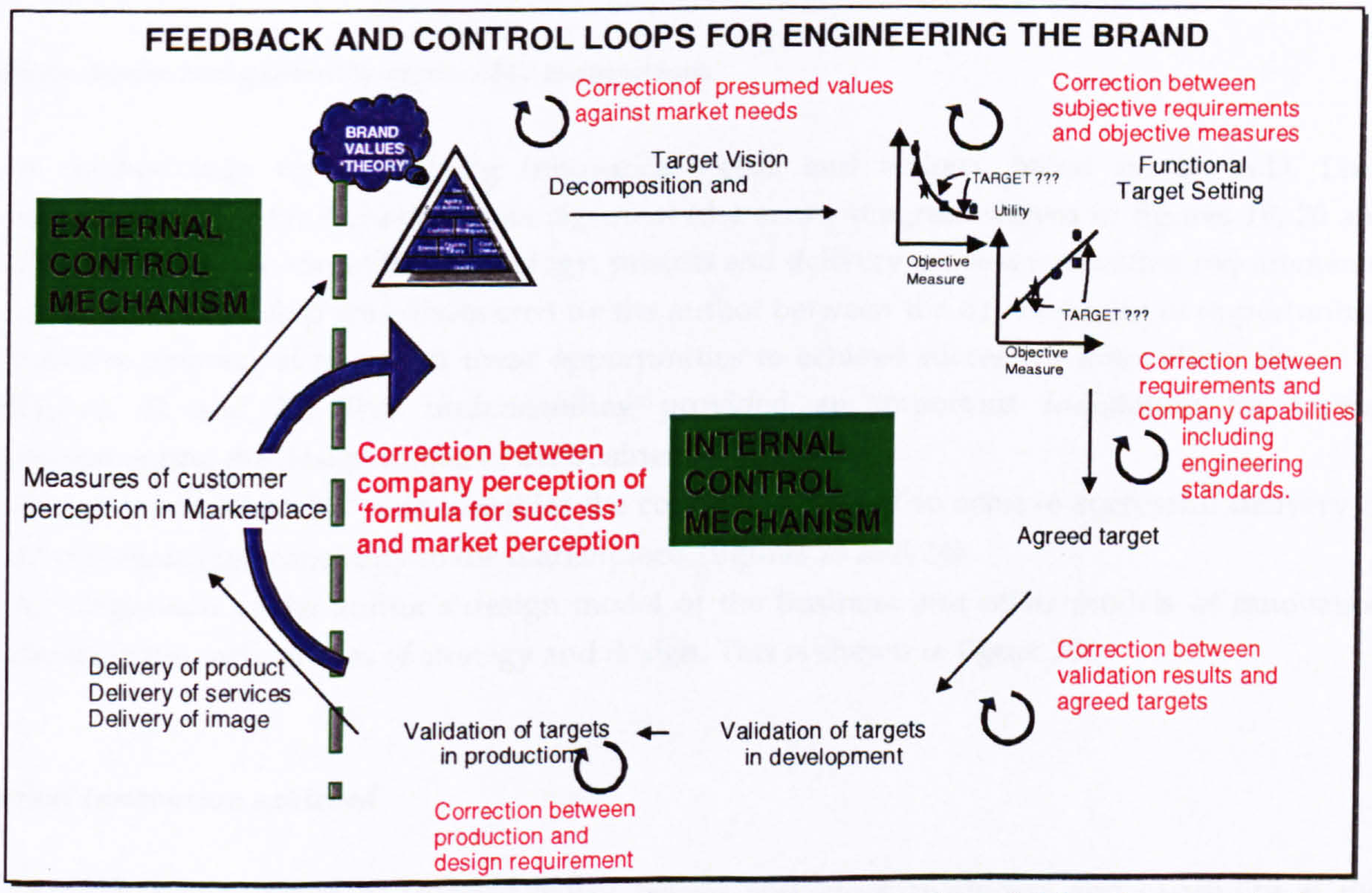

Figure 18 The use of the Engineering the Brand process as a control model for the organisation.

- The second aspect impacting the rest of the research is that the concept of the brand, when made manageable by the use of measures, can become a unifying principle for driving market understanding, innovation, aspects of business structure, competencies and product programmes. These aspects are discussed further in section 4.3.

2.10. PROJECT 10. CHANGING A COMPANY'S APPROACH TO INNOVATION

The objective of project 10 was to identify barriers to innovation and to deliver strategies for the targeting and support of innovation in an organisation. The existing and required core competencies of the business were also developed to recognise the basis of the organisation's competitiveness, and to develop those that were considered inadequate. These aspects were used to co-ordinate strategies in the business's change plans for the year 2000. To achieve this, two cross-functional groups were formed; innovation and core competence. The author was a member of both.

Using the definition of innovation as ***'the harnessing of an idea to create competitive advantage'***, a set of priority projects were developed and recognised by the business as being critical to the success of the business.

In addition, the climate for innovation needed to be developed in the business and supporting actions delivered, in particular competitive benchmarks and patent rate improvement. The author's contributions to these tasks were the following innovations: -

Both In-house and generally applicable innovations

- A methodology for identifying innovation needs and actions, based on an A.D. Little consultancy tool for technology management (the arrow diagram shown in figures 19, 20 and 21). This helped to target the technology, process and delivery process innovation requirements.
- A strong relationship was discovered by the author between the development of opportunities and the removal of risk from these opportunities to achieve successful innovation, shown in figures 22 and 23. This understanding provided an important foundation for further implementing the design model of the business.
- A model and 'checklist' that identifies the conditions needed to achieve successful delivery of an organisational capability to the marketplace. (figures 23 and 24)
- A comparison of the author's design model of the business and other models of innovation covering the early phases of strategy and design. This is shown in figure 25.

Internal Innovation achieved

- Through actions taken to identify patent targets and grow awareness and capability in the engineering team, a significant growth in patent filings was achieved from 114 per year to an average of 100 additional filings over the next two years. The author's part in this was as a facilitator in target setting and communicator to the wider engineering team.

- The joint development of a process to identify group core competencies and the understanding of gaps between their existing and required states.
- A list of brand-based product innovation targets was developed and applied in the business, based on the understanding gained in project 9.
- A 'customer journey' tool was developed and applied to stimulate creativity in the business based on customer needs.

A number of the innovations claimed are described in section 2.10.1, 2.10.2 and 2.10.3.

2.10.1 The Innovation Arrow Diagram

The arrow tool for identifying innovation needs for an organisation is shown in figure 19.

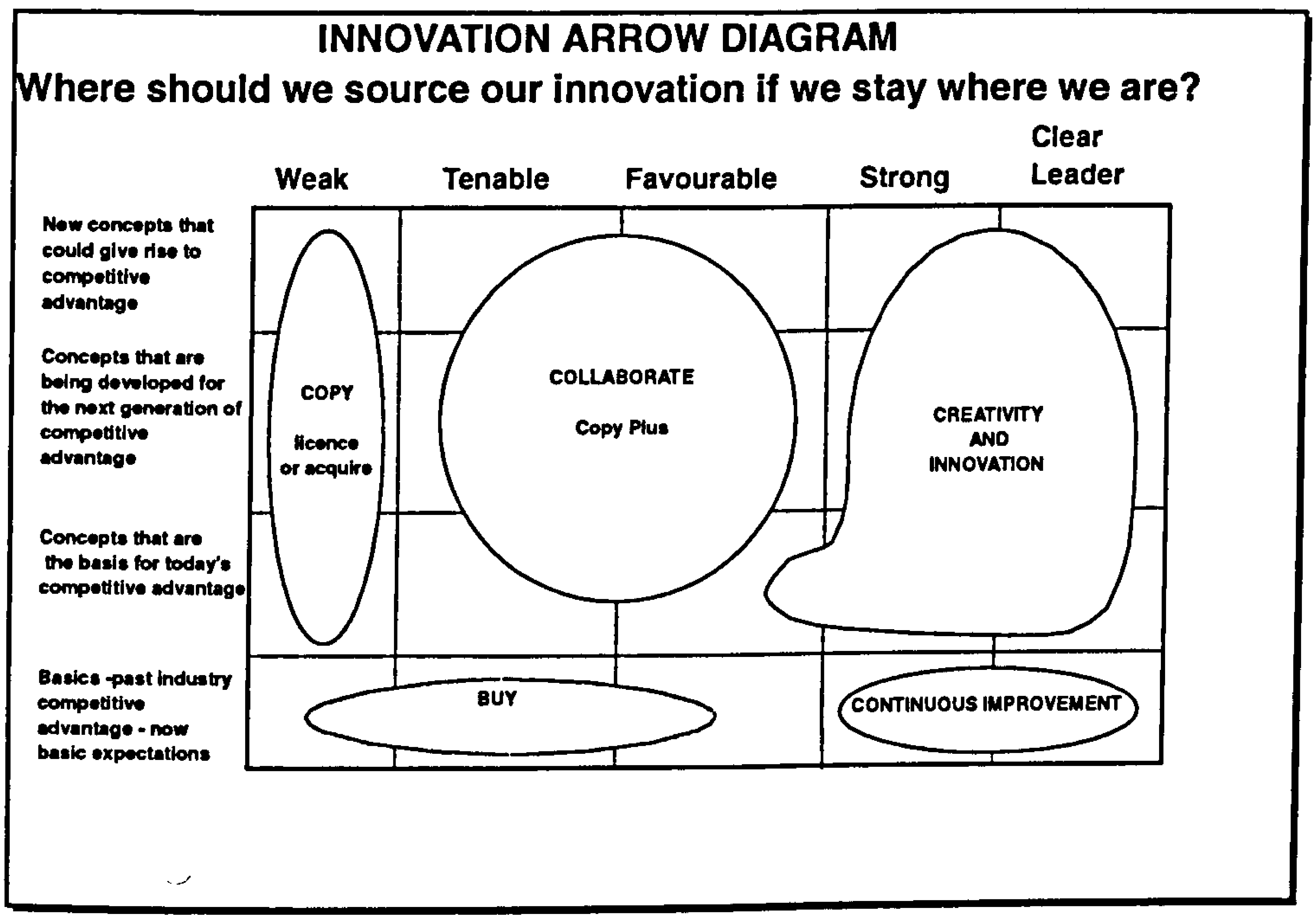

Figure 19 The basis of the innovation arrow diagram, modified from A.D. Little's technology management tool to aid understanding. This places future creativity needs to the top right of the chart. The left margin shows the maturity of the technology or capabilities that are vital for the organisation's success. The horizontal scale shows the organisations relative capability in its environment. The areas in the charts show the appropriate strategy for each position of the organisation's competitive technology position.

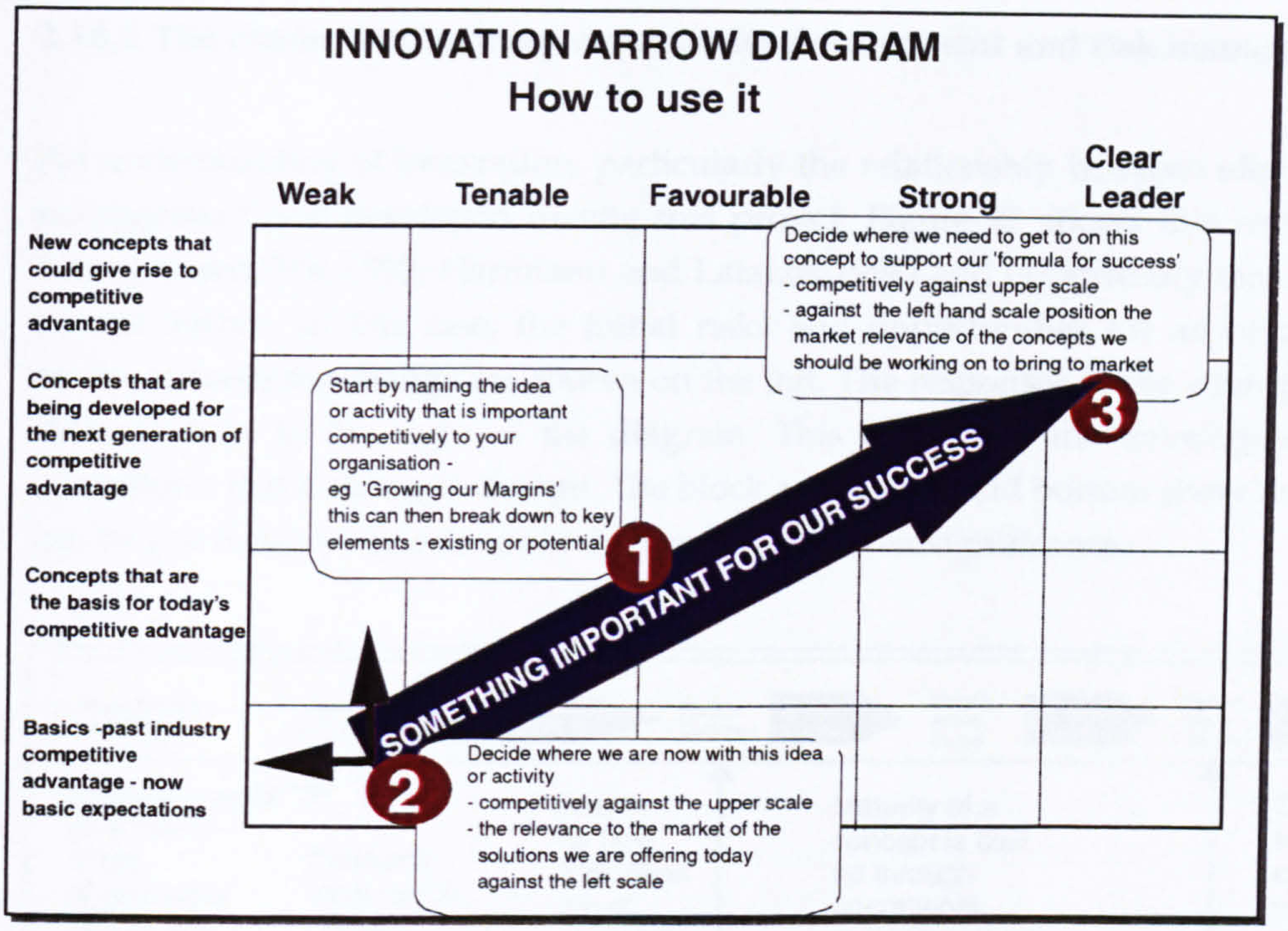

Figure 20 The second stage of the arrow chart. Each critical technology or capability for the organisation is mapped for its starting position and where it should be to meet the organisation's aspirations. Each arrow should be decomposed into its constituent capabilities to allow planning at lower hierarchical levels.

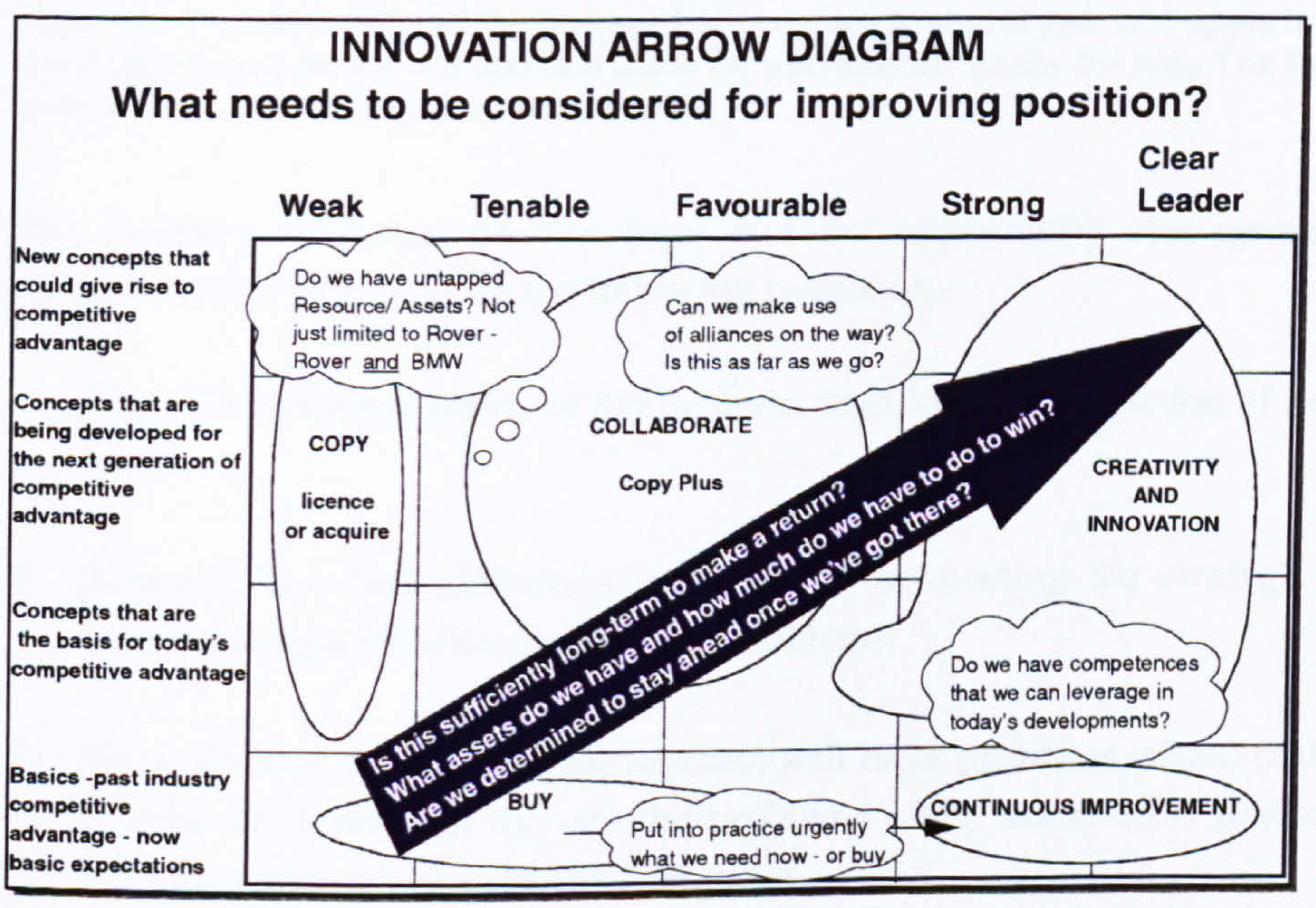

Figure 21 The testing and questioning of aspirations is critical to the deliverability of a plan. Shown are a number of considerations in the exercise.

2.10.2 The connection between opportunity development and risk management in innovation

An understanding of innovation, particularly the relationship between idea development and risk management was developed during this project. Figure 22 shows this relationship between risk management (Fox 1993; Hartmann and Latakos 1998) and opportunity management as developed by the author. In this case, the initial risks and opportunities for an organisation arising from strategic needs for change are shown on the left. The responses to the strategic need are developed through time to the right of the diagram. This ends with the development of a product that contributes to the strategic change. The block arrows top and bottom show the intervals where time can be lost between milestones in the process and their significance.

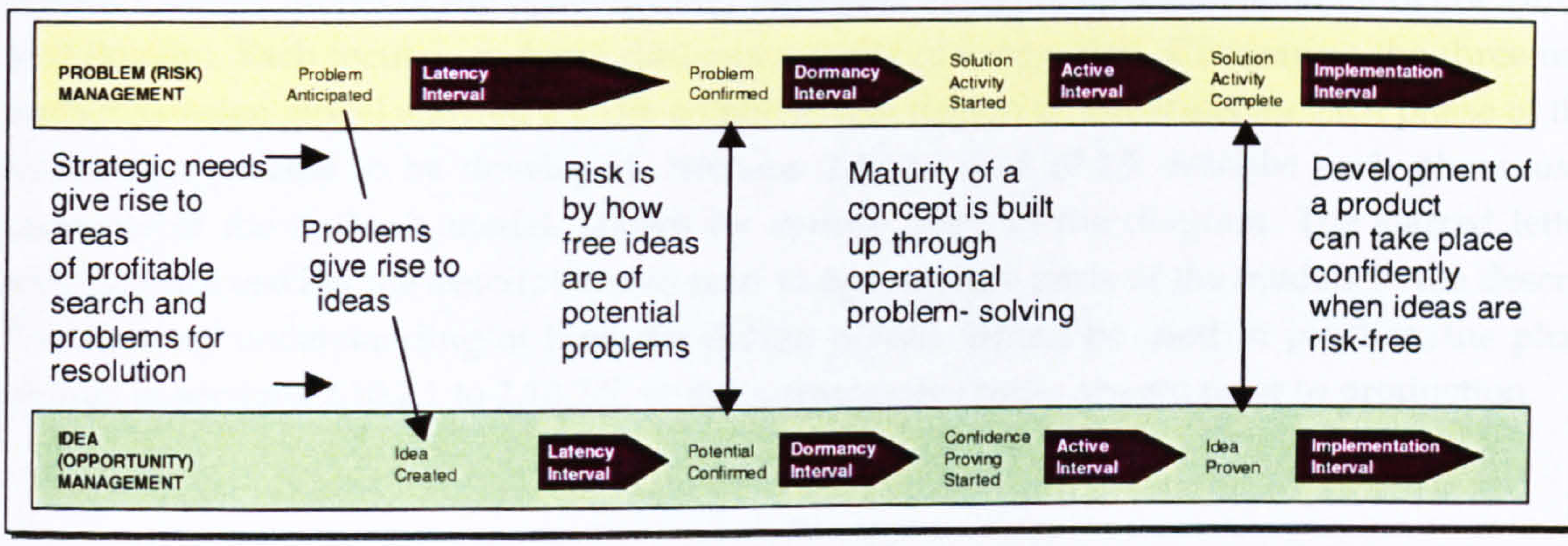

Figure 22 Demonstration of the linkage between processes for risk and opportunity management, with risks (problems) on the top line and ideas (opportunities) on the bottom. The linking thin arrows and text indicate the relationships between the two.

The problem resolution process (top) and the opportunity management process (bottom) are complementary and work in the following sequence: -

1. (Top). The strategic needs of the business lead to the anticipation of problems in meeting those needs.

2. (Bottom). The clear definition of problems in meeting the strategic needs gives rise to the creation of opportunities to solve the problems.

3. (Top). Each of the ideas (opportunities) will have problems (risks) that must be confirmed and defined. Only through this are the problems really understood to allow options to be chosen and maturation plans to be put into place.

4. (Bottom and top). The confidence in selected solutions can now be built up through operational problem solving.

5. (Bottom and top). When the opportunities are proven, they can be implemented with confidence.

A fuller comparison of different viewpoints of innovation is given in the relevant submission. One of the beneficial results of this comparison of innovation models was the clear visibility of a mechanism for innovation. As described above the innovation mechanism is one of a sequential cycle of problem (or target) setting, risk- (or gap-) analysis, solution-definition, and then target-setting for the next phase of design. This is repeated at deeper hierarchical levels of the organisation until the innovation is completely designed and ready to implement. A comparison of three models relevant to the early phases of business and product innovation is shown in figure 23. The upper model is that of the 'fuzzy front end' developed by Khurana and Rosenthal, the central model is the author's design model of the business, and the lower model is the innovation model of Tidd, Pavitt and Bessant. Each focuses on some different aspects of innovation. Comparing the three using the author's design model allowed a more complete description of the needs for each phase of the early innovation process to be developed. Sections 2.10.2.1 to 2.10.2.5 describe each phase using the template of the author's model, shown by vertical lines in the diagram. The starred letters and numbers are used in the descriptions to refer to appropriate parts of the models in the descriptions. To allow an understanding of how the design phases would be used in practice, the phases are named in sections 2.10.2.1 to 2.10.2.5, with representative times shown prior to production.

The comparison of innovation models

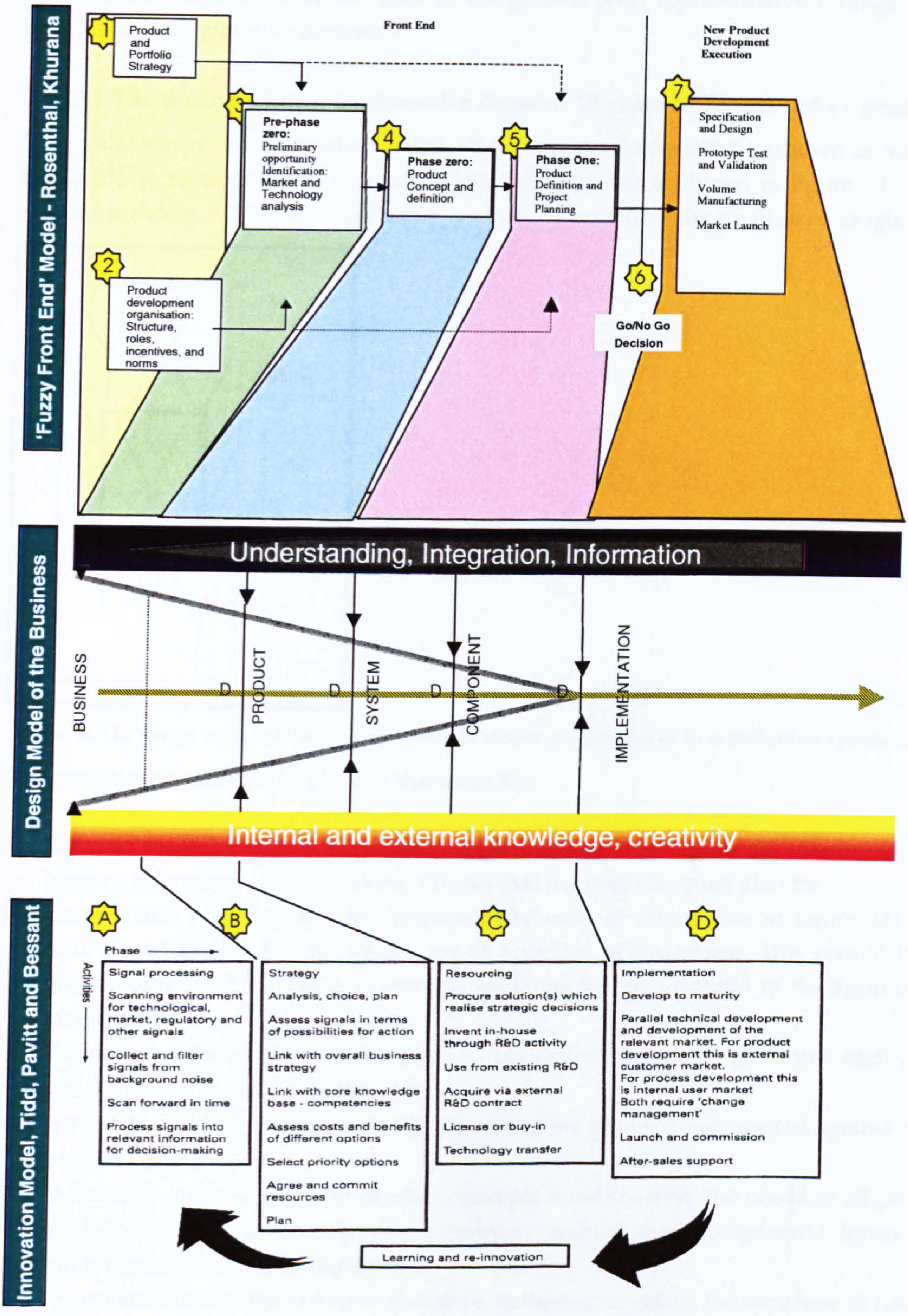

Figure 23 The comparison of innovation models: that of the 'fuzzy front end' (Rosenthal and Khurana, 1997), the design model of the business, and the innovation model of Tidd et al (1997). Note that the Design Model of the Business is presented horizontally, with time running left to right. The points shown as D in the middle process represent the decision points where all hierarchies must be in agreement.

The following sections describe each of the phases, with representative timings before product launch for the automotive domain: -

2.10.2.1 The Business Phase (Automotive domain; 10 years to 5 years before product launch)

The model shown is one product within the whole product portfolio (shown as star number 1 in figure 23). A representation of a whole product portfolio is shown in figure 24. The individual product is shown in the context of other products, bounded by the smallest rectangle.

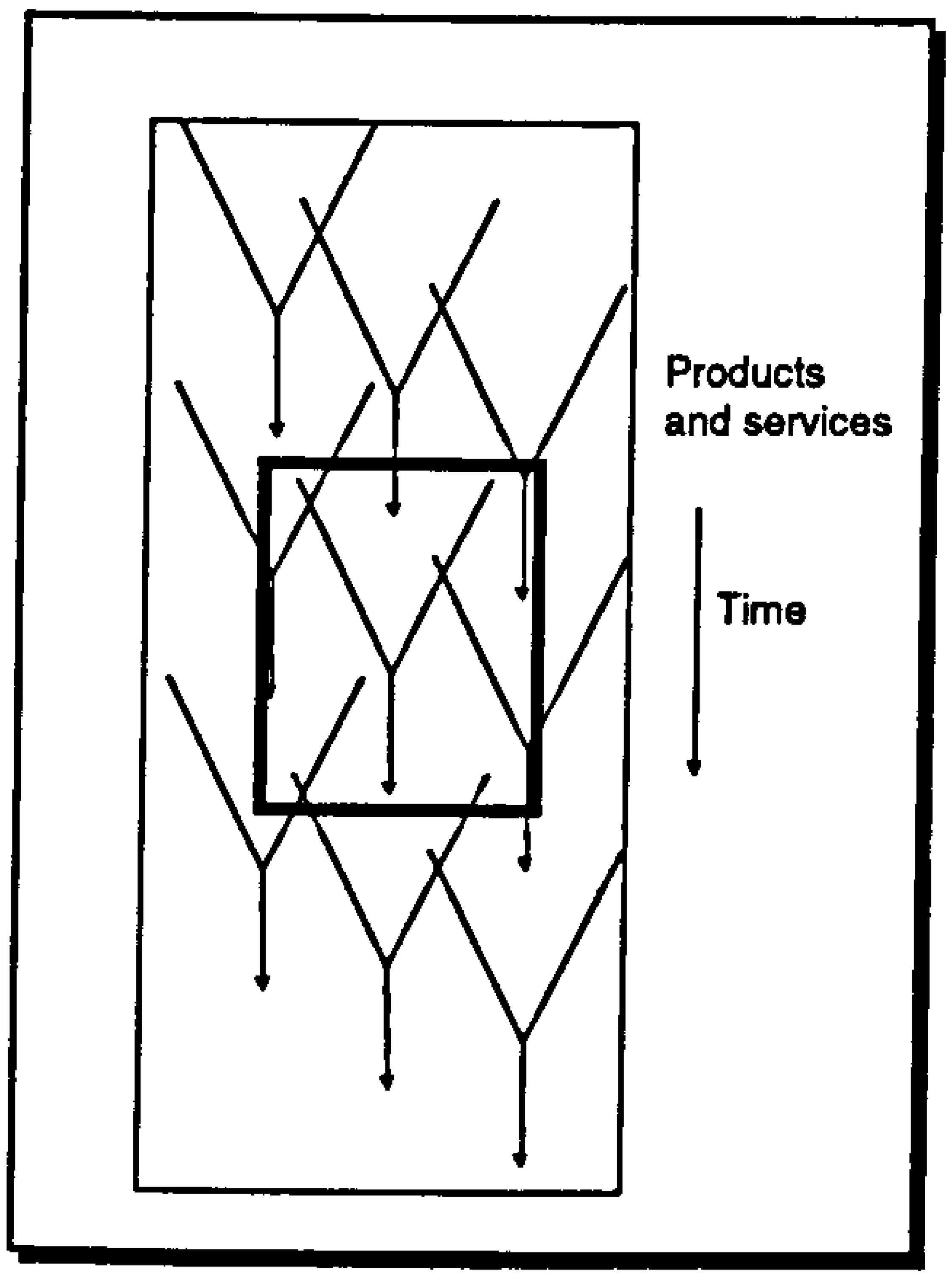

Figure 24 The design model of the product or service shown as a member of an organisation's portfolio

The activities that must take place at this stage are:

1. Scenario planning (signal processing, shown as star A in figure 23) identifying the range of market, technology and competitor futures that the portfolio must plan for.
2. The scenario planning activity (responsibility ends at dotted line in figure 23) provides the context and targets for the second set of activities in this phase. This should have separate responsibility and its role is to provide solutions for the portfolio to the appropriate level of maturity.
3. The needs of the whole portfolio must be understood to set the goals that each product must achieve for the organisation (Star 1).
4. The market and technology research responses are planned and started against the product's goal (star 3).
5. Technology and research and product concepts must consider the needs of all products in the portfolio, and the commonisation of strategies, technologies, components, future investments and processes (Star 1 and star B).
6. The organisation of the business should be optimised to reflect the structure of future products and processes (Star 2).
7. At the end of this phase, all technologies and concepts should have been proven in principle so that the business and customer targets will be met. Other innovations with shorter time scales

should have low risk alternatives available to allow fast-moving technologies to be integrated later.

2.10.2.2 Product Phase (Automotive; approximately 5 years to 40 months before launch)

This phase has a short (approximately 6 month) introductory phase, as in the latter stages of (star B), which allows an explicit assessment and focusing of the alternatives generated in the business phase, together with their risks and development needs. The outcomes of this assessment are the compatible alternatives for product, market and technology, and the predevelopment plans which resource the programme ready to meet the launch timing. As many options as are needed to ensure the future flexibility of the product against market changes should be commissioned. To keep these manageable, Pugh's concept selection process (Pugh, 1996) should be used to hybridise and choose from alternative routes.

The second part of this phase produces two outcomes:

- A product concept and explicit definition of the product, which is agreed by the business as being achievable (star 4). This must be committed at the highest level of the business as the end point of this phase so that everybody works to the same goals and values. Compatible systems targets must be available to allow the next phase to design immediately after commitment.

- A developed set of technologies and market capabilities that are capable of delivering the product concept within the quality, cost and time and resource requirements. All externally sourced technologies should be capable and understood to the same level as those that are internal to the organisation.

2.10.2.3 System and Component Phases (Automotive: approximately 40 months to 30 months before launch)

- From an initial set of consistent targets for the constituent systems for the product, systems must be designed and integrated to these targets so that the product requirements are met (star C). The technologies used are those available as technologically risk-free. Where fast moving technologies are involved, a low risk alternative should continue to be developed. Component targets and designs are developed during this phase.
- Where system designs are in conflict with the system targets, the effect on product targets should be minimised. A change to the strategic product target can only be sanctioned by the board of the organisation, who are the holders of the strategic product targets. This ensures that the product specification does not 'creep', as there will be a strong focus to minimise deviations from the strategic product targets.
- Agreement on the product targets must take place, with all components, processes and plans designed, and detailed performance specifications and interface targets in place and agreed. This represents the point at which an entire virtual product has a high level of confidence in its

solutions and the performance it will achieve for the business and the marketplace – at this point the business (the board of the business) can authorise commitment to development.

2.10.2.4 Implementation Phase (Automotive: 30 months to launch and beyond)

- The development and investment in the product, its manufacture and market development proceed to launch.
- The designs of the product are assembled and tested systematically initially at the component level, then assembling these to form subsystems. These are then tested before being assembled and tested to verify the systems level designs. Finally, the verified components, subsystems and systems can be assembled and the whole product design tested and verified against performance targets. The new knowledge gained where the operational results do not meet design expectations are installed in the knowledge base of the organisation.
- The product is continually verified for its expected performance in the market, and lessons learned absorbed systematically. From the lessons learned, and the flexibility available to the design, the product is upgraded to meet its goals. The brand and its appropriateness in the marketplace are also understood, and evolved, although at a slower pace than products.

2.10.2.5 The need for a motivation for the innovation process

A significant point identified in this work, and consistent with the findings of Engineering the Brand was the need for a motivator for the innovation process. This is the set of values that drives an organisation to find worthwhile problems in the environment, the solutions for which are beneficial for the success of the business. This point, and the basis for the early phases of the process, was taken forward to project 11.

2.10.3 Core competence development and the delivery of value to the marketplace

Figure 25 shows a conceptual model of skills in an enterprise (shown as points A through to E) and how they are delivered through design and development processes into the marketplace. The routes to delivery are tortuous, needing to be combined to form distinct capabilities, which are used to develop technologies (which could be product, process or service innovations). These technologies will only reach the marketplace if they are combined into a product of the business, and their benefits pass successfully through distribution, sales and service to the eventual customer.

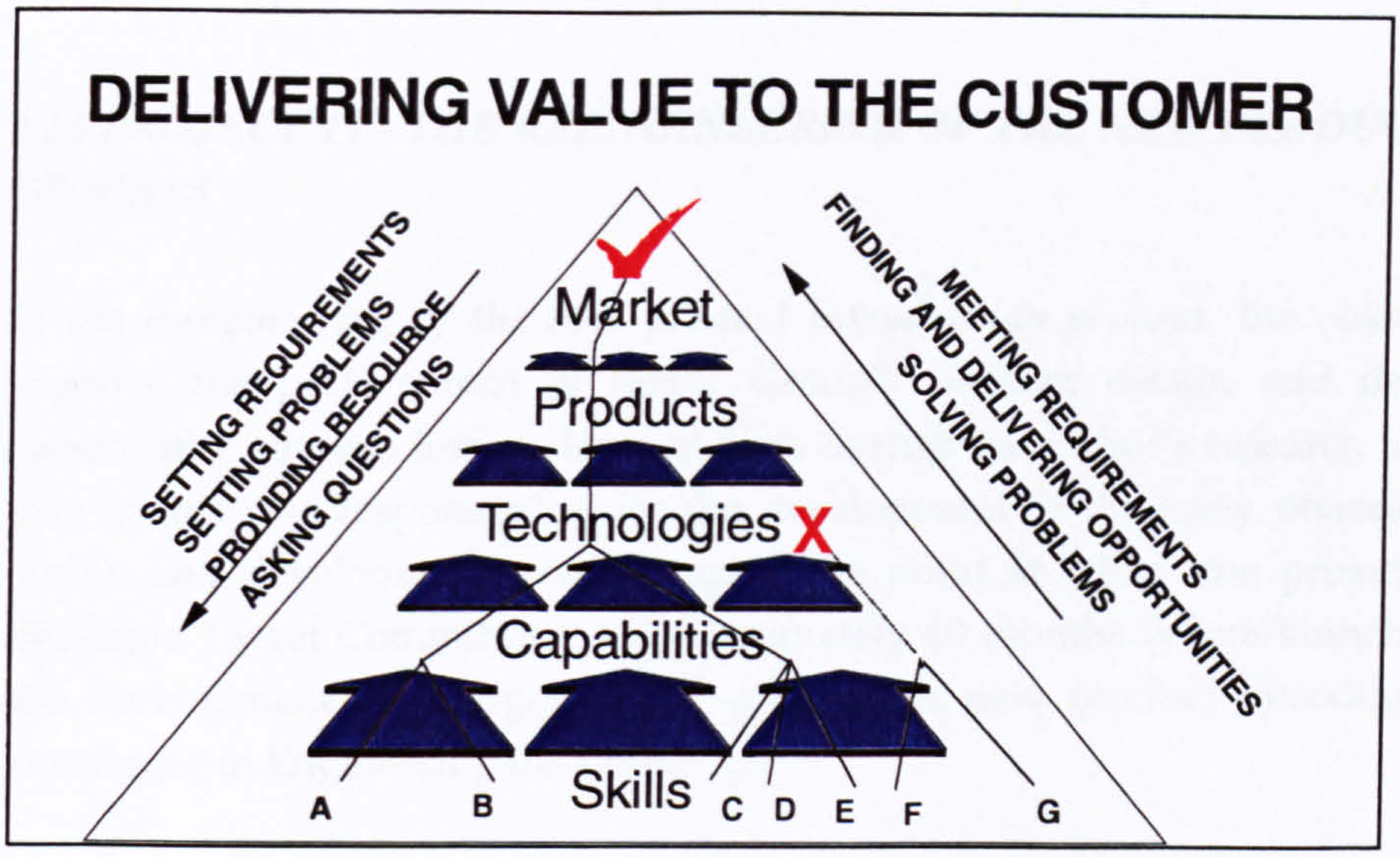

Figure 25 Hierarchy showing the delivery of value from skills to the marketplace.

Figure 26 shows the conditions that were found from internal investigations to be factors in successful transfer of skills to produce strong capabilities. Poor performance in these capabilities produced bottlenecks or even failure in the delivery of these qualities to the marketplace.

SUCCESS FACTORS INDICATIVE OF STRONG CAPABILITIES*

Leadership and Direction

- Strategic fit
- Clear goals and objectives
- Clear priorities
- Appropriate empowerment

Processes and Structures

- Customer focused targets
- Relevant objective measurement
- Working to the right process
- Effective problem anticipation and resolution
- Creating, developing and applying the right technology

People and Resources

- Development and application of expertise
- Training - focused and measured learning
- Having the right resources
- Capture and re-use of relevant knowledge (company and
- individual)
- Managing key people
- Clarity and communication of policy
- Common interest communication across groups

Developed from interviews and observations of excellent practice and key bottlenecks in the capability areas investigated.

Figure 26 Findings of best internal practice and bottlenecks for delivery of core competence values developed by the author.

2.11 PROJECT 11 - THE REENGINEERING OF THE NEW PRODUCT INTRODUCTION PROCESS

In the ***reengineering of the new product introduction process***, the objective was to permanently improve the performance of Rover Group's product design and development process. This opportunity allowed lessons learned from during the author's research to be applied. The author's part in this was responsibility for the development of the early phases (predevelopment) of the design and development process, up to the point at which the project targets were committed (Strategic Target Commitment - approximately 40 months before launch). An additional role was the development of a target setting process for new product introduction, due to the author's experience in Engineering the Brand.

The development of the reengineered process was interrupted in 1999 by the absorption of the Rover design and development process into the BMW design and development process, also undergoing reengineering, and then by the sale of Land Rover to Ford Motor Company in the year 2000. While the business was incorporated successively into two other automotive concerns, the author was involved in their early phase and target setting processes. Innovations were introduced into both environments, and the operational experience allowed confidence to be gained of the compatibility of the author's design model, and the concurrent engineering processes as applied in these businesses.

The innovations produced by the author in this phase of the work were: -

Internal Innovations

- A conceptual model of the earliest phases of the new product introduction process, developed with a senior group in the Rover business. This takes into account the findings by the author that the brand should be the motivator for the innovation process. This diagram is shown in figure 26.
- A rationale and principles for target setting in the new product development process, consistent with the design model of the business.
- A detailed model, workflow and organisational requirements for the early phases of new product introduction, from the time a product is introduced to the portfolio, up to the commitment of strategic targets for the project (Approximately 40 months before launch)
- The operational development and implementation of a risk management phase (64 months to 58 months before launch) for a product programme.

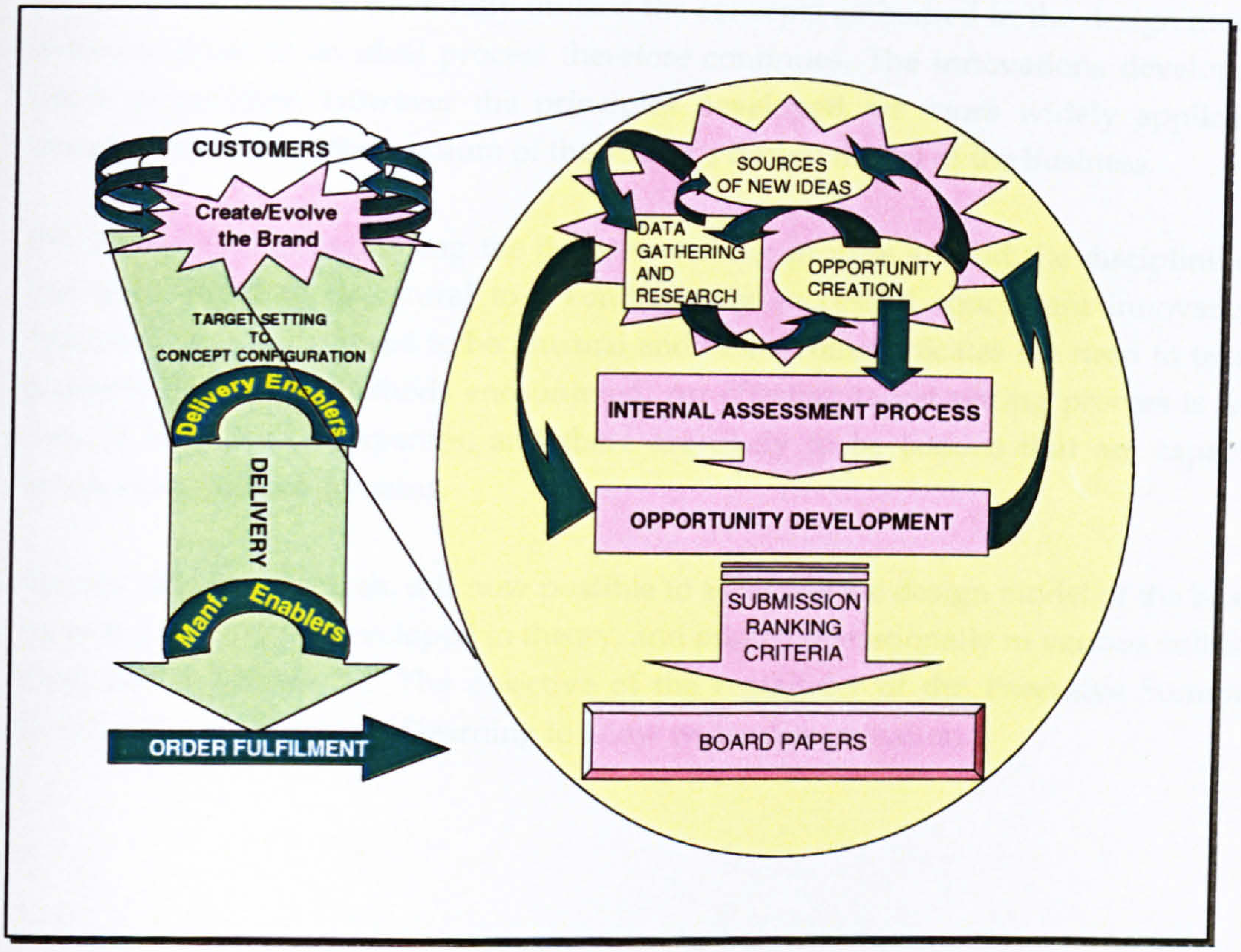

Figure 27 Early conceptual model of the re-engineered new product introduction process with the 'create/evolve the brand' process further defined.

Successfully applied within the BMW design and development process

- (Also a generally-applicable innovation) A model of business process innovation.
- (Also a generally-applicable innovation) An effective method for rapidly achieving target agreement.
- (Also generally-applicable) Improvements to a target agreement process and management information system to avoid dysfunctional decision-making.

The relevance of modularisation to the author's model was developed through BMW's processes, which also has wider application with the design model to other types of business.

Successfully applied by the author within the Ford design and development process (at Land Rover)

- (Also externally applicable) A governance process for the management of a product portfolio, applied within the business.

These organisations have distinctive decision-making cultures and products, but have evolved towards the principles set out in the author's design model of the business. However, neither business was found to have fully utilised the concepts embodied in the design model. The work of drawing closer to an ideal process therefore continues. The innovations developed are, in many cases, proprietary. However the principles developed are more widely applicable and can be demonstrated using the medium of the author's design model of the business.

The importance of organising the decision-making process around the discipline of target setting has been found to be central to a continuously successful concurrent innovation process. The approach taken is believed to be unusual and better communicates the need to take this route in a business than other methods encountered. An effective target setting process is seen to be at the core of long-lived companies, and there are likely to be lessons that are capable of beneficial application in other domains.

To conclude this research, it is now possible to assemble the design model of the business using the tools and techniques developed in theory, and piloted operationally in various cultures. This will be described in section 3.2. The objective of the remainder of the Executive Summary is to draw together the main points of learning to allow wider dissemination.

3. AN OVERVIEW OF THE DESIGN MODEL OF THE BUSINESS

This chapter develops a deeper knowledge of the context and features of the 'Design Model of the Business', introduced in chapter 2. The first section shows the level of knowledge available to the author when the initial model was developed. Section 3.2 then provides a 'geography lesson' of the model that allows further exploration in later chapters. Academic learning has moved swiftly in related fields since the model was invented, and the model must be seen in the light of recent work in the area, reported in overview in section 3.3 and in detail in the appendix. This review against the wider span of literature is for three reasons

- To show where the design model of the business is innovative.
- To inform the reader of the breadth of literature against which the design model can be used to provide continuing insights.
- To provide a background against which further specific topics can be developed in later chapters.

3.1 SOURCES FROM WHICH THE MODEL WAS DEVELOPED

The model of the design process was developed from an original concept by the author. However, external knowledge influenced the model through its evolution. The following gives an overview of the state of knowledge from which the model is drawn.

At the beginning of the research, the sources used to inform the development of the model came from the areas of technology strategy, strategic planning and product design and development. The benefits of scenario planning to maintain flexibility against uncertain futures (Millet 1991) were known to the author through training with the Battelle consultancy of Columbus, Ohio. Quality function deployment (Hauser and Clausing 1988) (decomposition of needs to functions) had been advocated in the engineering function of the author's company but had few successes due to its intensity and lack of engagement with senior levels of the business. The design funnel (Wheelwright and Clark 1992) was already advocated as a visualisation of the design process, but was seen primarily as a screening device for alternative ideas. Methods of customer understanding (Flores 1993) such as the Kano model (Kano, 1984), and utility functions (Golob et al 1993) were understood from quality techniques and external research done on meeting environmental legislation. However, these functions were not normally used as marketing tools in the author's business. Useful benchmarking of the new product introduction process had been carried out by the author with Unilever, with valuable insights gained in customer understanding techniques. Product systems decomposition and systems engineering (Sawyer, 1992) was being discussed in the automotive industry but was not yet applied in the author's business.

The objective of the work was to start the development of a model from a thoroughly understood foundation rather than following established formulae gained from the observation of existing models of organisational innovation. The operational models of design and development such as those of Cooper (1990, 1994) arise from observations on the development of products, and not from the integrated business. So, while authors such as Wheelwright and Clarke (1992), Smith and Reinertsen (1991, 1997) were studied, their most integrated structures were set to one side to avoid the unconscious adoption of the embedded concepts that they held. Similarly, much work derived from the study of organisations operating in these structures could not be used in the design model approach. Also, commentators suggest that much work on technology strategy, business strategy (Porter 1980, 1998) and design and development did not form an integrated body of work, and that some aspects of strategy are not recognised by all researchers (Tidd et al. 1997b).

Instead, the primary driver to segmenting the design process into appropriate hierarchies came from rules derived from the author's investigation of responses to external challenges to the business. These are reported in project number 3. The decision hierarchies (business, product, system and component in the model) are broad in their application, but dependent in their composition on the structure of product or process that the enterprise delivers. These products will tend to structure the functional organisation and detailed design process appropriately.

Of more value to the further development of the design model were operational methods where confidence could be gained in their application and effects. The approach of Pugh (Pugh 1991) was appreciated for the transparency of his logic in developing the 'Total Design' approach, and confidence gained in his concept selection method. The work of Rouse (Rouse, 1991) in human-centred design provided valuable insights into design decisions for stakeholders and targets. The application of the IT tools embodying these concepts showed both their promise and their Achilles' heel – the reliance on a reliable decision-making culture. Rouse's needs-beliefs-perceptions framework (Rouse, 1993) helped in identifying the problems. Argyris' (1993) approach was found valuable for the social science framework for study – and eventually a correlation was found between the organisation's and Argyris' reported decision-making behaviours.

As the design model developed, further areas of learning became visible as being relevant to the model – particularly more recent interpretations of concurrent engineering, modularity, resource-based competition and the complexity/cybernetics sciences. Interest in these areas has grown greatly since the design model was first assembled. Their impact and consolidation with the design model is described in section 3.3, after an overview of the model.

The aim of the research has been to understand the problems with operating a design process for a large, complex engineering business. While the innovations were applied to the automotive industry, the lessons learned will be shown to be more generally valid. This will allow the innovations to be translated to other sectors where more formal design processes covering the business could be beneficial.

3.2 THE DESIGN MODEL - A REPRESENTATION OF THE WHOLE BUSINESS PROCESS

A model of the design process (Figure 28) has been assembled to relate together the individual attributes found to be important for an organisation in responding successfully to strategic challenges. The identification of these attributes is covered in various submissions to the portfolio (Projects 3, 4, 6 and 10). The main features of the design model are described in section 3.2.1. As the design model of the business covers the whole organisation and its alliances, it becomes a means of visualising the whole organism. An overview of how the model is used to represent the whole organism is described in section 3.2.2. Finally, section 3.2.3 is used to discuss some of the applications of the design model of the business.

3.2.1 Major features of the design model of the business

Figure 28 shows the design model and points to a number of the features that will be described in this section.

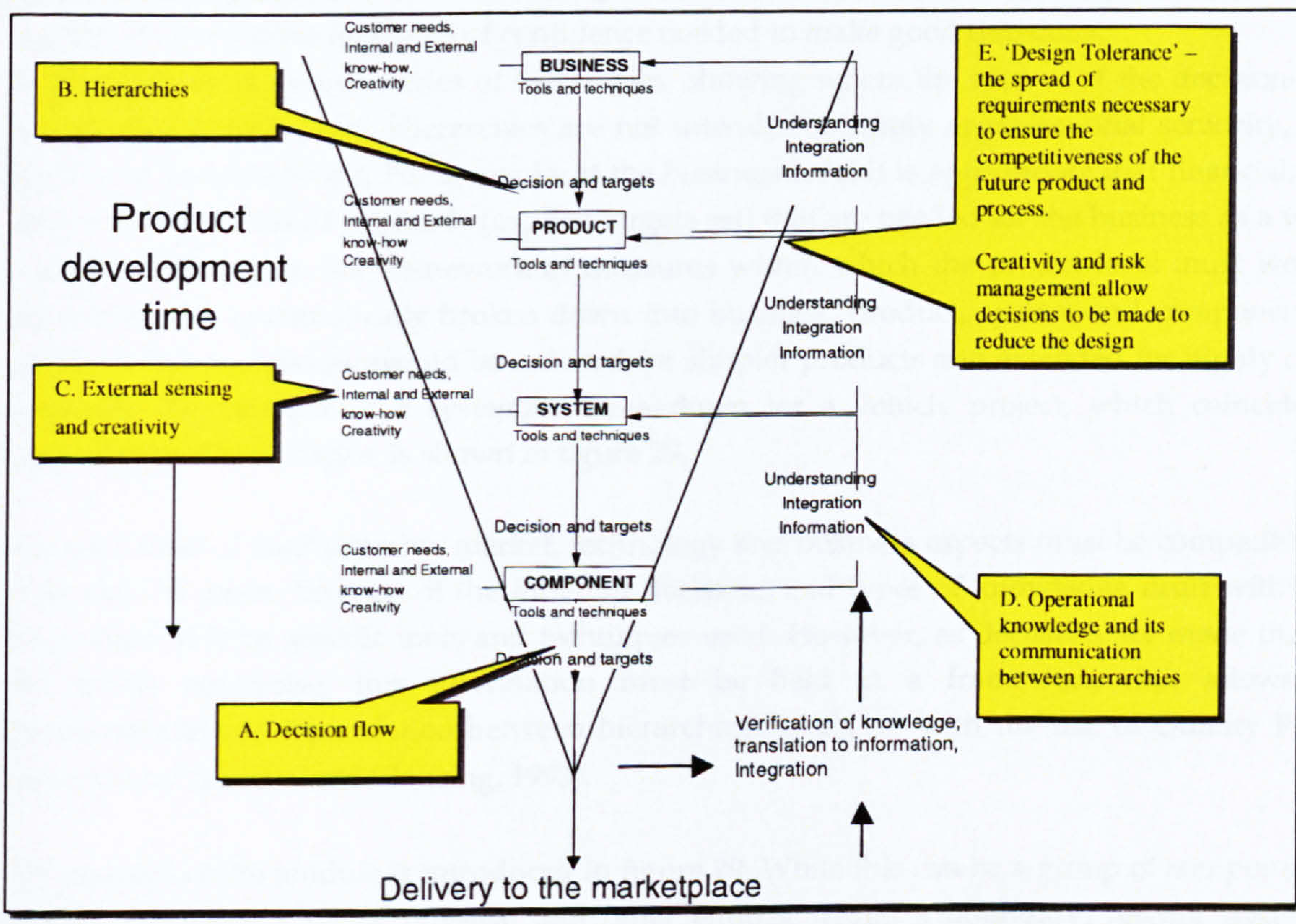

Figure 28 Model of the design process

The model shows the design of a response by the organisation to external and internal needs. This starts at the top with the understanding of why the organisation needs to change its performance. The response to this is through the design, development and launch of a new product or process (the term product will be used to represent both product and process from this point). The focus on products is deliberate in the case of this model, as in most organisations, the health of the organisation is affected primarily by products provided for the marketplace, and the quality and efficiency of the processes used to deliver them. As the design progresses through time (shown vertically downwards in this model), the future market for the product becomes better understood, as do the solutions used to deliver the product. The solutions become more detailed, until at the end of design funnel, the whole product or process is understood in every necessary detail. The development of the product into production and introduction to the market now begins, with the business investment necessary.

While this general overview is true for any new product introduction, the integration of the following elements, if properly applied, produce the right product for the future of the business, meeting future market needs, on time, and to competitive cost.

- **A. Decision Flow.** A central vertical line, representing the decision-making flow affecting the product. Formal irrevocable decisions are made at particular points through the process. These reduce in scope, but increase in depth as the project progresses. Good decision-making also requires an appropriate decision-making culture. This defines what is important and sets the quality of information and level of confidence needed to make good decisions.

B. Hierarchies. A vertical series of hierarchies, showing where the control of the decision-making process lies at each level. Hierarchies are not intended to imply organisational seniority, but the nesting of decision levels. For example, at the business level it is appropriate that financial, market and technical decisions are made (explicit targets set) that are needed for the business as a whole to succeed. This is then the framework of measures within which the project level must work. The hierarchies are systematically broken down into business, product, system and component levels although this complexity would be reduced for simpler products and extended for highly complex products. An example of a systematic breakdown for a vehicle project, which coincides with organisational boundaries, is shown in figure 29.

For each level of the hierarchy, market, technology and business aspects must be compatible when a decision is made. Because of the different decisions and types of knowledge dealt with at each level, there will be specific tools and techniques used. However, as decisions are made that affect the whole enterprise, this information must be held in a framework that allows ready communication and translation between hierarchical levels, as with the use of Quality Function Deployment (Hauser and Clausing, 1993).

The concept of the module is introduced in figure 29. While this can be a group of components, the module describes a set of physical and other entities within a boundary, having well-defined interfaces with the rest of the design. As used in figure 29, it represents a managed team that is responsible for meeting the financial, geometric, functional, physical, data and informational targets of a well-defined section of the product. The separation of responsibilities of a product in this way allows work to be carried out within these boundaries with reduced levels of interaction and waiting across teams (Suh 1990). Modularity underlies progress in concurrent engineering and was identified as an essential complementary for the successful operation of the author's design model (project 3, Design Process Study, Appendix 2). The implications of modularity will be discussed further in section 4.4.

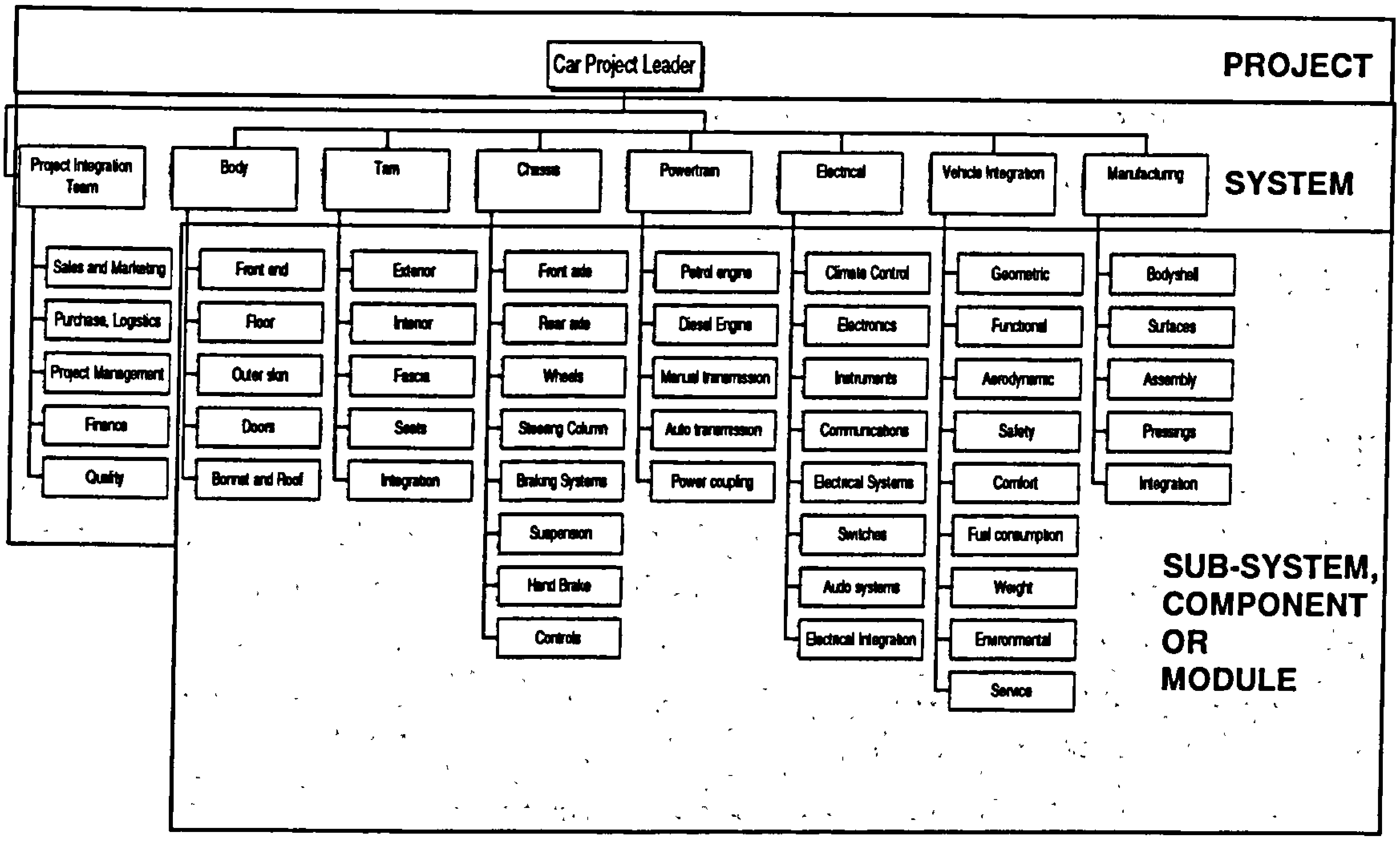

Figure 29 Overview of the relationship between project, system and component hierarchical levels in vehicle design. Shown is the structure of a vehicle project team, which allow the physical and functional properties of a vehicle, its cost, construction and lifetime performance to be managed.

- **C. External Sensing and Creativity.** The sensing of the outside world, with customers, competitors and developments in technology as they affect each of the levels is essential to maintain a true sense of the organisation's position against threats and possible opportunities. Each level will have defined roles, responsibilities and skills in the hierarchy. This implies that each level of the hierarchy has a unique knowledge of the outside world and its relationship with their knowledge and decisions. Creativity arises from the tension between perceived external need and opportunities against operational capabilities. However, creativity without a strong connection to the true needs of the business and its co-ordination with other parts of the organisation will lead to failed or ineffective innovation. Hence there is a need to communicate the needs for creativity and assess ideas in the formal decision process.

- **D. Operational Knowledge and its communication between hierarchies.** Each hierarchical level, within its own sphere of responsibility, must understand its operational capability, the external world and opportunities open to the business. The information needs to be integrated and represented (codified) to communicate the capabilities, opportunities and constraints of that part of the overall system. The essential aspects needed to store and represent operational knowledge are shown in figure 30:

- Parametric information, which sets out the performance and characteristics of the system in a way that initial possibilities for a product may be quickly explored by combining its constituent systems.
- Performance measures set against competitive systems and customer needs. This provides a benchmark against which the system should be improved or replaced.
- A detailed design guide obtained from operational information, which allows confident development and implementation to proceed.

The information is used in decision-making, to gain confidence of capability, to identify risks for amelioration and to provide opportunities for exploration. The information is that which is useful to the decision-making process of that level of the hierarchy and those above it. This is the experiential learning base of the business, which must be continually challenged and improved to meet the needs of the future environment, both by incremental improvement (kaizen) and by strategic challenges. The provision of constraint and opportunity information for decision making in a higher level of the hierarchy can be developed through explicit codified information, or through the direct involvement of fact-holders. To identify risks, constraints and opportunities, it is necessary for each level to be represented in decision-making. Where this representation can be done adequately through the use of already-set down operational knowledge, the benefits in terms of development speed and investment can be highly significant. The scheme is shown in figure 31.

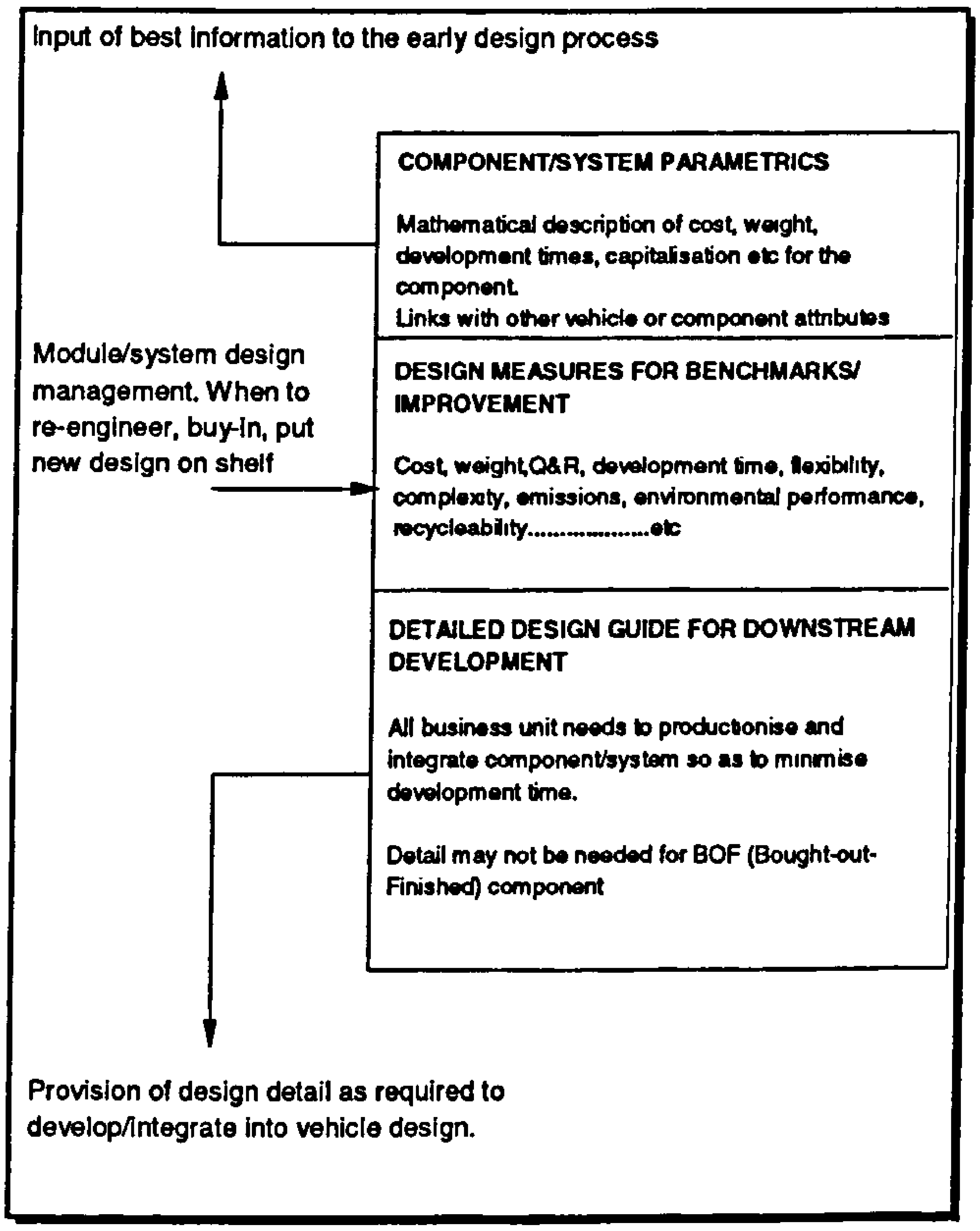

Figure 30 The codified knowledge for the system or module needed to allow information to be transferred for decision-making between hierarchical levels

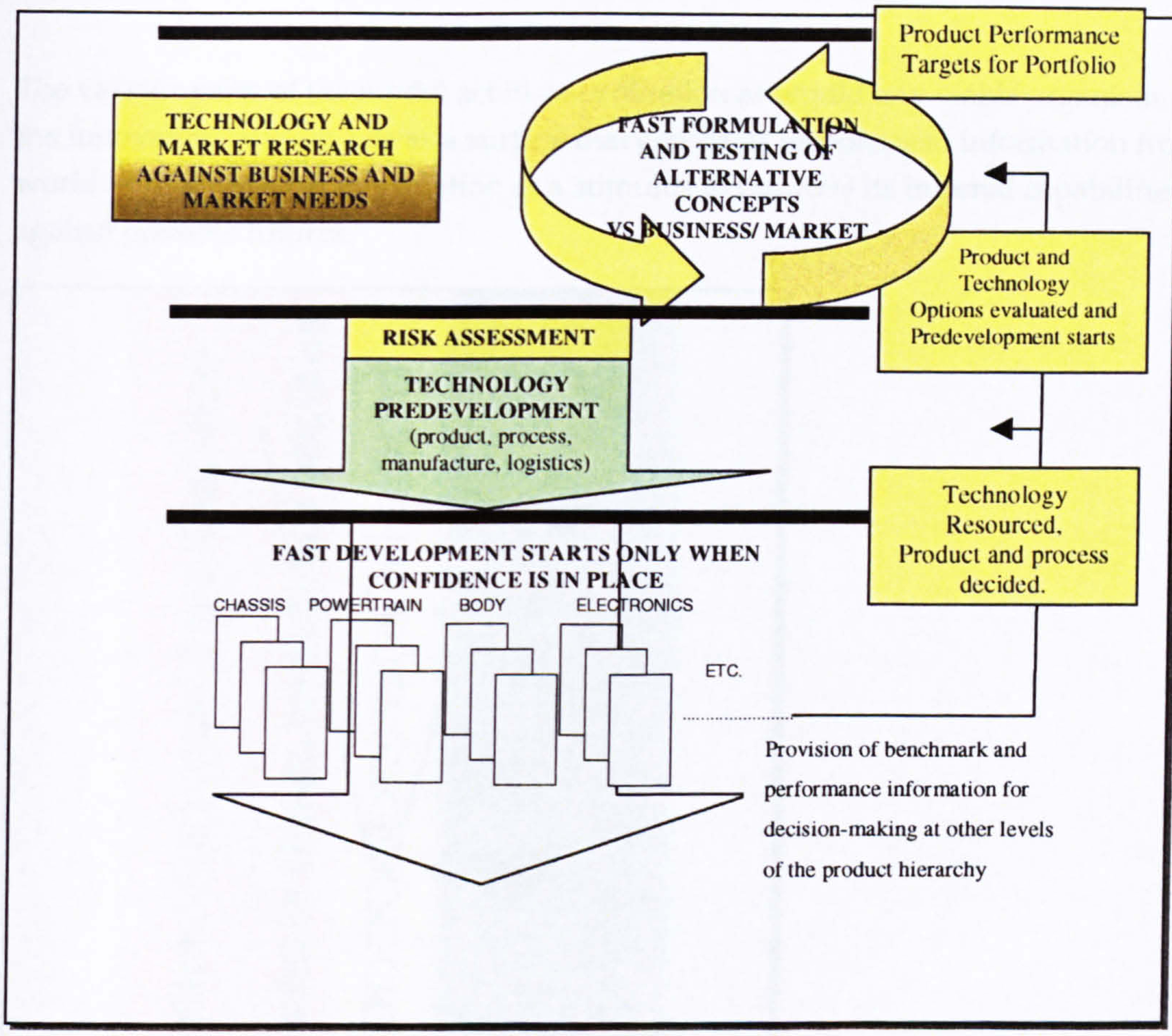

Figure 31 General scheme for separating technology development from product development to give faster product development. Aiming to achieve modular products can give faster development with investment shared over many products.

- **E. The design tolerance of decisions**, represented by a funnel, shows that the scope of possible solutions is broad at the business level of decision making, and progressively narrows as

1. The competitive future is better understood, for requirements are more closely defined
2. Alternative market, technology and business possibilities are explored, hybridised and selected through the hierarchical levels.

No iteration is shown between decision levels, which is not necessary if the funnel explicitly contains the 'set' of potential solutions from which market, technology and business opportunities and threats are satisfied. In overview, the design process need never abandon or delay a business need, so long as the constraints of the resources of the business are respected.

3.2.2 The design model of the business as a representation of the whole organism

This model differs from models of the product introduction process, as it covers both the business as a whole and the knowledge of the enterprise in depth. A symbolic description of the coverage of the model has been developed and described in section 2.6.

The various parts of the model act in co-ordination as would any viable organism. Figure 31 shows the innovation process acts as a surface that generates responses to information from the external world. It uses external information as a stimulus to improve its internal capabilities for survival against possible futures.

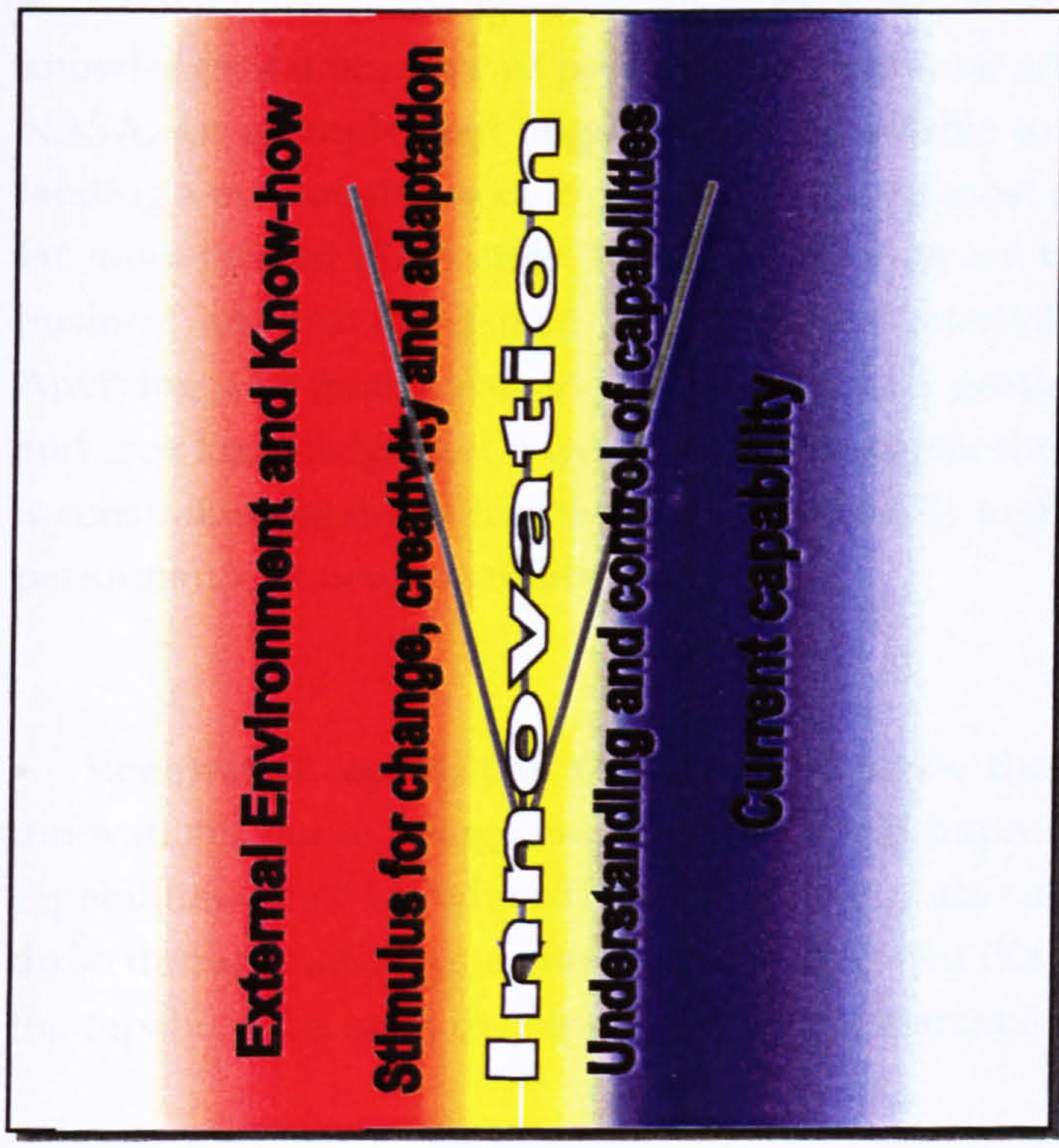

Figure 32 Integrated view of the design model as an innovation process

The left-hand side of the model represents the sensing of the external world and the assimilation of external know-how. The core of the model is the ***will*** of the organisation: that is, the decisions it makes to survive and prosper against external influences, within a framework of values that influence decision-making. These decisions represent the drivers for innovation across the business, the product, systems and components. It is argued that all change that is tangible to the outside world is co-ordinated through a business's products and services, and so the core innovation line is what brings together all parts of the enterprise. The interior of the organisation is on the right-hand side and represents current capability, and it is this that represents the competencies, capabilities and constraints of the business.

These entities are brought together by the enterprise in the following way:

- **Self-image of the organisation**. The enterprise has an image of itself and values that form its identity and decision-making culture. This is the 'engine' that processes information against values and constraints to arrive at decisions which commit its resources.

- **Knowledge of the outside world** can be sensed at the context of each level. It is the continuing preservation of the enterprise and the growth of its influence in the perceived competitive future that provides the stimulus for change. This drives innovation – change in the capabilities in the organisation that preserve the entity or extend its influence (DeGeus 1997).

- **Constraints.** If change were unconstrained, then the organisation could readily absorb new knowledge and improve its performance to counter any threat or achieve any desired performance. NASA, for example, had huge resources available to it when President Kennedy committed it to landing a man on the moon by the year 1970. In most organisations, the resources available to it are far more limited (Reinertsen 1997). These limits are the experiential and operational assets of the business, and that that can be drawn from the external world with the time and resources available. Anything new entails risk and uncertainty to a greater or lesser degree. It is this body of explicit and tacit knowledge that must be engaged against the innovation process, firstly to reveal where it is constrained against a future need, and secondly to put learning into place that brings in enhanced performance or new capability.

- **Renewal of capabilities.** Organisations renew their capabilities and performance through new innovations, but to a large extent preserve and improve existing, already introduced products and capabilities. Once introduced, these operations also must respond to external challenges and may do so through radical or continuous improvement (Kaizen). At some point, without radical change, the capability becomes uncompetitive for the market it serves.

- **Alliances with other organisations.** For the organisation to be successful for an extended lifetime requires that it has all the capabilities needed to survive and prosper in its competitive niche. Some of these qualities are differentiating and unique, and the organisation will spend significant resources to maintain this competitive edge. For it to evolve all its own unique capabilities, even those that are basic requirements across its competitors, calls for an expenditure of resource that is inefficient and unlikely to sustain short term viability. Hence in the biological world, there is much evidence of symbiotic relationships with other organisms and the sharing of DNA. The human being, for example, has energy providers at the cellular level (mitochondria) that are derived from bacterial DNA, and shares higher basic structures such as organs and limbs with other members of the animal kingdom (Capra 1997). The business analogues at different hierarchical levels of the organisation were examined in project 4 (The application of a design model to the automotive industry).

3.2.3 Applications of the design model of the business

The model described has a number of qualities that make it useful in thinking about businesses and organisations more generally. Firstly, nothing is left out of the model, so far as an individual product or service is concerned. Resources, assets, information, decision-making and operations are included and the relationships between them shown. There is a boundary to the organisation, forming a membrane through which information, materials and individuals pass. It is therefore classed as an open system, where it is influenced by, and itself influences the outside world. Further insight can also be gained by deeper examination of parts of the model.

Two of its uses are described here to show some applications in the real world. The first is to use the model as a diagnostic tool. Figure 33 shows some of the dysfunctions possible within a business that may be brought to light using the model.

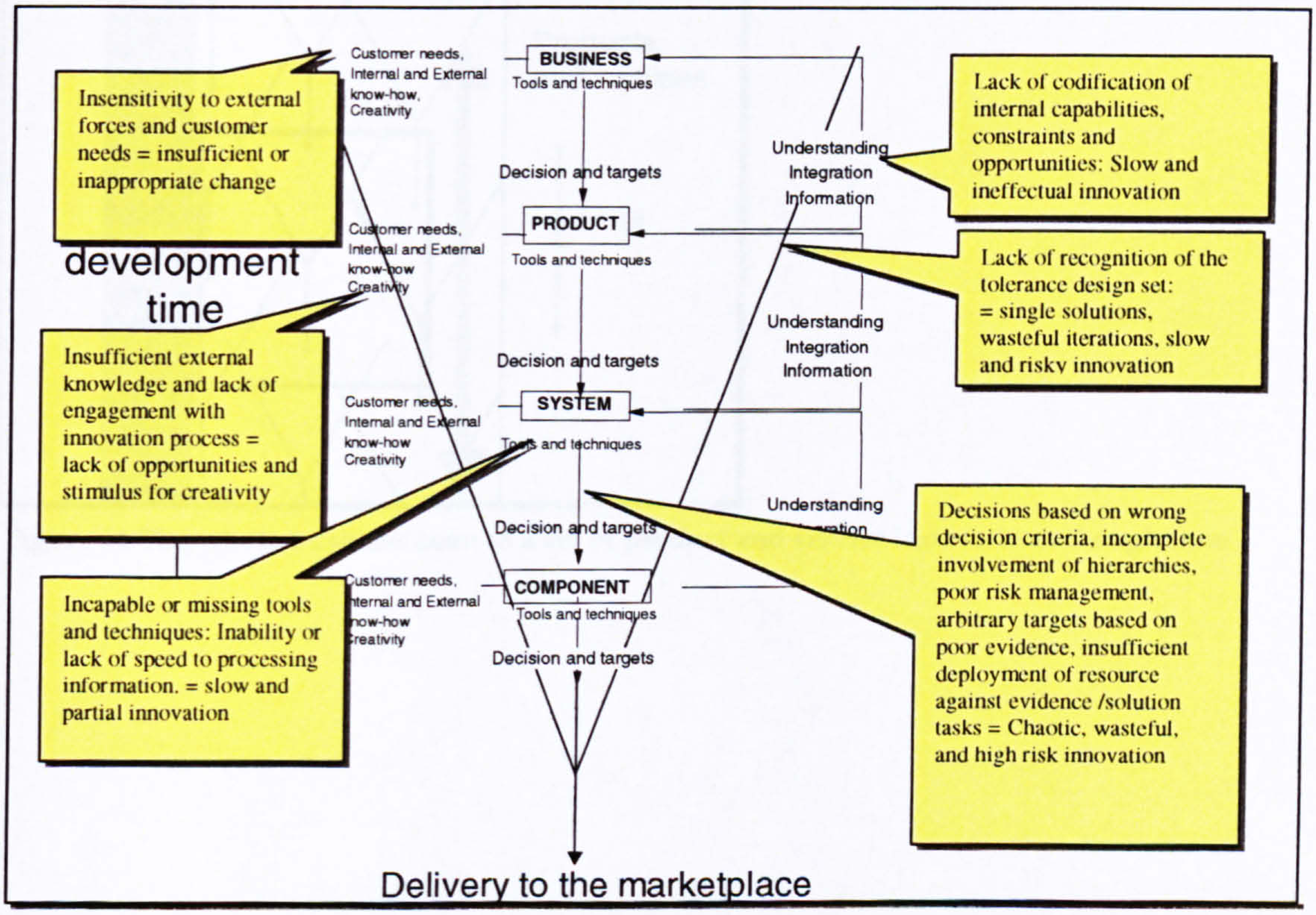

Figure 33 Potential dysfunctions of a business that can be identified by the model

Another use for the model is to support wider thinking about the business. In a complex business, there is often more than one product and many entities in the decomposition of the system. In fact, the model represents simply an interrelated network of entities that together form the whole business. However, seen from the perspective of the whole business, many products may be running in the business simultaneously. This can be represented as in figure 34, showing many simultaneous product developments, their activities and resource requirements progressing through time. It can be seen that other measures for the health of the business are needed, distinct, but linked to each project: Overall investment of the business through time, resource availability through time, coverage of market, and overall profitability amongst others. A grey band is shown at the left of the diagram. This shows the existence of a partnership enterprise, where a partner integrates fully with the organisation at the strategic, product and system and component level on one product line. Various types of partnership are possible, which are explored in project number 4. Specific aspects of the model will be developed in chapter 4 and 5, while section 3.3 sets the design model of the business in a wider framework of literature.

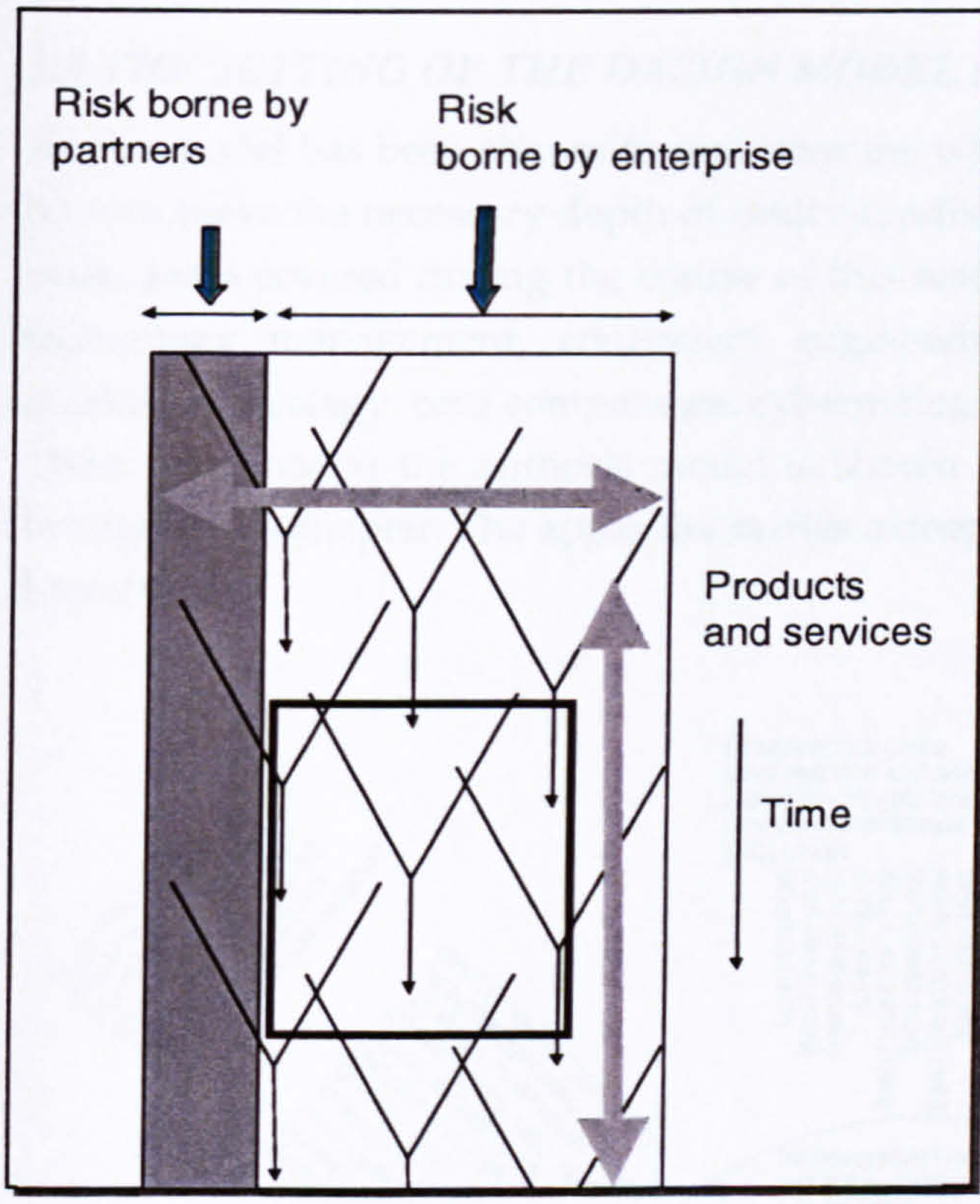

Figure 34 The whole business seen as a set of product and service innovations though time

3.3 THE SETTING OF THE DESIGN MODEL IN LITERATURE

As the model has been shown to represent the whole business, many disciplines have been drawn on to achieve the necessary depth of understanding and translation to operational competence. The main areas covered during the course of this research have been strategic planning, research and technology management, concurrent engineering, innovation strategy, quality management, marketing strategy, core competence, cybernetics, complexity and competence based management. Their relevance to the author's model is shown diagrammatically in figure 34, and is discussed briefly in this chapter. The appendix carries a deeper review of how the overall model relates to the literature.

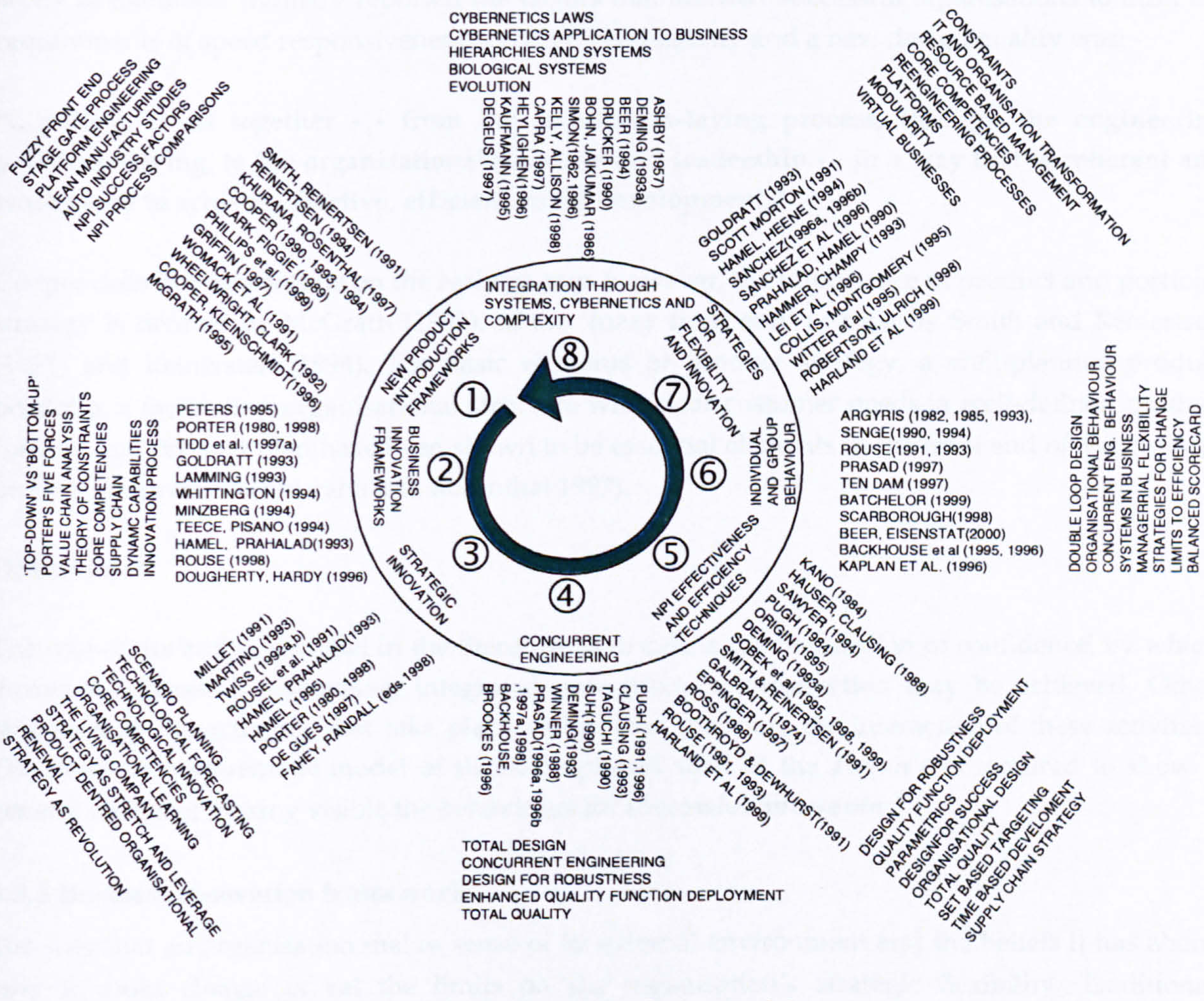

Figure 35 Individuals and their literature relevant to the design model

The relevant literature will be discussed in overview from business benchmarking and goals, anticlockwise around the inner circle in figure 35. The parts of the circle are discussed sequentially in sections 3.3.1 to 3.3.8 in the numerical order shown on the inner circle.

3.3.1 New product introduction frameworks

The stage-gate models of Cooper (1990, 1993, 1994) have been instrumental to the improvement in design and development processes since the late 1980s. These have provided steps and a common system of benchmarking that could be used across industries. There is some correlation between successful new products and the use of a stage gate process (Griffin, 1997). However, the key factor correlating with product development success is a high quality, rigorous new product process. This is characterised as emphasising up-front homework, tough go/no go decision points, sharp early product definition, quality of execution and flexibility, a clearly defined new product strategy and adequate resources and time (Cooper and Kleinschmidt, 1996). Clark and Figgie (1989) in their study of the motor industry reported the factors that allowed successful organisations to meet the requirements of speed responsiveness and high productivity and a new design quality was: -

"...putting it all together - - from the foundation-laying process, through the engineering problem solving, to the organisational structure and leadership - - in a way that is coherent and works well to achieve effective, efficient, rapid development."

Cooper does not concentrate on the early phases. However, the importance of product and portfolio strategy is defined by McGrath (1997), of the 'fuzzy front end' in total by Smith and Reinertsen (1991) and Reinersten (1994). The basic elements of product strategy, a well-planned product portfolio, a facilitating organisational structure with clear customer needs, a well-defined product concept and product plan have been shown to be essential elements in the front end of a successful product programme (Khurana and Rosenthal 1997).

Observation:

The role of the author's model in the literature is to define the maturation of confidence, by which means a successful, responsive, integrated new product introduction may be achieved. Other models map the <u>activities</u> that take place, rather than mapping the interaction of these activities. The need for a systematic model of the early phases such as the author's is required to show a general means of making visible the behaviours for successful innovation.

3.3.2 Business innovation frameworks

The way that an organisation makes sense of its external environment and the beliefs it has about how it could change or set the limits on the organisation's strategic flexibility. Traditional incremental strategic planning prevents innovation (Mintzberg 1994) as starting purely from existing capabilities does not support long–term survival (Tidd et. al 1997a), while starting from a clean sheet of paper (Porter 1980, 1998) is often undeliverable (Whittington, 1994). The qualities required to be strategically flexible are : -

- To work within the constraints of the organisation (Goldratt, 1994)
- To make strategic partnerships with external suppliers and other players (Lamming, 1993)

- to take into account competitive markets, firm-specific technologies and competencies to produce a dynamic capability (Teece and Pisano 1994)
- To use an innovation framework that senses the outside world and comes to a conclusion about it, formulates alternative strategies to provide options, and then resources chosen options to technological and market maturity before implementing them (Tidd et al 1997). Such processes can prevent organisations from deluding themselves as to their true competitive position (Rouse 1998), and assists established organisations that often have difficulties in supporting innovation (Dougherty and Hardy 1997).

Observations

The author's model represents a process of sensing the outside world, consciously setting a span of possible futures, understanding the requirements of these against its competencies and technologies and then maturing its options through to delivery. The innovation of the model is in integrating these, and providing a motivation for continuous, rather than sporadic, organisational innovation. It is proposed that the brand concept is a long-term driver for this, which keeps the organisation on a true course in the marketplace.

3.3.3 Strategic Innovation

An effective innovation route is through the products and services of the organisation (Dougherty 1992). The scenario approach facilitates the organisation learning and allows it to evolve before it faces extinction through external disturbances (De Geus 1997). Scenario planning is a tool that allows an organisation to maintain a range of possible futures in its thinking, and maintains options against these possible futures (Twiss 1992; Millett 1991; Martino 1993; Fahey and Randall (eds.) 1998). Technological innovation relies on the quality of understanding of the business and its needs (Rousell et al 1991) that make it stretch to solve strategic problems (Hamel and Prahalad 1993, Hamel 1996).

Observations:

Product innovation has been identified as a primary means of organisational renewal, supporting the author's use of the whole product lifecycle as the basis of the design model of the business. The design model requires the use of a technique such as scenario planning to make visible an explicit range of futures, and the organisational responses to these. Processes have been developed and improved in concept to support the visibility of competitive futures, and the development of new options against these, both radical (Open Door process) and incremental (Business process for cycle planning).

3.3.4 Concurrent Engineering

Concurrent engineering is **"..a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is**

intended to cause the developers from the outset, to consider all elements of the product lifecycle from conception through to disposal, including quality, cost, schedule and user requirements" (Winner 1998). Its main tools are those of target setting (Pugh 1992; Clausing 1993) and the uncoupling of a complex product into hierarchies of the product, process and organisation and work structure (Prasad 1996a, 1996b, 1997a, 1998). The latter allows the modules of the product to be designed and developed semi-independently with low communication and co-ordination required between modules (Suh 1990). This approach facilitates the use of geographically separated contributors to the design and development process. The combination of modularised products, processes and organisations with explicit measures and targets allows IT to be used to speed design communication. The structuring of information also allows fast learning and maintenance of technological, process and organisational knowledge.

Observations

The principles and application of concurrent engineering have, by study, been found to be identical with the author's model. Where the design model is innovative is that it applies these principles for the early phases of design and development, which include portfolio planning, business strategy formulation, and strategic innovation. Concurrent engineering models cover product design and development and not these early phases. Lessons from the application of concurrent engineering to a variety of organisations show that hierarchical breakdowns of product, process and organisation should be influenced by the structure of the product and the organisation's level of complexity (Backhouse and Brookes 1991, 1996; Backhouse et al 1995). This suggests that the author's model should also be capable of applicability across a range of organisational types.

3.3.5 NPI (New Product Introduction) Effectiveness and Efficiency Techniques

A number of tools and techniques are used repeatedly at all levels of the design process. These include quantitative understanding of customer needs through the Kano model (Kano 1984) and QFD (Hauser and Clausing 1988), a targeting tool that decomposes needs from one hierarchical level to the next. Systems engineering (Sawyer 1994) allows the decomposition and co-ordination of hierarchies of the product, and the concept selection process of Pugh (Pugh 1996) is valuable in the development of fit design concepts. The use of set-based targeting has been explored (Sobek et al 1995, 1998, 1999) and has been found to be the equivalent of scenario planning – but in the product design process. Parametrics allows the fast estimation and transfer of information upward from one hierarchical level to the next (Origin 1995). This facilitates the fast understanding of potential new products and processes. Design tools such as Design for Manufacture (Boothroyd & Dewhurst 1991) Design of Experiments and Robust Design (Ross 1988) have been increasingly applied earlier in the design process, and the acceleration of previously qualitative product and business targeting processes can be facilitated by new tools supporting human capabilities (Rouse 1991, 1993). The design of organisations to facilitate the necessary decision flow is recognised as a critical factor for product innovation (Galbraith 1974). The integration of supply chains in conventional businesses is understood but not optimised (Lamming 1993), while there are few models of how potential future supply chains should operate in a globalised future (Harland et al 1999). Good control of the delivery process for new products can be optimised for cost, performance, resource constraint or time, and the focus and control measures need to be intelligently decided at each hierarchical level (Reinertsen and Smith 1991; Reinertsen 1997)

Observations:
The research has developed practical techniques for integrating the organisation through its hierarchies. QFD in its original form was found lacking in its ability to decompose brand values, and in its usability in three automotive businesses. Alternative implementations were necessary to overcome these drawbacks, leading to the development of Engineering the Brand during the research. This allows the targeting of an organisation from its motivational values (the brand) through all the levels of the hierarchy. The quality that this gives is that it prevents the stagnation and 'core rigidity' of an organisation by making visible otherwise tacit assumptions of the world. This then allows the testing and evolution of an organisation's core values against the changing external world. The potential complexity of dealing with a range of possible targets emerging from scenario planning and set-based targeting can be simplified by embedding these into a range of product options, and then hybridising the options at stages during their development using concept selection (Pugh 1996). Various levels of supplier integration have been found compatible with the model, and have been observed in Toyota (project 4, The application of a design model in the automotive industry and Womack and Jones 1996), giving a new way of considering supply chain relationships. None of the 'Design for X' approaches have been invalidated by the author's model, but their effective introduction into the design process is facilitated through the author's development of the early phases of a reengineered new product introduction process.

3.3.6 Individual and Group Behaviour

Models of human behaviour have been developed (Argyris 1982, 1985, 1993) that explain dysfunctional businesses. The same type of dysfunctional behaviour is found worldwide, at any age group. Its governing values are '..to achieve your intended purpose, maximise winning and minimise losing, suppress negative feelings and behave according to what you consider rational.' Individuals craft their positions, evaluations and attributions in ways that prevent enquiries into them, and their being tested with other's logic. Organisations using these behaviours reward limited organisational learning, inhibit understanding of the system, and overprotect the individuals and the organisation (Senge 1990, 1994; Ten Dam 1987). The alternative behaviour uses valid information to make decisions, where individuals openly illustrate how they reached their evaluations and attributions. In this type of organisation embarrassment and threat are not covered up but engaged. Organisational learning takes place in such an atmosphere (Beer and Eisenstat 2000), and requires all to co-operatively aim for a single, consistent set of organisational targets (McGrath 1984; Kaplan et al 1996). The application of concurrent engineering principles to organisations needs to take account of their individual circumstances, goals and resources (Backhouse et al 1995, 1996). The use of modular division of an organisation to reduce human complexity allows outsourcing of areas of competence not vital to an organisations current success.

This allows an organisation to concentrate on its core competences, but the modular approach could reduce its capability for future innovation (Scarborough 1998, Batchelor 1999).

Observations:

The model of a dysfunctional decision-making culture found in the research is consistent with that identified by Argyris. The design model of the business, its processes and principles has been purposely developed to support appropriate decision making with valid, transparent targets and good evidence for confident decisions. The appropriate type of decision-making behaviour at all levels of the hierarchy is a requirement of the model, and needs to be facilitated by the appropriate organisational structures. The author's design model concentrates solely on the quality of information and decision-making behaviours rather than declaring a rigid structure. This allows changes to be made to current organisations through an understanding of the gaps to be addressed, making the model generally applicable. The concerns of modularity preventing future innovation are addressed in section 4.4.

3.3.7 Strategies for Flexibility and Innovation

Strategic Planning is moving away from the failures caused through incremental, analytical management towards the practice of 'Competence-based competition' (Simpson 1998; Prahalad and Hamel 1990; Hamel and Heene 1994; Sanchez et al 1996a). This builds a set of unique resources and capabilities, '..but with a sharp eye on the dynamic industry context and competitive situation, rigorously applying market tests to these resources' (Collis and Montgomery 1995). To avoid being undervalued, firms must apply leverage to utilise these values – in other words, to make as much of themselves as possible.

The enablers and drivers of new product strategies are the concepts of modularity in products and organisations, which allows the product development process to be decoupled and become '..fast, concurrent, autonomous and distributed.'(Sanchez 1996b) The greater potential for losing knowledge with open organisations is handled by explicitly handling know-why, know-how and know-what. This allows, say, drawings to be shared, but for the embedded know-why of architectural interfaced to be retained (Scarborough 1998). However, modularisation is not beneficial within areas of extreme complexity. Here, organisational boundaries must be chosen to allow management by a balance of planning (prediction) and emergent approaches (theory and experimentation). The platform concept and evolutionary architectures are ways of managing modularity to allow modules to be changed around a stable architecture to give customer variety at low cost (Rouse 1991; Roberson and Ulrich 1998, Witter et al 1995). The inclusion of new supply strategies is important to this vision, as discussed in section 3.3.5. The strategic exploitation of valuable competencies can take place using a 'hammer and anvil' approach to strategy development (Scott Morton (ed.) 1991). The organisation becomes much more like a living organism in these conditions. The aims of the business strategy become highly important in regulating the decision-making of a distributed business. DeGues (1997) proposes an organisation 'should become as great as it can be'. Deming (1993) proposes that an organisation should aim for win/win, while Sanchez (1997) suggests the need for a guiding 'attractor' that provides a relatively simple means of guiding resource and asset decisions in an organisation.

Observations

Leading edge strategy planning concepts call for strategic flexibility through the use of a modular and platform approach to organisations and their products. The author's design model was originally aimed at providing flexibility through a modular and platform approach, and is closely aligned to the needs of a strategically flexible organisation. From the author's research, a means of guiding a business can be provided successfully by using the concept of the brand. This is the entity in the author's model that drives the innovation process and defines competencies, products and decision values in the organisation.

3.3.8 Integration Through Systems Cybernetics And Complexity

In the growing complexity, uncertainty and ambiguity organisations face (Drucker 1990), learning becomes a more important mechanism than top-down control (Bohn and Jaikumar 1985; Senge 1990, 1994; De Geus 1997). The systematisation of an organisation allows the interaction of relatively simple and autonomous parts to form a complex and 'intelligent' whole (Khurana 1999).

The science of cybernetics studies the control of biological and human systems (Weiner 1985). It shows that the fitness of a living organism to survive is judged by its ability to maintain constant a critical internal set of parameters constant against external disturbances (eg political, social, economic, competitive). To achieve control.....

'...The variety of actions a control system is able to execute must be at least as great as the variety of environmental perturbations that need to be compensated. The larger the variety of available counteractions, the larger the set of disturbances that can be corrected, and the larger the domain of potential environmental situations the control systems can survive' (Ashby's Law, Ashby 1957)

The science of complexity studies the self-organisation of simple bodies to give organisms with complex (ie high fitness) behaviours that also provide evolutionary fitness (Dawkins 1974, Beer 1994, Kaufman 1995; Heylighen 1996; Capra 1997). Organising for complexity requires systematic hierarchies (Simon 1992). Corporate interest is growing rapidly in this area. Recently published findings for organisational fitness (Kelly and Allison 1998) reinforce the initial findings of the author – that the decision-making culture is critical for the fitness of an organisation to survive. These lessons identified are the same: -

- Trust information from others – if they have a process and follow it, respect the results. Believe people when they identify risks – better to help solve it before it happens. Don't just expect people to bring solutions or you will never hear the problems before its too late.
- Share information – speak out when there is disagreement or lack of listening. This is the basis of learning, particularly important when organisational weaknesses are challenged.

- Align choices: Deep commitment – make sure that plans drawn up are real and committed and not ignored.
- Co-ordinate co-evolution: Responsible interaction – Creating one or more scenarios for potential action and then acting according to the one they select allows a team to mentally test the projected consequences of actions before proceeding.

Observations:

The author's work agrees with the principles of cybernetics and complexity. Many of the features of the design model of the business coincide with the need for systematic hierarchies. The use of targeting and environmental scanning is to identify potential disturbances for an organisation to provide a response before the disturbance happens. That organisations are not adept at this is evident: only 1% of all organisations survive the first 30 years of life (de Geus 1997). Those that do survive for longer appear to have characteristics similar to those identified as desirable in this research (De Geus 1997). Where the author's work is in advance of that published are the models, tools and processes developed to support an organisation to be strategically flexible.

4. THE WIDER APPLICATION AND IMPLICATIONS OF THE DESIGN MODEL OF THE BUSINESS

One of the main objectives set for this report is to explain how the design model of the business is relevant in wider domains than the one in which it was created. A review of other relevant literature was reported in Section 3.2. This showed that the principles embedded in the model are more generally applicable to organisations needing to increase strategic flexibility.

This chapter is now used to describe the application of the design model in general terms. A number of points will also be made on how the model impacts on the current understanding of organisations. This is done through describing particular aspects of the model and its implications in the following sections:

4.1 The decision-making culture and its improvement.
4.2 The process of target setting and target agreement.
4.3 The use of the Brand for organisational integration.
4.4 The modular structure of the product and its influence on organisational structure and knowledge management.

4.1 THE DECISION-MAKING CULTURE AND ITS IMPROVEMENT

This section looks at the behaviour that supports strategic flexibility of the individual and groups in the decision-making process. With a dysfunctional decision culture, resources will tend to be allocated in inappropriate ways that lead to the loss of survival fitness of the company (Ten Dam 1987). Approaches to introduce and encourage the correct working of decision-making are introduced in section 4.1.1.

The decision-making process affecting the author's work at the start of this research provides an example of how decision-making can degrade an organisation's ability to respond to its environment.

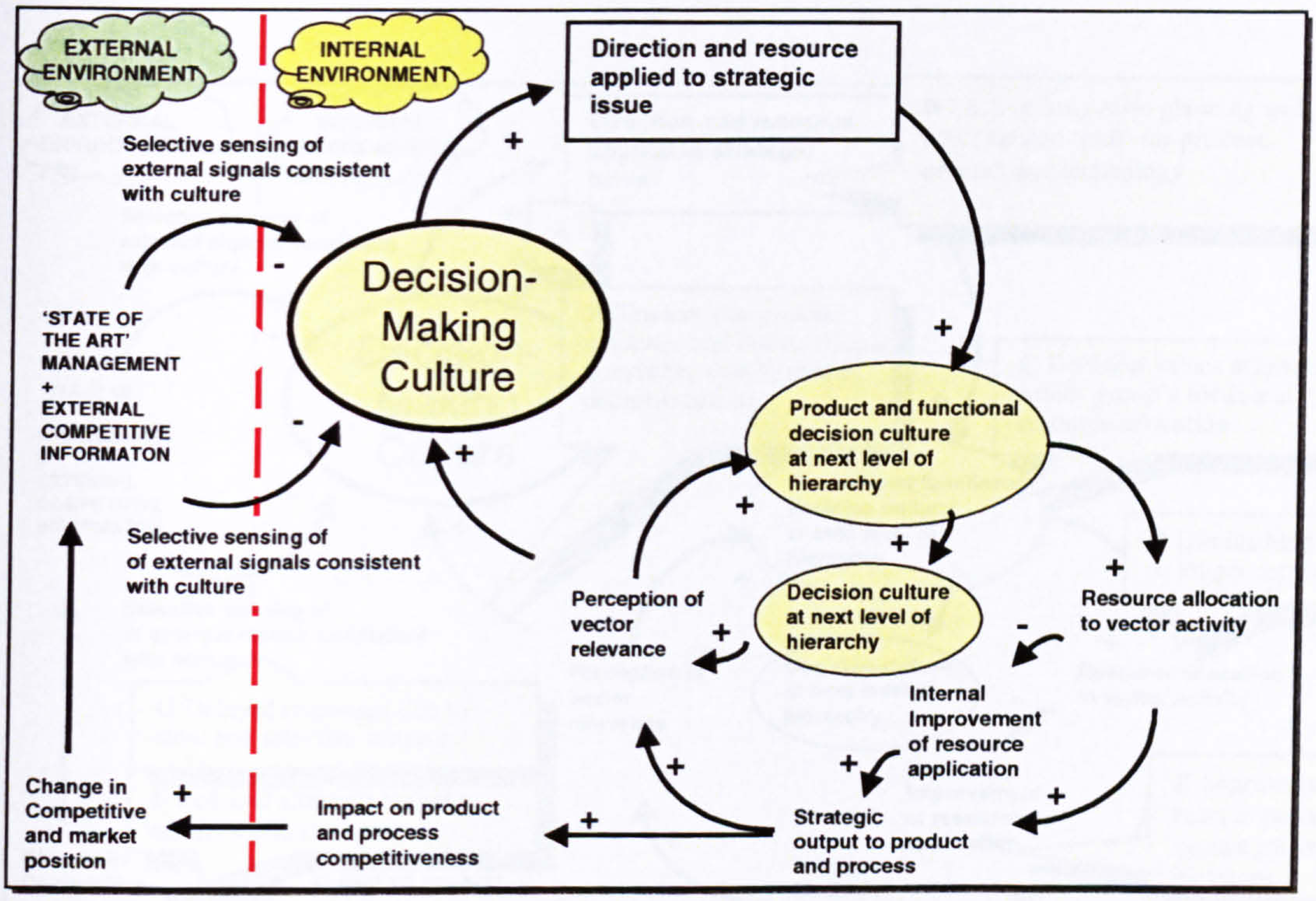

Figure 36 A system diagram showing the influence of a decision-making culture on organisational performance

Figure 36 shows a systems diagram (in the style of Senge 1994) of an organisation's decision-making culture. The discontinuous vertical line to the left of the diagram shows the external boundary of an organisation, with the internal environment to the right of the boundary. The items linked by the arrows are activities or influences. The direction and sign of the arrows show how one entity affects another. An arrow with a positive sign at its tip shows that a growth by the entity at the origin of the arrow also grows the entity at the tip of the arrow, and conversely reduces the entity when it reduces. A negative sign on the arrow shows that a growth in the start of the arrow reduces the property it acts upon. Pointing text boxes are used to describe a case study.

Figure 36 is reproduced in figure 37, with pointers added to allow explanation.

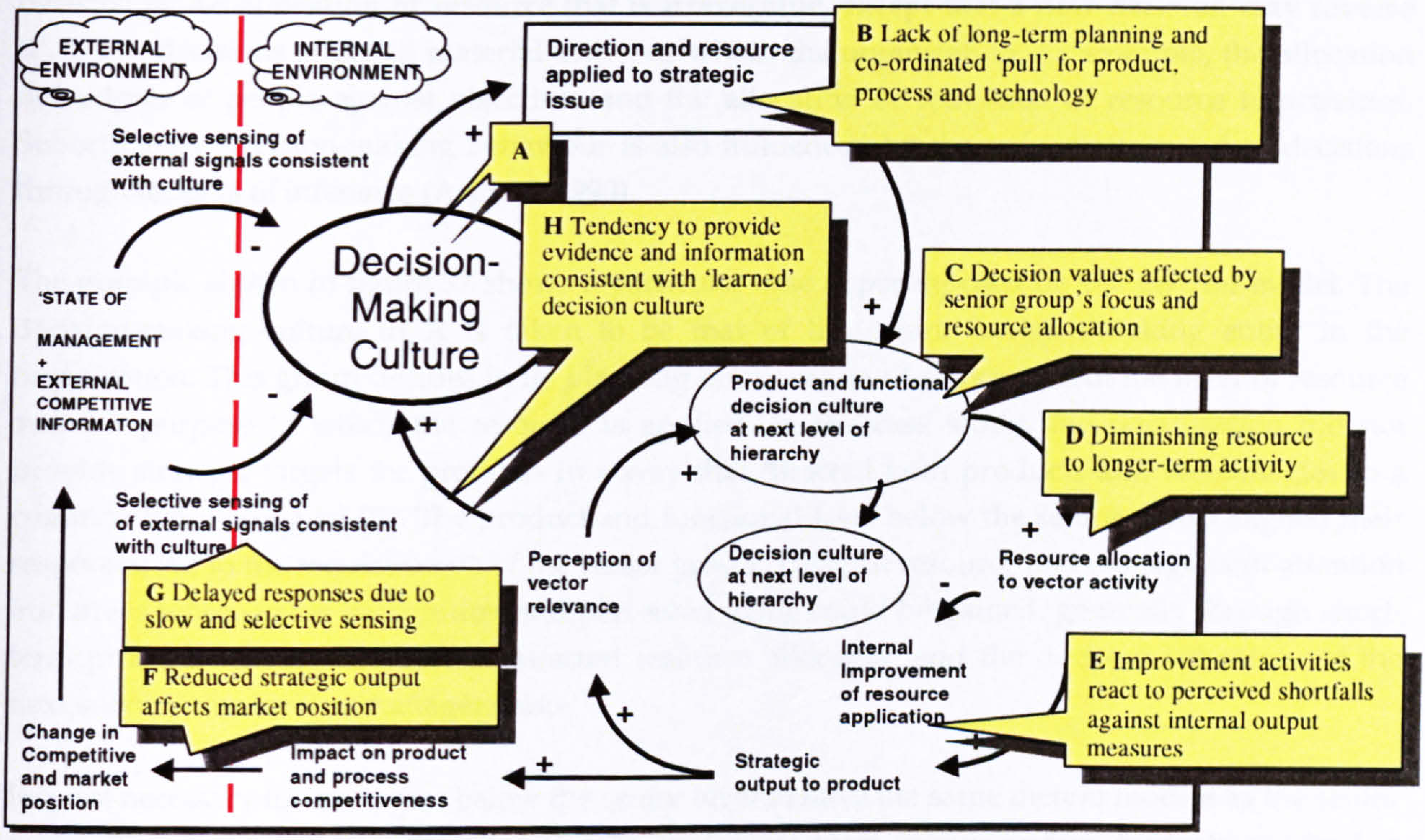

Figure 37 Decision-making culture - system diagram with annotations

The decision-making culture in **(A)** can be defined as **"The set of values applied to the selection and evaluation of evidence and approaches to decision-making'**. The decision-making culture includes: -

- **The values** that are used as the guidelines for decision-making. These are based on the beliefs and needs of the decision-making group (Rouse 1993). These values include the importance and recognition of external threats, the value of long term planning against those of short term profit, activities and customers that are considered relevant to the organisation and those that are not.

- **The openness to contrary views** from internal or external sources (Cooper and Kleinschmidt 1996). An insular decision-making culture tends to hold a set of values within the group, and is less open to alternative possibilities, both of interpretations of the situation and to alternative solutions to problems.

- **The rigour of decision-making**, which includes the level of evidence required, testing of evidence and consequently, the confidence in the decisions made. This factor is inversely related to the level of risk that the group is willing to tolerate. Low tolerance of risk leads to a greater optimisation of plans – but only if the goals for change are set high enough. Without such goals, known solutions of low differentiation value will become acceptable – and hence a tendency for the product to fail against objectives.

It is also useful to define a decision as used in the model, as the term is not used in a trivial sense. A decision is **'An allocation of resource that is irrevocable, except that a new decision may reverse it'**. These decisions affect all material activities within the organisation, for example, the allocation of budgets or people against objectives and the allocation or reduction of resource to activities. Subordinates' decision-making behaviour is also influenced by the values attributed to decisions through ladders of inference (Argyris, 1990).

The example shown in figure 37 shows a particular case superimposed on the general model. The decision-making culture in A is taken to be that of the senior decision-making entity in the organisation. This group decides in its planning or allocation of resource both the level of resource and the purpose to which the resource is applied. In the case study, the organisation did not provide strategic targets for products in a way that directed both products and technologies to a common long term goal (B). The product and functional level below the senior group aligned their responses (C) to the requirements of the senior group. This put resource and management attention into areas where better recognition and perceived value could be gained, generally through short-term product delivery needs. This affected resource allocation and the decision behaviour of the next subordinate level of managers also.

It is not necessary for managers below the senior level to have the same mental models as the senior group. The control of resource allocation by the senior team (remuneration, budgets, promotion prospects) would lead to the subordinate group 'learning' how to best obtain these resources (H), by tailoring their actions and reporting in a way that would gain the senior team's approval. Their internal beliefs may not be affected, but their overt reporting and decision-making behaviour in this system would be. Without explicit assessment, these learned behaviours and solutions may become deeply embedded and difficult to change.

An activity aiming to resource technology and products for the longer term would be affected adversely by low resource (E). Diminishing resources tend to produce reducing outputs against external needs and consequently produce a poorer market position (F). A natural tendency to increase the efficiency of the activity would slow the decline in output, but a change in senior decision-making values would be required to increase resources to this activity.

External competitive and customer information can come back in to the organisation via the 'membrane' dividing it from the outside world. However, the organisation's openness to information and its interpretation are subject to the set of values of the decision-making group. In the case of a value that conflicts with accepted values, slow sensing (G) delays organisational learning until the topic is recognised through legislation or becomes accepted through common public knowledge. Thus the values of the top decision-making team paralyse the business from making change to respond proactively to a problem, or to make the most of an opportunity.

This style of management has a further effect, which can be seen in the model. Due to its insensitivity to new values outside of the existing set, and the 'learning' of subordinate levels to provide reinforcing information back to the senior group, the existing decision culture tends to be self-reinforcing. Thus the strategic flexibility of a whole organisation is affected by the values at the highest levels of the organisation.

4.1.1 A decision-making culture to respond to the needs of strategic flexibility

The organisation can be generalised as a mechanism for countering strategic threats. These are disturbances from the external world that could strongly affect the performance or viability of the business. The representation of the system shown in figure 38 is adapted from Ashby (1957). For an organisation to respond to threats and opportunities properly, it must be able to sense the external world, and know how important each aspect is, to be able to focus attention on the real threats and opportunities that affect its future. It is the role of responses developed by the organisation to prevent these disturbances from adversely affecting the essential functions. The more fit an organism is to survive, the more complex its range of responses. The term complexity provides a measure of the range of circumstances the organism can survive in, but an organism is not necessarily larger or slower to be capable of complex behaviour.

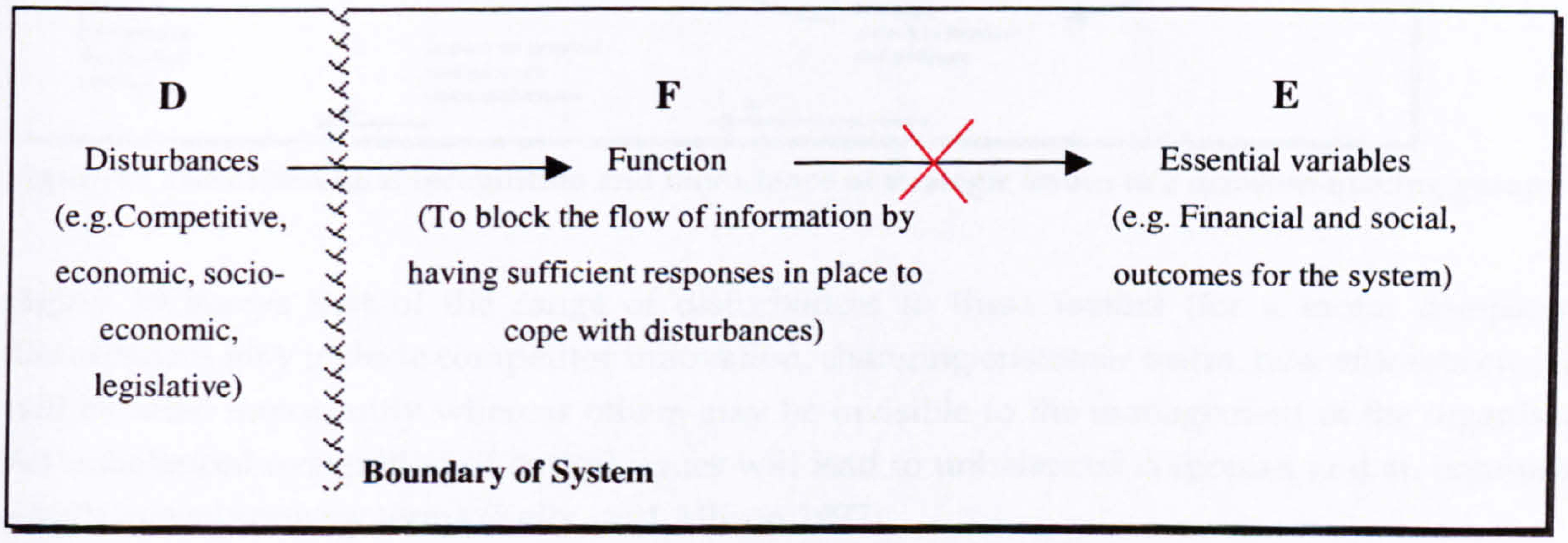

Figure 38 Model of a dynamic system. To survive it must protect its essential variables from external disturbances.

The 'essential functions' are the variables that the organisation must keep stable to remain viable – for example profitability, competencies, liquidity and legality.

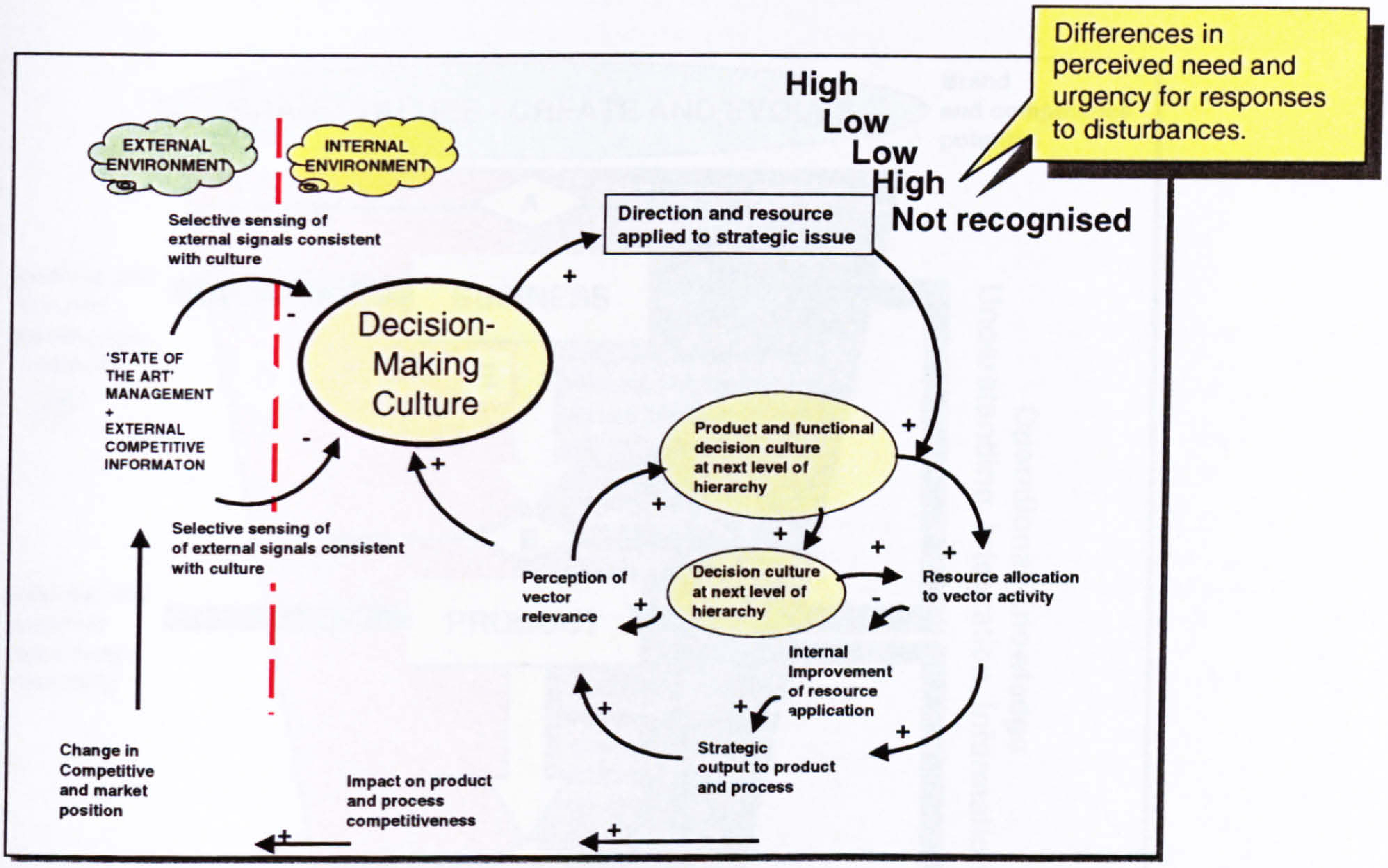

Figure 39 The differential recognition and importance of strategic issues to a decision-making group

Figure 39 shows that of the range of disturbances to these factors (for a motor company the disturbances may include competitor innovation, changing customer tastes, new entrants etc.) some will be rated importantly whereas others may be invisible to the management of the organisation. An unbalanced recognition of critical issues will lead to unbalanced responses and an organisation less fit in evolutionary terms (Kelly and Allison 1997).

The design model of the business provides a set of requirements for decision-making. Figure 40 shows part of the design model of the business. The decision making culture must recognise: -

A. The **values** that the level is responsible for maintaining and ensuring that these values are communicated and held in appropriate forms at the levels below it.
B. The **understanding of its own operations**, and access to the operational understanding of the level below, including its constraints.
C. That it must have an understanding of the **external world** relative to the important values for that level, and an openness to new external threats and opportunities from other levels.
D. There are **alternative futures** possible, and the decisions that are made need to be robust for the range of futures.

E. The appropriate use of **tools, techniques and processes** to integrate and communicate information, and make decisions transparent.

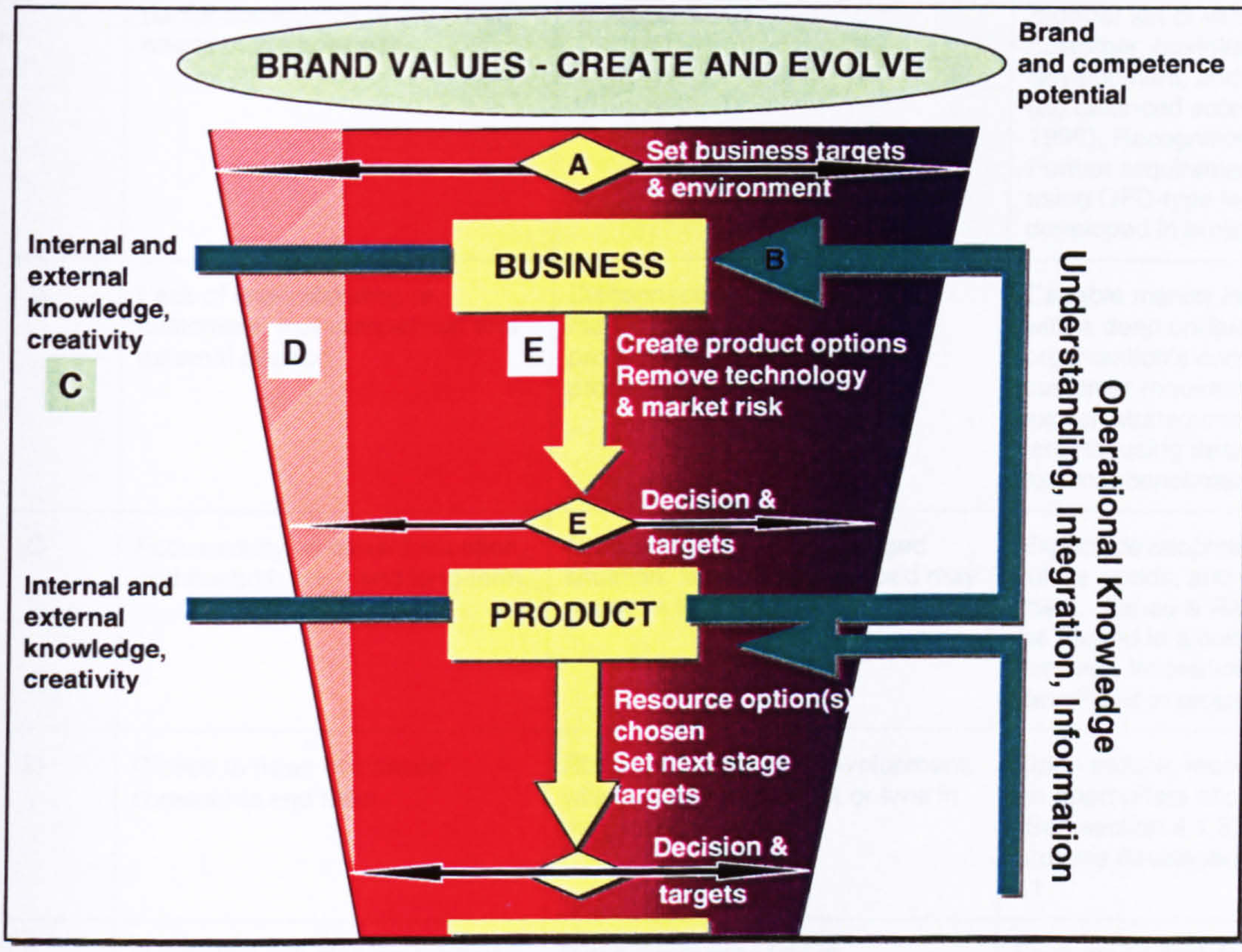

Figure 40 Partial view of the Design model of the Business to show influences on the 'Business' level of the hierarchy. The alphabetic labels show the decision-making factors shown in the text.

Potential problems with the decision-making process have been identified in the research (see section 3.2.3) , and a number of solutions identified. Potential solutions are assembled in table 1, while figure 41 shows these in the context of the design model of the business.

Ref	Problem	Effect	Solution
A	At the whole organisation level, a partial acceptance of the critical needs of the business.	Delay in organisation responding to strategic needs.	Examination and installation of a broader set of values covering customer, business, people development, and innovation areas. (eg balanced scorecard Kaplan et al. 1996). Recognition of brand values. Further requirements for products using QFD-type techniques. Process developed in project 9.
B	Lack of understanding of customers, true competitive and external position.	Disconnection from the marketplace. Inappropriate products and uncompetitive processes.	Capable market intelligence, coupled with a deep understanding of the organisation's competitive and customer requirements. The setting of explicit strategic and customer targets, using desired position against external benchmarks.
C	Focus solely on current situation, and not both short and long-term.	Growing unfitness for changed situation. Solutions developed may not be fit for the future.	Explicit development of alternative future worlds, and responses for them. (Fahey & Randall, 1998). Must be framed in a suitable innovation process. Innovation process developed in project 11.
D	Closed to news of internal constraints and risks	Risks realised late in development, with loss of quality, cost or time in the product.	Open culture, recognising concerns in an appropriate escalation process. (See section 4.1.3). Principles and process developed in projects 9, 10, 11
E	Insufficient risk management of targeted requirements	Risks discovered late in development. Long-term, an aversion to innovation.	Each major decision point to be preceded by risk assessment against identified targets and individual responsibilities. Process developed in Project 11.
F	Lack of strong business partner relationships.	Uncompetitive products, due to low-performing competencies or relative in-house inefficiency.	Brand and core competence linkage, in-and out-sourcing exercise, then identification of strategic, and lower tier suppliers. See chapter 2 processes.
G	Parts of the enterprise not aligned to deliver the needs of one set of goals. Individual profit centres being optimised to the detriment of others.	Optimisation of a part of the enterprise at the expense of the whole.	Use of one targeting system from the enterprise goals down. 'Democratic' target agreement process. Deep recognition of the relationship of the individual's goals with the enterprise need and goals.

Table 1 Potential problems with the decision-making process, their implications and solutions. All of the above problems and solutions are closely associated with organisational leadership behaviour. The reference letters are shown as corrections to the decision-making process in figure 41.

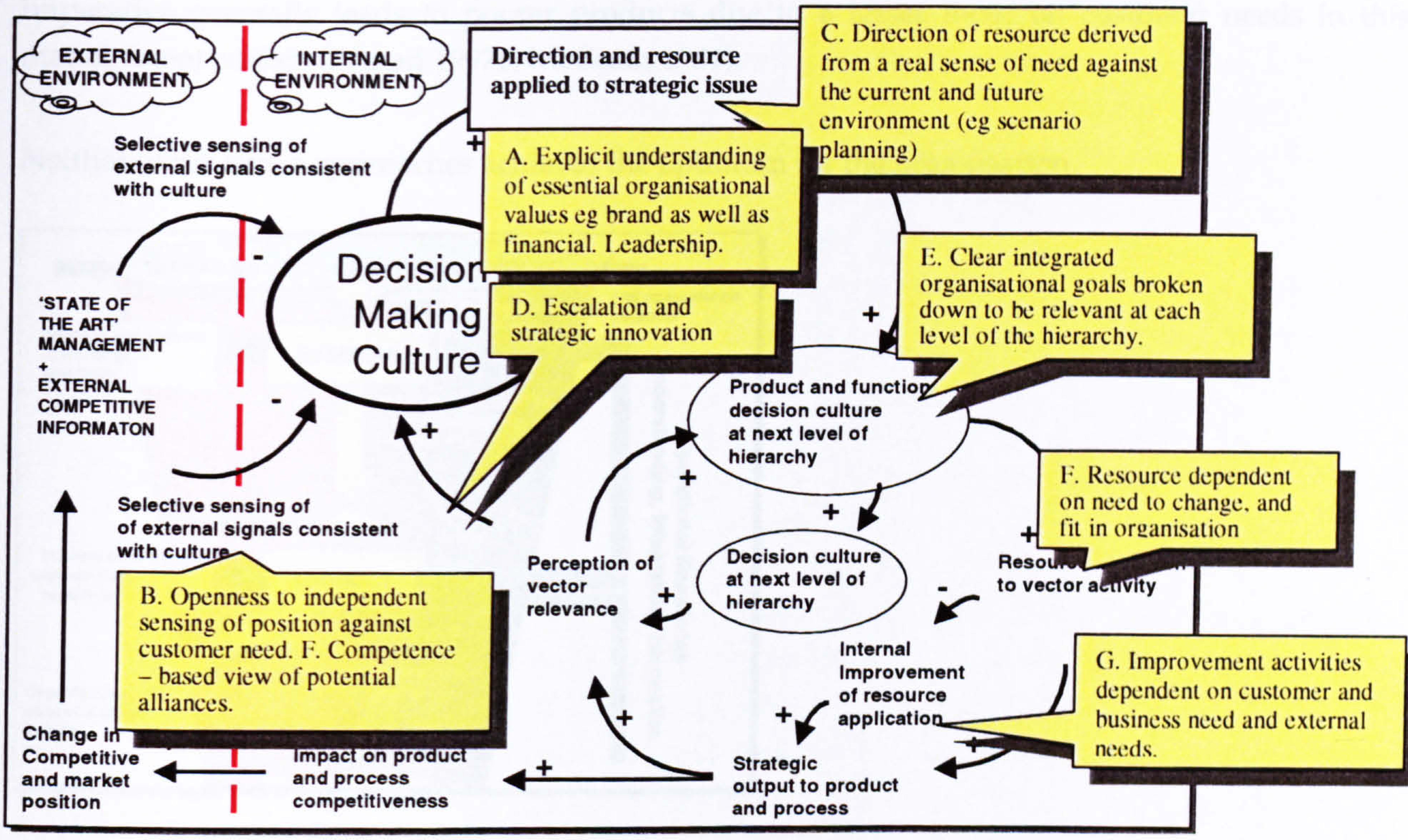

Figure 41 Solutions to improve a dysfunctional decision-making culture

4.1.2 A method for ensuring organisational openness to internal constraints

A feature of the design model is the agreement and setting of consistent, integrated targets at each level of the hierarchy. This involves a sequential process from one hierarchy to the next, with targets proposed and agreed. Every part of the organisation will be involved, as will business allies.

There are times when the target setting exercise is likely to fail to achieve its set goals, either as a result of technical conflicts or organisational constraints. Such a situation is shown in figure 42, which shows that the target set for a part of the organisation is outside of that that can be achieved. This could happen in any part of the design model, but with a directive management style this is more likely to become apparent at a later stage of the design process, with greater consequences. This is known to be a factor in poor product development performance (Sullivan 1986; Hartmann and Lakatos 1998).

Where targets have been set for agreement and this seems undeliverable by an individual in the organisation, the individual's behaviour, and those of others involved is strongly influenced by the decision-making culture. The temptation in a directive culture is to avoid blame, and to 'cover up the cover-up' (Argyris 1993). Here senior managers will ignore or penalise the bringer of bad news. In a supportive management style, or management by objectives, a more co-operative process of target-setting is the norm. However, the internal negotiating culture without a strong customer imperative generally leads to poorer products due to a lesser focus on customer needs in this management culture (Prasad 1997b, McGrath 1984).

Neither of the above approaches achieves the optimum for the organisation.

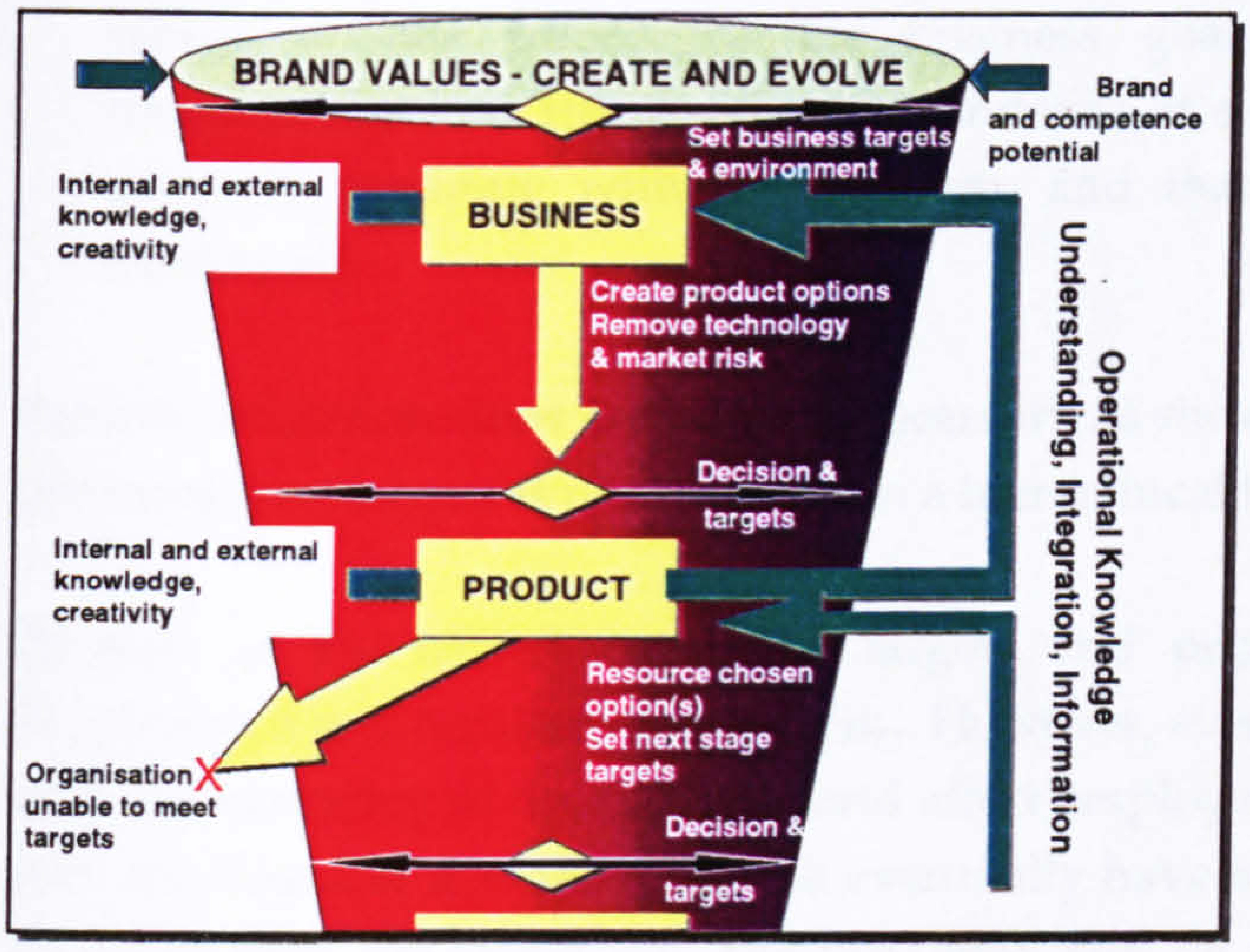

Figure 42 Situation where organisation forecasts it cannot deliver product targets

To overcome this, the first requirement is a set of targets that are set from real customer and business need, and not arbitrarily negotiated from within the business. Next, these targets must be decomposed through the organisation to provide the visibility of the outcomes the individual needs to achieve within their role and responsibility. A culture of regularly reporting a forecast against required outcomes should be introduced. However, even with this step, a problem has been identified (project 11) of a loss of face for the individual when forecasting failure. This tends towards the dysfunctional behaviour described above. A response to this has been found effective by taking the following steps described for a systematic product team organisation, as shown in figure 43. The steps refer to those shown in the diagram, and cover the principles that are repeated at higher levels of the hierarchy:

- **Step 1.** At the level where the problem has been identified, the individual (module leader) formally reports the forecast to their system leader. Alternative strategies to address the problem are also provided if possible, together with a recommendation.

- **Step 2.** The system leader decides whether to require further problem-solving work from the module leader responsible, if there is a potential for meeting the target. This allows the leader to coach the sub-ordinate if necessary to improve their problem-solving skills and capabilities. The evidence for solving the problem or further action is reviewed.

- **Step 3.** If the problem to meet a target can be addressed within the system team, the system leader promotes a short study with nominated module leaders. The module leader responsible gathers alternative solutions, evidence, and recommendations. The leader then reviews these to gain confidence in the results. If the target cannot be met, the problem must be escalated* to the next level of the hierarchy. This is accompanied by an explanation of the problem, its likely effects on the project or the business goals, the possible alternatives, evidence and recommendation. This produces confidence at senior levels that this level of the hierarchy is properly engaging with the problem, and that effects on the whole enterprise are being minimised.

Further escalation steps are taken if necessary as shown in figure 43, until the problem is solved or the impact on targets is negated within a hierarchical level.

Because of the nested nature of targets and organisation, an inability to meet a strategic requirement will escalate the problem. However, every effort will be made to resolve the problem, with transparency of the evidence and effort employed. Assuming that a strategic target cannot be met, the board of management will eventually have to face the limitations of their business or of a problem with the target set. The goal may still be the right one, but the organisation may be incapable of meeting it. Normally, the outcome would be a sub-optimisation of the project outcome, producing a detrimental effect on the business (Cooper et al. 2000). The benefits of a good escalation process are important – every level of the business works to the same process, plays to the same rules, and understands reality of what it can and cannot do, and the consequences. A supportive environment to achieve this clarity is needed so that the people in the system can behave in an ideal way within the design of the model of the business. The design of the escalation process described is aimed at increasing the confidence of the decision-maker in escalated concerns and solutions. This allows the organisation to work quickly towards overall system optimisation, and learn from its experiences.

* Escalation in this context means the raising of an inability to meet a target up to progressively higher levels of the hierarchy. Optimising actions are taken sequentially at each level up to the highest affected level, until the effect of the problem has been negated or the result of the deficiency has been minimised across the whole system.

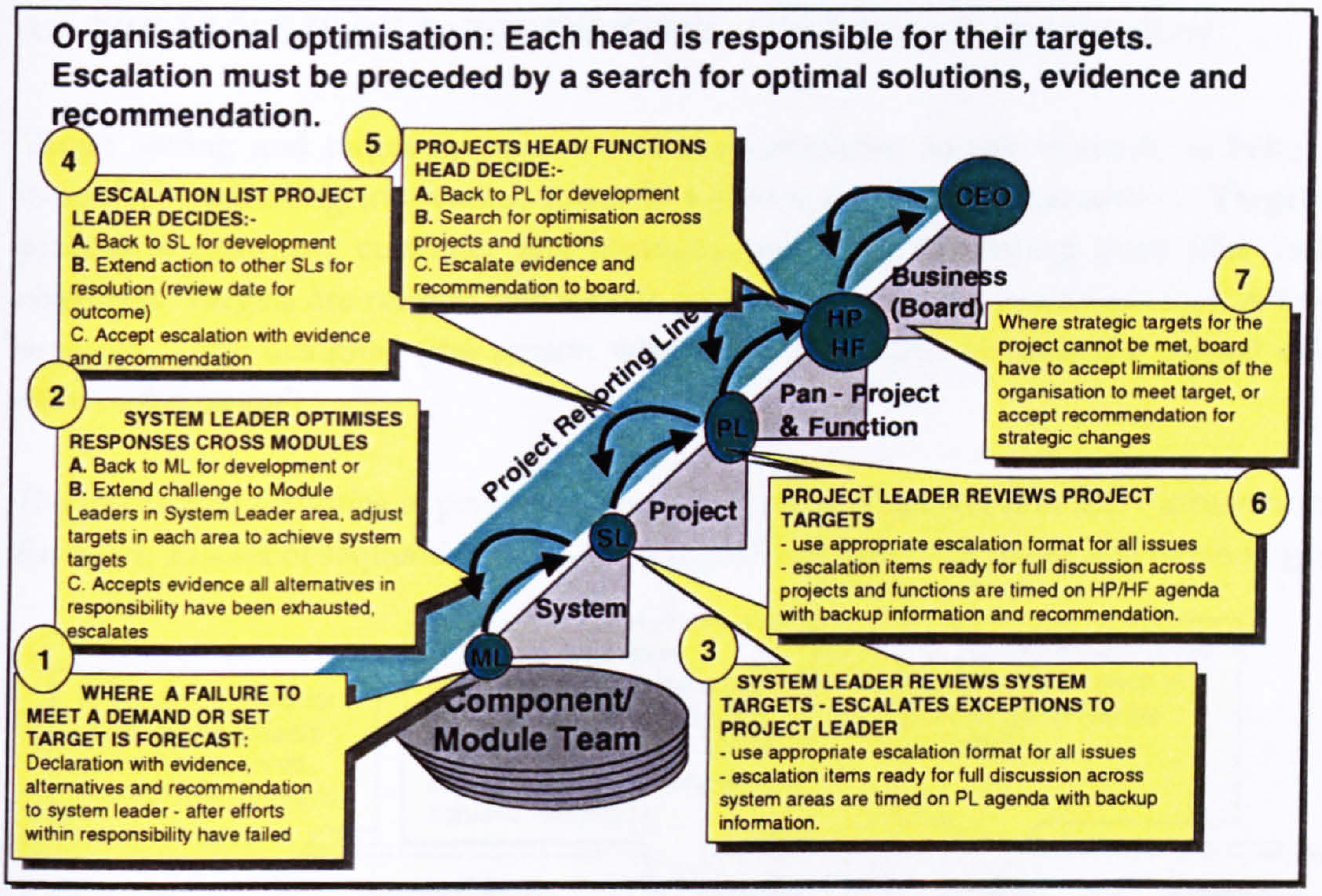

Figure 43 A representation of the escalation process for the design model of the business. Each of the levels represents a level of the organisation for a product programme. One additional escalation level has been found necessary in practice, that of the heads of projects and functions. These are responsible for recommending changes to the product portfolio and strategic innovation. Key: ML=Module Leader (or component leader), SL= System Leader, PL= Project Leader, HP= Head of Projects, HF= Head of functions, CEO= Chief Executive Officer.

4.2. THE PROCESS OF TARGET SETTING AND TARGET AGREEMENT

Target setting and target agreement has been identified in the research as being an important means of controlling innovation towards a future successful organisation. **Target setting** is the process of capturing customer and business needs and translating them into design goals and objectives. Targets are refined and further detailed through the design process. **A target** is 'what is required' - the **designer** (the person who seeks a solution to meet the target) decides 'how to achieve the target'.

The interacting activities of problem setting and solution finding that drive innovation are shown in figure 44, as a set of sequential problems (targets) and solutions (ideas and technologies).

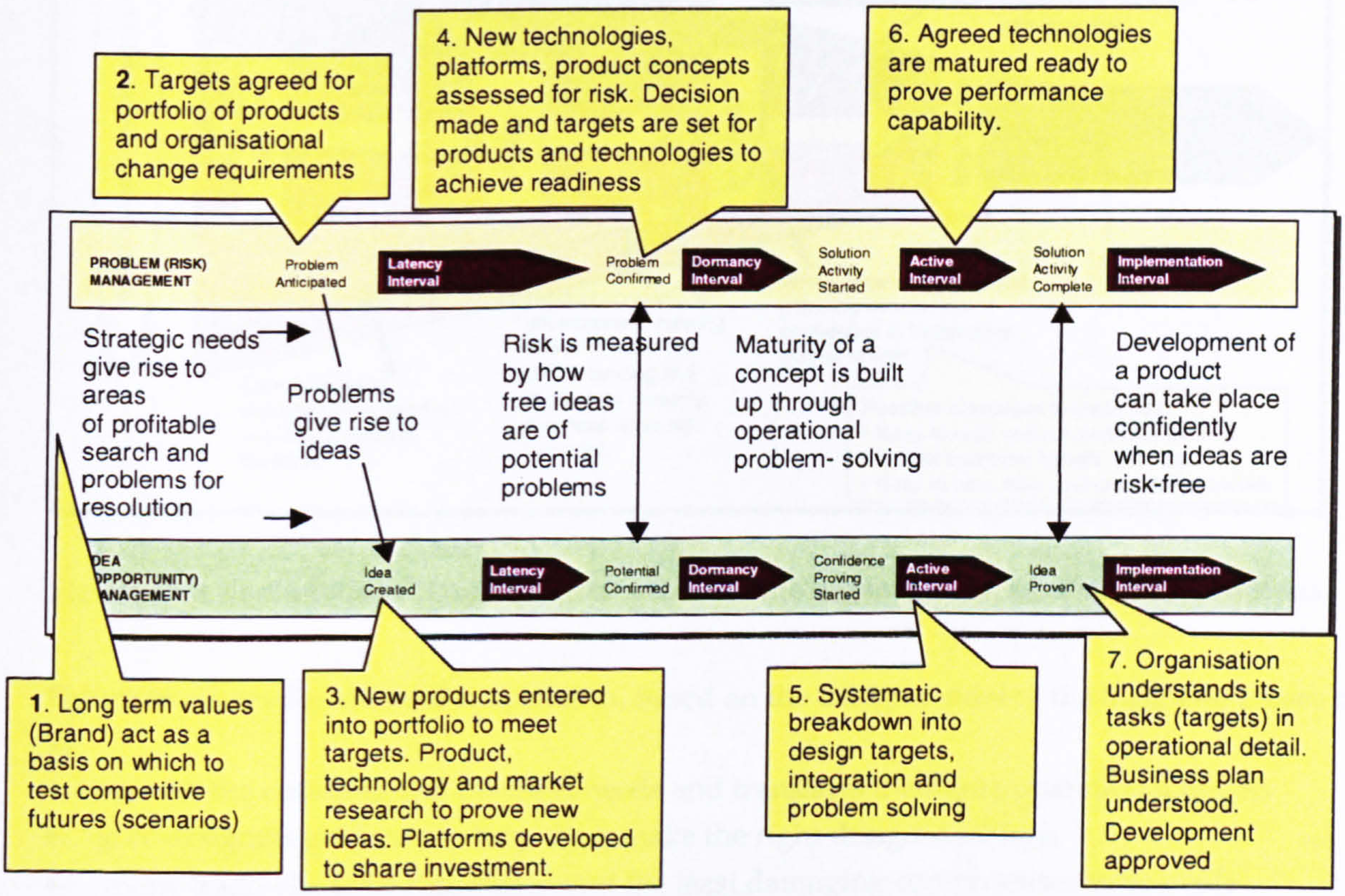

Figure 44 The relationship between targets, risks and solutions in the innovation process.

Figure 37 has shown the case of a decision-making process malfunctioning where there is no target setting process in place. Figure 45 shows how the situation would develop in detail. The model used is based on the design model of the business, but laid out horizontally with the time dimension moving from left to right. Here, there is no constancy in the goals of the organisation, and a lack of targets prevents the innovative needs being understood or acted on by the organisation as a body. The results are products that cannot meet cost, quality and delivery targets – unless the organisation has its sights set low. As discussed in the introduction, competitive pressures for innovation will be such that haphazard and partial innovation across the organisation is unlikely to be capable of keeping a business competitive.

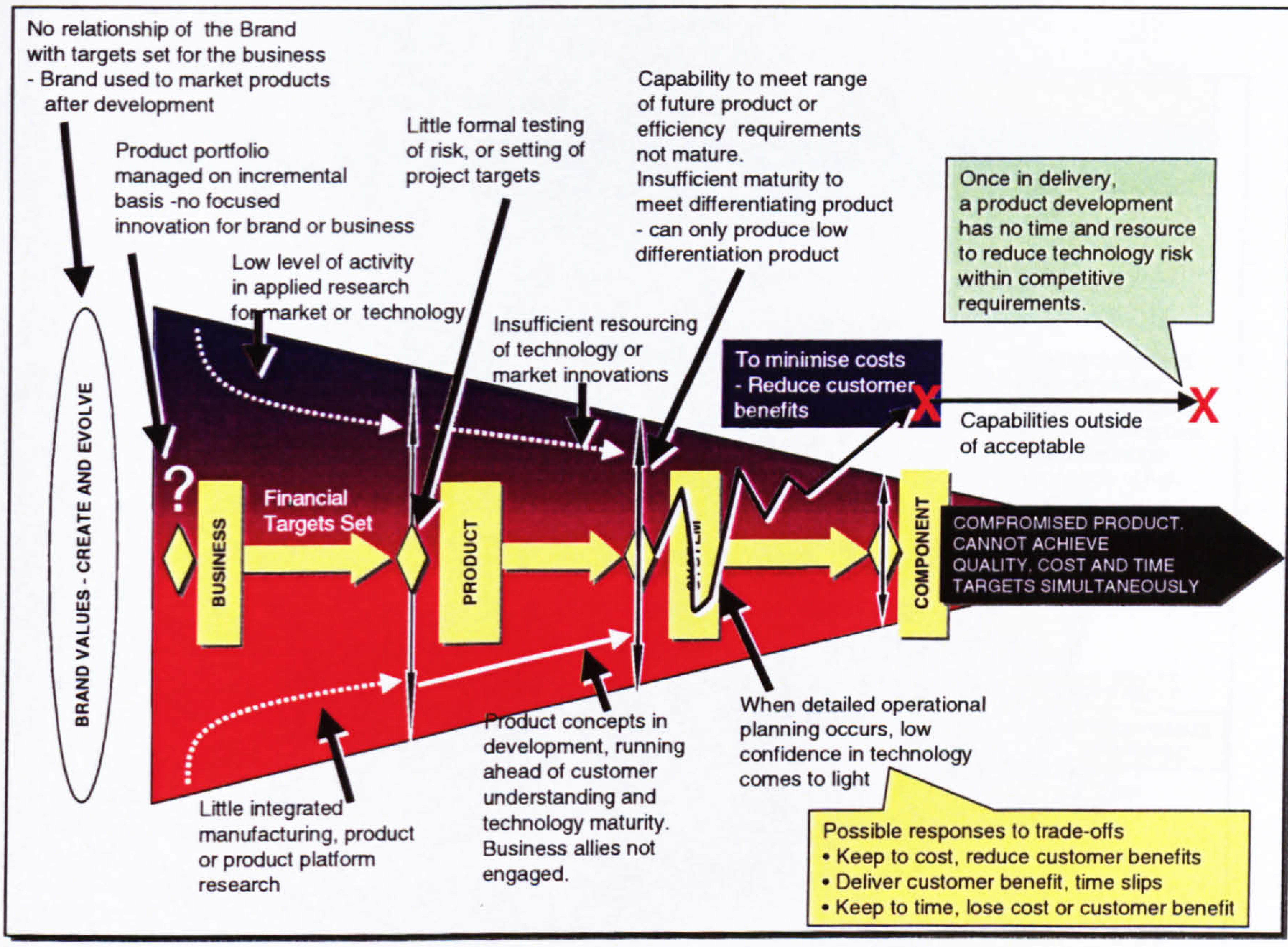

Figure 45 A dysfunctional target process prevents the organisation meeting its aspirations

Figure 46 shows the alternative approach, based on the design model of the business. It uses targets to:

- capture the customer and business needs and translates them into operational targets
- give designers guidance to help them make the right design decisions
- allow trade-offs to be recognised and the least damaging compromises to be made
- provides checks that the design is developed to meet the original requirement

The first phase (**Brand and Portfolio evolution, previously described as the 'Business Phase' in 2.10.2.1**) sets the product portfolio targets through the use of the brand and business needs. The brand is taken to be the value set that the business shares with its marketplace. This must be periodically set against the 'competitive future' by testing a brand's differentiation and competitive aims against the future customer, future technology changes and competitor's research. This provides a better understanding not only of new differentiation needs, but also improvement targets against costs, development time and competitive needs. Scenarios for possible future worlds are generated, which together with the business's financial and qualitative needs, set the range of future worlds within which the product portfolio must succeed. Where there are deficiencies of the product portfolio against the possible futures, targets for strategic innovation are set. These targets cover all functions and solutions for these are managed to ensure that the organisation will be fit to survive and prosper.

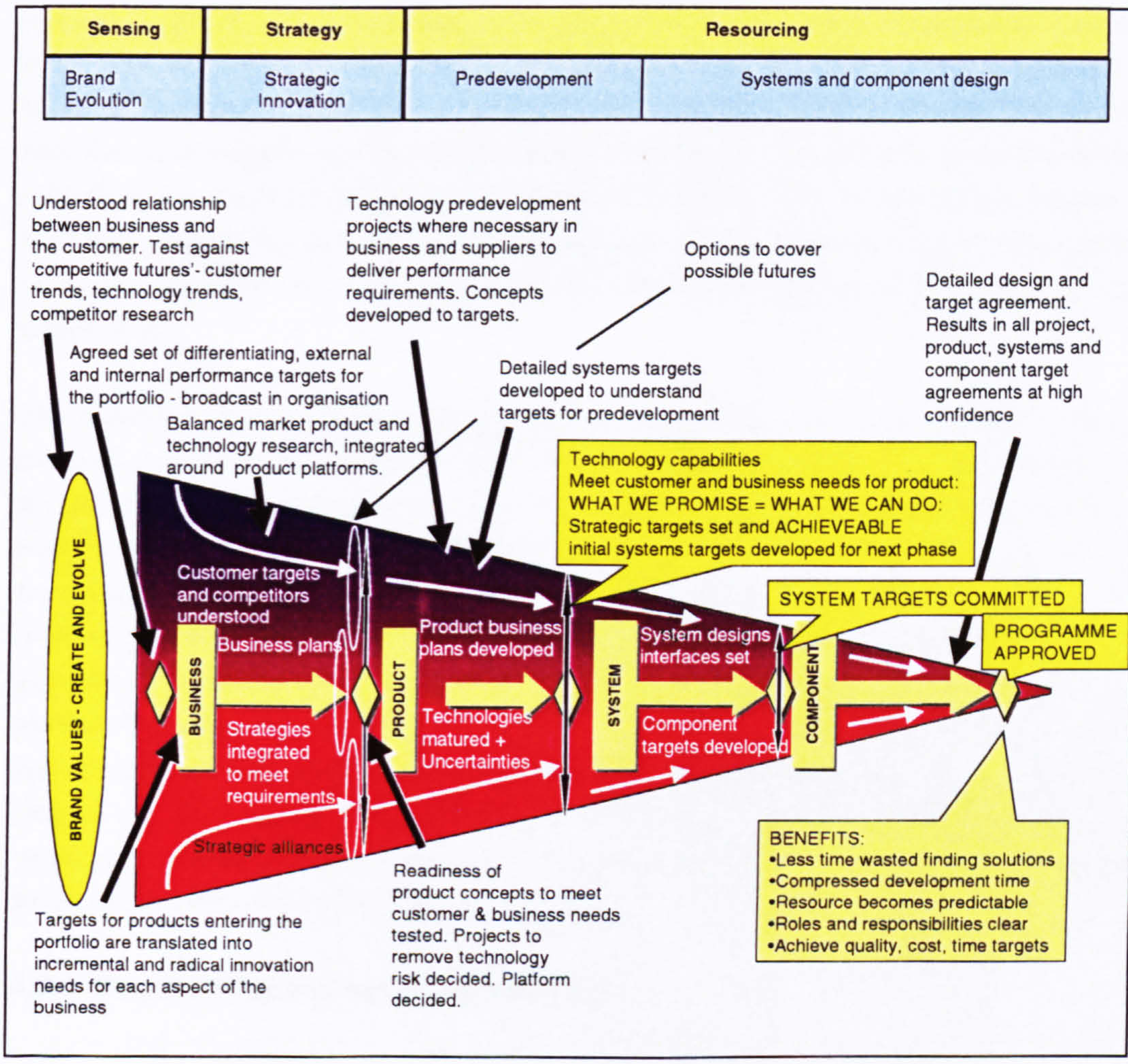

Figure 46 Design model of the business – targets shown. The diamonds represent decision points where targets and solutions are decided (confirmed) at the end of each phase. These are, from left to right: Brand/portfolio targets, business targets for the product, Project strategic targets, system targets, component targets. Top row of blocks show innovation phases of Tidd et al. 1997. Second row shows the author's nomenclature

The '**Strategic Innovation**' phase allows research for new products, technologies and market needs to be co-ordinated at all levels. Solutions must be proven in principle at the second decision point shown. Changes to external disturbances and changes to business needs are adapted to through the development of product, process and technology strategies. This leaves a set of product, technology, process and market options, which are fit and integrated for products.

At the end of the strategic innovation phase, a short assessment must take place of the maturity for the existing technologies of the organisation and the new solutions. This should be carried out by the core of the team that will bring together the integrated project to a confirmation of the ability to meet the critical targets for the project. The remaining technological and market risks or lack of maturity will have been understood, and projects decided to overcome these over the next phase of the programme, known as the predevelopment phase.

In the **Predevelopment** phase, several product options may then be 'pre-developed' to ensure that market needs are met and that risks are covered. The team responsible also co-ordinates the enterprise in removing the areas of technological and commercial risk identified in the strategic innovation phase, so that the technologies are ready for implementation. This provides confidence that the main targets required for the project can be met. At the end of the predevelopment phase, each function must be confident that the project will be able to deliver the targets committed and formally commit the overall project performance to the business. One product option is the likely outcome, although this may still have alternative technologies and features to cope with market uncertainty.

The **Systems and component design** phase co-ordinates the organisation to the point where all internal functions and alliances have fully detailed and agreed plans and designs for the product and its delivery over its lifetime. A set of systems targets supporting the project strategic targets will have been assembled and integrated during the predevelopment phase. These become the basis for designing and integrating the product in detail. These cannot be confirmed until the component level targets have been proposed and understood as likely to be feasible. The final phase in target agreement is where the detail component-level targets are set out and agreed as a contract by all parties. It is when the targets are decomposed to the detail level that the business can confirm that it has operational understanding of the product, its manufacture, logistics, distribution environmental impact etc. This signifies the point that the business can irrevocably commit to developing the product to manufacture and sale – when the confidence of all parties is sufficient to commit to the project's success against all targets.

4.2.1 Target setting and agreement rulesets

Targets are set at key points in the design process. These points, or milestones, fix a design decision at one high level so that more detailed targets can be developed at the next level. <u>Aspirational targets</u> are those set to stretch capability but are not necessarily achievable or contracted. <u>Committed targets</u> are those that have integrity, do not change once set and are contracted by those responsible for their delivery.

The structure of each phase is similar in that to achieve confidence in the targets, the next level of the organisation must be involved. To do so requires that the next level of targets has been drafted and is acceptable in principle. The way that decisions and tasks interact is seen in figure 47.

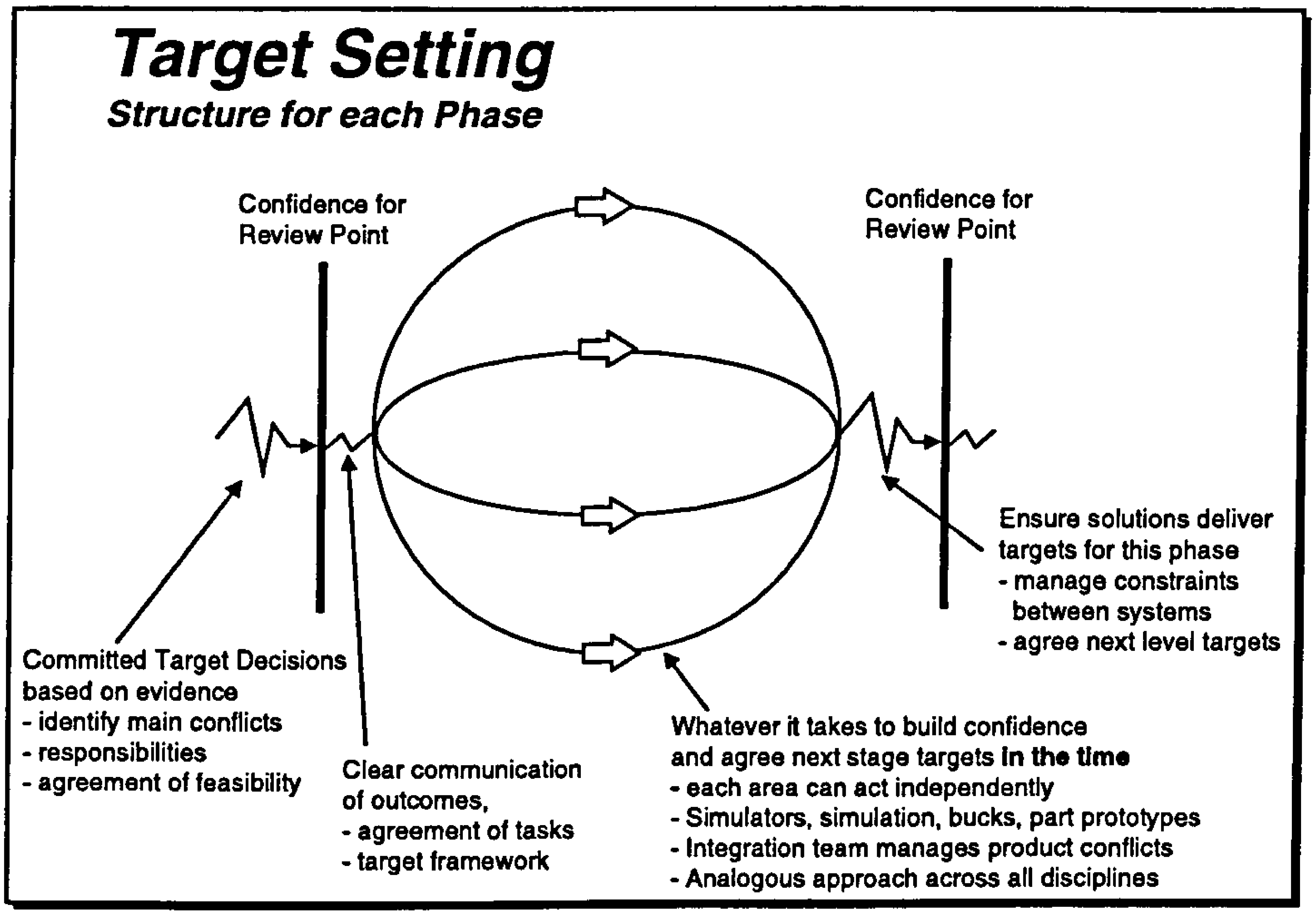

Figure 47 Structure of each phase of target setting

The basis for rigorous target setting has been found to be the following:

- The only valid targets for delivery are those that are committed, achievable and compatible with the business and market goals.
- Targets, once committed, are fixed and individuals are responsible for their delivery.
- No one should commit to a target unless they know they can deliver it to the quality, cost and in the time needed.
- Targets must be managed in a model that allows conflicts and trade-offs to be seen and managed.

In a complex product with many hierarchical levels, it is advisable to make use of IT tools to automate the target agreement process to some extent. This has been found to be desirable for two reasons. The first is that each target demand will have one owner, but the target may affect a large number of other product areas. The main areas affected must have a voice in whether the targets are acceptable. To do this by manually checking with each person affected brings significant complications and loss of time. This is particularly valid when hundreds of targets are involved, and each target may have ten or more people affected. The second reason for using an automated method is to ensure that the person agreeing has rigorously considered the target with their capabilities and constraints, as is given freedom to voice their concerns. The questioning must be done in a way that allows the person concerned to act in a professional and responsible manner. In the author's experience, a 'voting' approach based on a shared IT database has been found successful. However, while an IT-based approach gives scope for concurrent working at a distance, there are limitations to this practice. Where the target is not understood well, voting only reveals a disagreement. Even mechanising the responses does not lead to a rapid clearing-up of the confusion. Here, face-to-face contact with the target demander is necessary where designs are complex or their need is not understood. Where voting leads to a rejection of the target, leaders must be made responsible for co-ordinating work to solve the problems. The author has identified and implemented successful processes that accelerate target agreement, which allow problems to be escalated and responses optimised. These processes are detailed in section 4.1.2 and in project number 10.

4.3 THE USE OF THE BRAND FOR ORGANISATIONAL INTEGRATION

The value of a brand has been identified in this research as a useful device for aligning an organisation. The reason for this has been found largely due to the structure of the brand's properties. A brand as reported in section 2.9 was **"the promise of the bundles of attributes that someone buys and that provides satisfaction... The attributes that make up a brand maybe real or illusory, rational or emotional, tangible or invisible"** (Ambler, 1992).

Figure 48 is repeated above from section 2.9. Many brands have been applied to a product after it has been developed from business and competitive needs alone, and little from the psychological needs of the customer (Ambler and Styles 1996). These products generally find little additional value from being branded. By contrast, strong brands have high premiums, recognition and loyalty from their customers (Ries ad Ries 1998). This has clear financial value for a business, but there are other attributes that make the brand valuable as a design tool for the business.

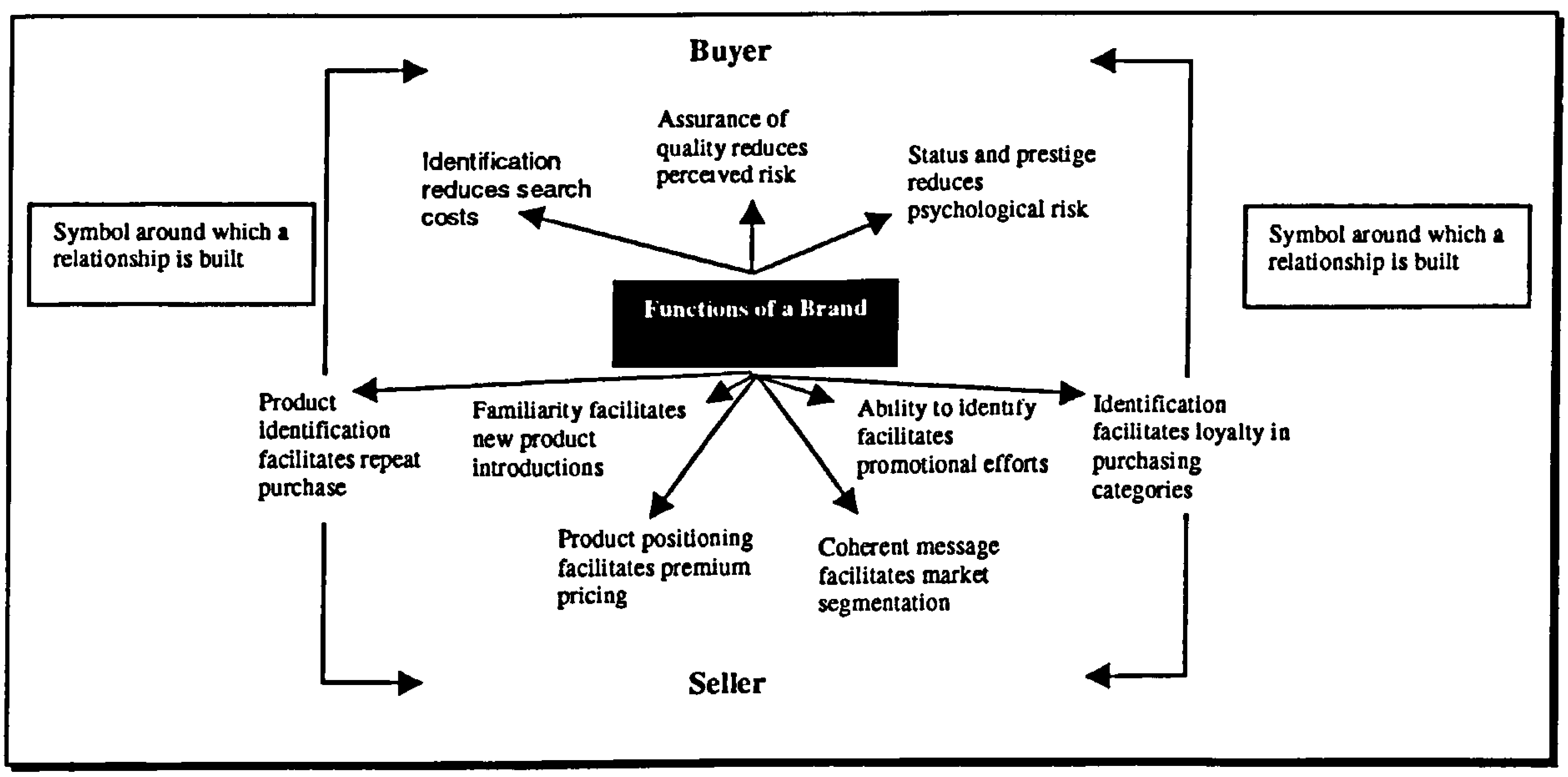

Figure 48 The functions of a brand (Berthon, 1999)

Firstly, the brand can be an emotional connection between the company and the customer, which makes customers more likely to accept new products from the brand in the future. The needs that are met can fall into one or more than one area of the Maslow triangle of human needs, and can give a long-lived reliance on the brand for more than functional reasons (Ambler and Styles 1996). Secondly, ***being best*** at something valuable to the customer implies that the competencies of the business are able to provide some real competitive value, which the customer recognises (Ries and Ries 1998). This suggests that an organisation should align its competencies with customers' changing needs – or find new customers that value the competencies that have been built up over time.

In the research, the brand has been found useful in various applications as a means of focusing competencies, technology and product choices. The target pyramid introduced in section 2.9 suggests a value for the customer for the look and concept of the product, its dynamics, and its potential to be customised to the personality of the owner. This has a number of uses, shown in figure 49.

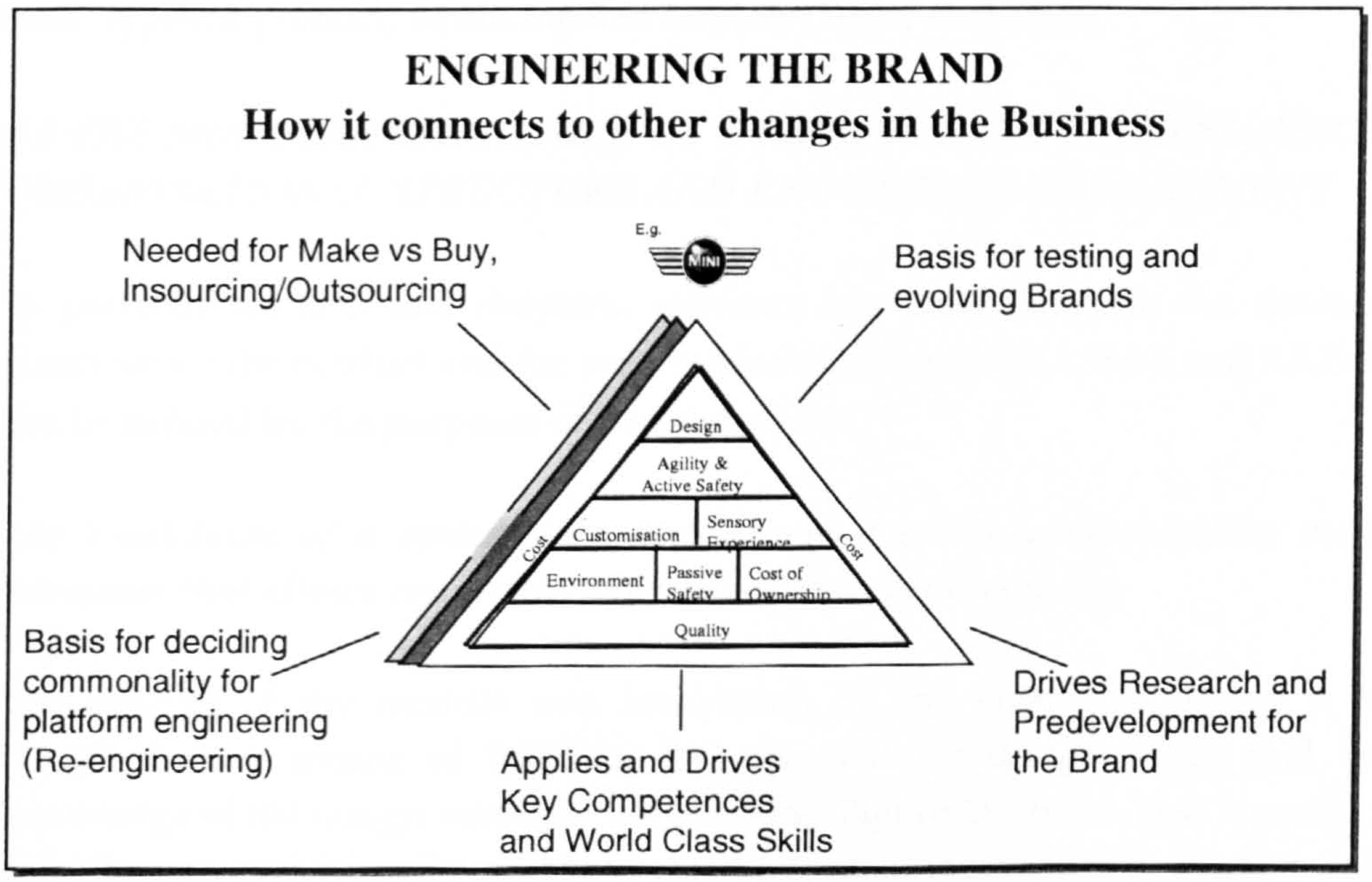

Figure 49 Applications of brand understanding to organisational integration

The ***competencies*** that would be required to maintain a high degree of value in the marketplace would be design (style), materials, dynamics and engine tuning, with probably a strong capability for engineering safe cars in small packages. If the brand requirements had been well-interpreted, and the brand was valuable in the customer's eyes, then the business could achieve a high profitability by ***insourcing*** on valuable aspects of design or manufacture, and ***outsoucing*** the provision of others (Quinn and Hilmer 1995). Understanding why the brand is valuable allows these values to be the basis ***for driving research and skill development*** for unique differentiators and new product concepts. Also, understanding the valuable elements of the product concept and the aspects of uniquely differentiating product performance allows these aspects to be preserved while sharing components with other products. This is known as ***platform engineering*** (Robertson and Ulrich 1998). In the long term, the values that the product stands for can either become irrelevant in the marketplace, or the product becomes so old that its previous differentiators are no longer delivered. Testing a brand against the marketplace, and gaining qualitative information in this way prevents products and their businesses from becoming dinosaurs through retaining an unquestioned 'magic formula'.

Further benefits have been derived from the brand in aligning other parts of the organisation and its business allies. Marketing and advertising agencies clearly need to understand and provide the right image for the product to appeal to customers. Manufacturing assembly areas realise that they must provide opportunities for the customised fitment of accessories, or unique material or paint finishes, while meeting competitive standards in the marketplace. This is clearly a better solution for longer term planning of a business than doing this by individual products passing through the business.

While automotive examples have been used, the target pyramid approach can be applied to many other types of product, which include services (Ward et al 1999).

4.4 THE MODULAR STRUCTURE OF A PRODUCT AND ITS INFLUENCE ON ORGANISATIONAL STRUCTURE AND KNOWLEDGE MANAGEMENT

In previous sections and chapters, reference has been made to the desirability of a modular structure for the product and the organisation in sections 3.2.1, 3.3.4 and 3.3.7. A modular structure can be defined for the purposes of this section as;

The breakdown of a system into discrete sub-systems, each resulting module having defined interfaces that allows concurrent and semi-independent working.

The concept of the module was introduced by the author in project 3 as a necessary and complementary means of fulfilling the potential for design speed and economical reuse of knowledge of the design model of the business. Figure 29 shows how a product and its associated manufacture and lifecycle functions can be broken down into a hierarchical structure. At the module, or sub-system level, a module team is responsible for the design and delivery of a part of the product and its performance. The boundaries of a module in physical (eg weight), geometric, functional (e.g. power, stiffness, noise), financial (e.g. investment and material cost) and data flow (e.g. electronic protocol) terms is well-defined to allow easy delineation of responsibilities and exchange of design information between modules. Also, the sum of module properties (physical, financial and other qualities) adds up to the properties of a system, allowing clear management of the hierarchy. Similarly, the system areas of a product add together to give the product properties. At the highest level, the set of products adds together to give the product portfolio and its properties, as shown in figure 50. Such a modular breakdown of the product-based organisation has many advantages:

- Organisational structures can be reused from one product to the next.
- The performance of modules can be understood and reused from one product to the next.

- Semi-independent module teams can work concurrently, in parallel, as their co-ordination needs with other teams are simplified and take place at defined points of synchronisation.
- The technological improvement of modules can be managed semi-independently from other modules, so long as module boundaries are respected, giving the benefits of speed in design and development.
- The process steps for each module in the design and development process can be reused from one programme to the next. This provides a platform of knowledge which can be assessed for effectiveness and efficiency, and improvements added rapidly from one programme to the next, on top of a stable foundation.
- The clear structuring of the organisation and the product and process technologies into modules allows the definition of architecture for a product, setting the interfaces to which future products must conform. The use of a variety of alternative modules on a predefined architecture allows rapid and efficient product innovation by reusing many of the modules.

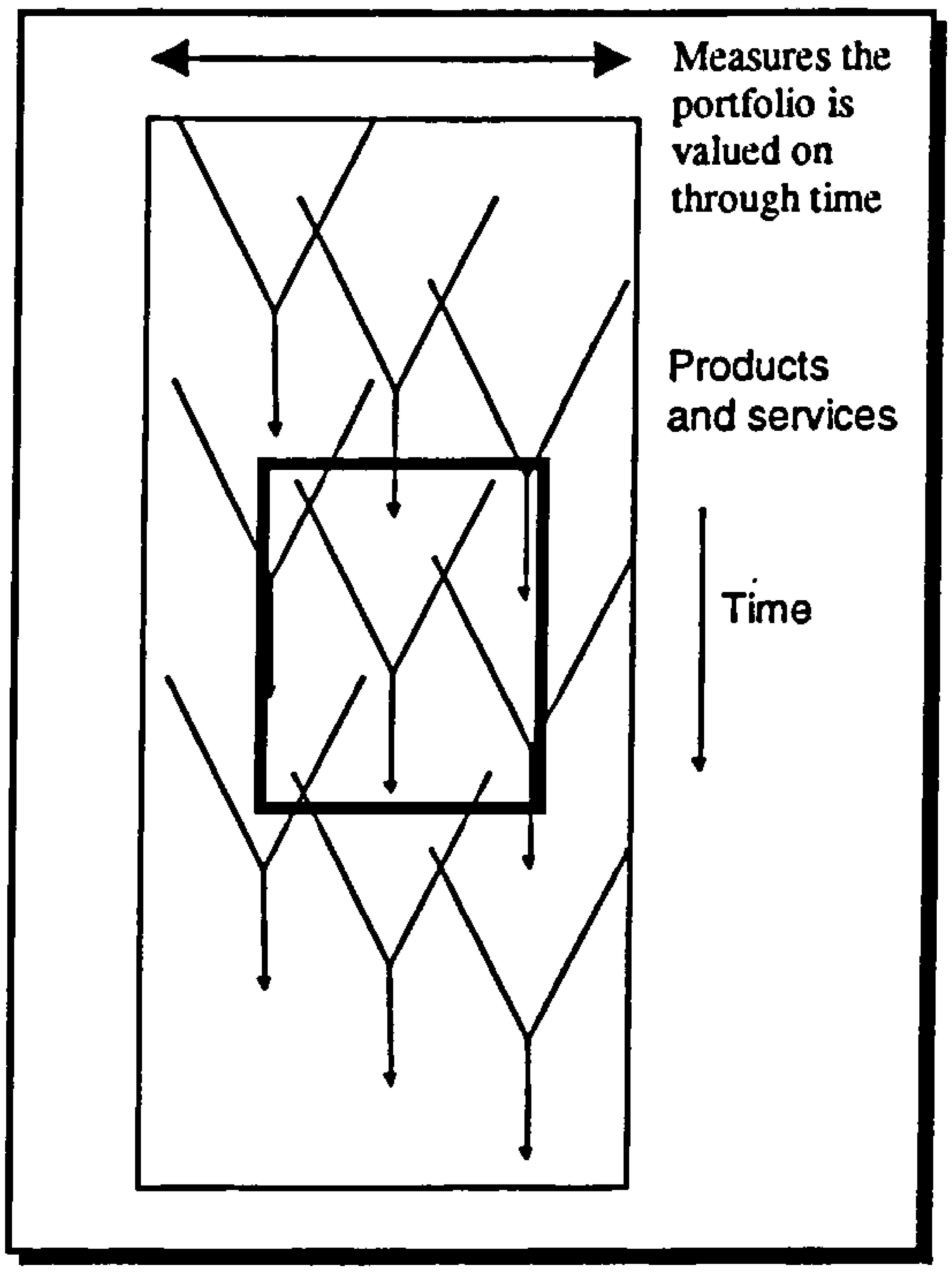

Figure 50 A representation of the product portfolio. The business targets for an individual product arise from the requirements of the portfolio, and the role of the product within this. In the case of complex organisational ownership, the product will belong to several sets of portfolios simultaneously.

At the highest level of an organisational hierarchy is the product portfolio, shown in figure 50 as a set of products bounded by time. A simplified structure for an automotive product team is shown in figure 51.

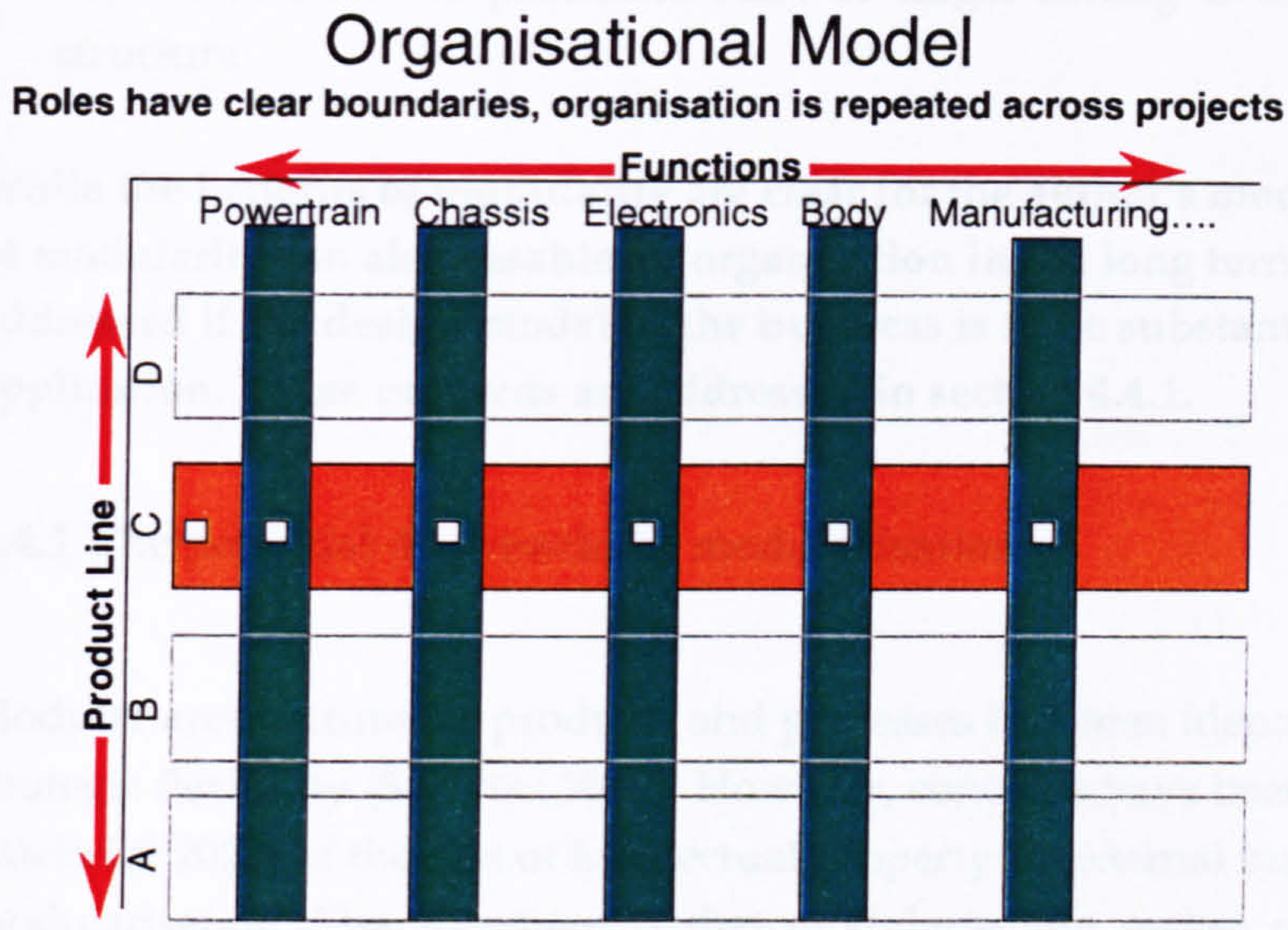

Figure 51 Conceptual organisational structure of a project team

To simplify the arrangement only a part of the functional areas are shown, and each would have a number of modules making up the team, which divide responsibility into semi-autonomous groups. Such a modular team is shown in figure29. A typical number of modules for a complex product such as an automobile are 50-90. The automotive example above would also include non-engineering functions – marketing and purchasing for example. The product line consists of the product leader and the integrating functions, their responsibility being to functionally and geometrically form the virtual product to integrate the efforts of the entire team. The benefit of such a structure is that: -

- The **roles and responsibilities** for each product are repeated across each phase. This allows the individuals to become used to the same process from one product to the next, and for that process to be improved and passed on to the next team.

- The **modular breakdown** of the product is repeated, with boundaries remaining similar. This allows expertise in the internal and external co-ordination and problem solving to be improved with time.

- The **initial structure and properties** of a module (for example, its bill of material, weight, cost and investment understanding, resourcing and performance targets) **can be reused** from previous programmes as a starting point for a new programme. This supports the parametric needs for fast design described in section 3.2.

- The modular nature of the product allows **external suppliers to engineer within a set of targets** bounded by the module. This allows simpler engagement and communications with a team.

- The automation of processes such as target setting is simplified by the reuse of modular structure.

While the benefits of modularity are clear for the author's model, there are concerns that the use of modularity can also disable an organisation in the long term. These concerns must be addressed if the design model of the business is to be substantially of benefits for organisational application. These concerns are addressed in section 4.4.1.

4.4.1 The potential drawbacks of modularisation

Modular architecture for products and processes has been identified as an important component of strategic flexibility (Sanchez 2000). However, concerns have been raised in research (Schilling 2000; Batchelor 2000) of the loss of intellectual property to external businesses through the application of modularisation. The argument is that modularisation makes parts of the product more loosely-coupled from a organisation to allow it to be outsourced. Once outsourced, the design and manufacture of the module effectively never comes back into the organisation because the organisation loses its capability, making reinvestment in assets prohibitive. As modularisation proceeds, the ability to engage in radical architectural innovation (new product concepts or new platform architectures) is lost. Figure 52 shows the author's interpretation of Schilling's points. The right hand side of the diagram equates to the firm's internal competence, and can be compared to the author's overview of the design model, shown in figure 53. A concern that this raises for the design model of the business is that it will ultimately lead to the loss of competitiveness of the business.

The important points to note in this are that there are two reasons why a business should move away from modularity in some areas of the product:

- Functionality from component specificity (only a unique component will give differentiating performance)

- A business desire to retain market power or architectural control

4.4.2 How the design model of the business overcomes the drawbacks of modularisation

Benefits to moving to internal modules are numerous, particularly when there is a high rate of external change or competition, and customer risk from technological change. Many of the pathways lead to external modularity. While there are pressures in an unstable world to lose distinctiveness, this trend has always been the case. Modularity provides a means for finding cheaper sources of supply, and for providing strategic flexibility, and on its own it is a strategy for losing distinctiveness. However, there are two reasons why this is avoided in the set of principles proposed in this research:

- The design model of the business aims for planned differentiation through platforms and modules. There is a very clear strategy to form on how a brand and product should be differentiated.

- The benefits of long term strategic alliances with appropriate partners increases the likelihood of being able to continue a differentiating, innovative business (Lamming 1993; Quinn and Hilmer, 1995). This was the situation found with the symbiosis found between Toyota and its strategic suppliers (project 4).

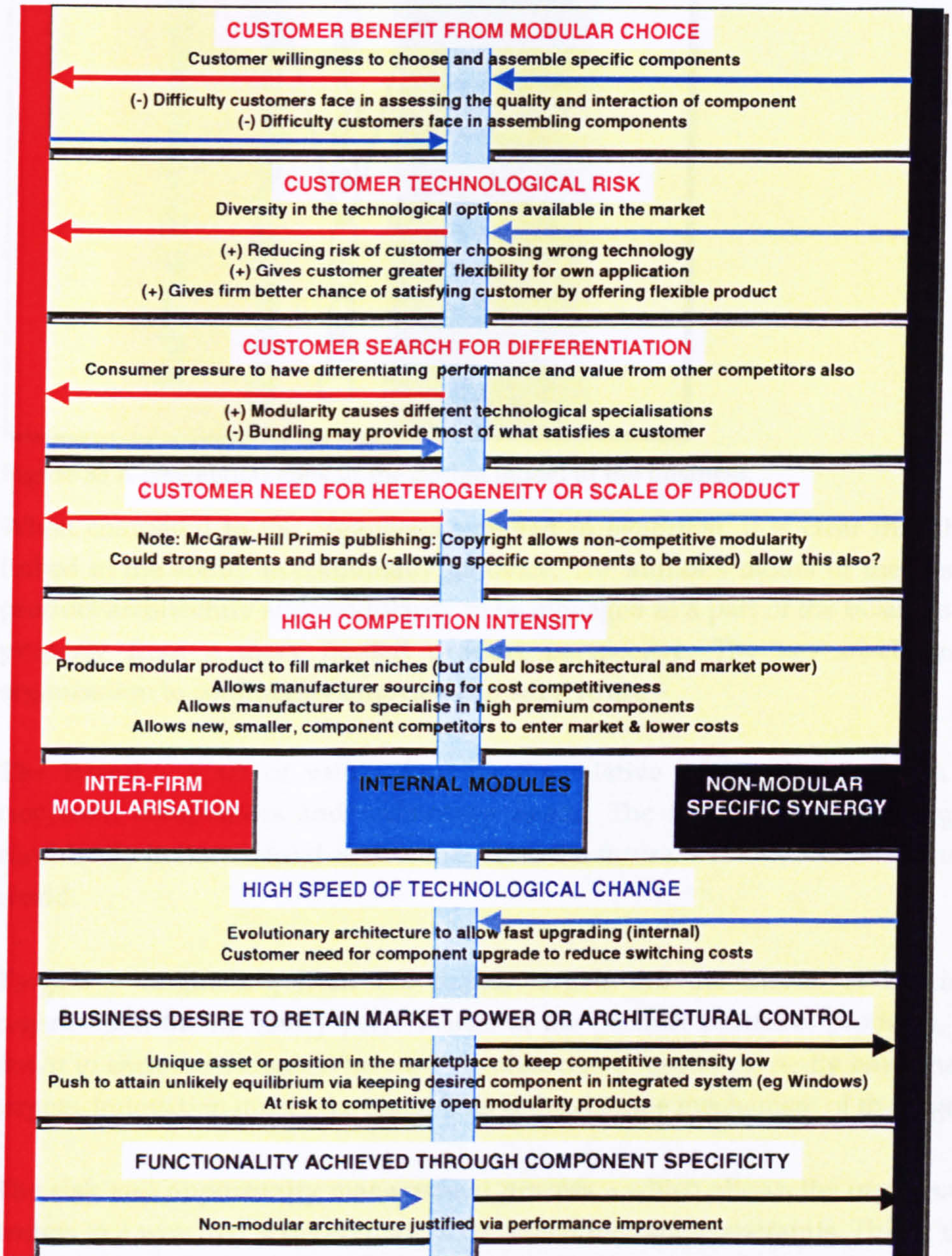

Figure 52 Pressures for introducing or moving away from modular products. Moving to the left moves away from modular designs, to the centre increases internal modularity, while to the left moves to open supply from other organisations

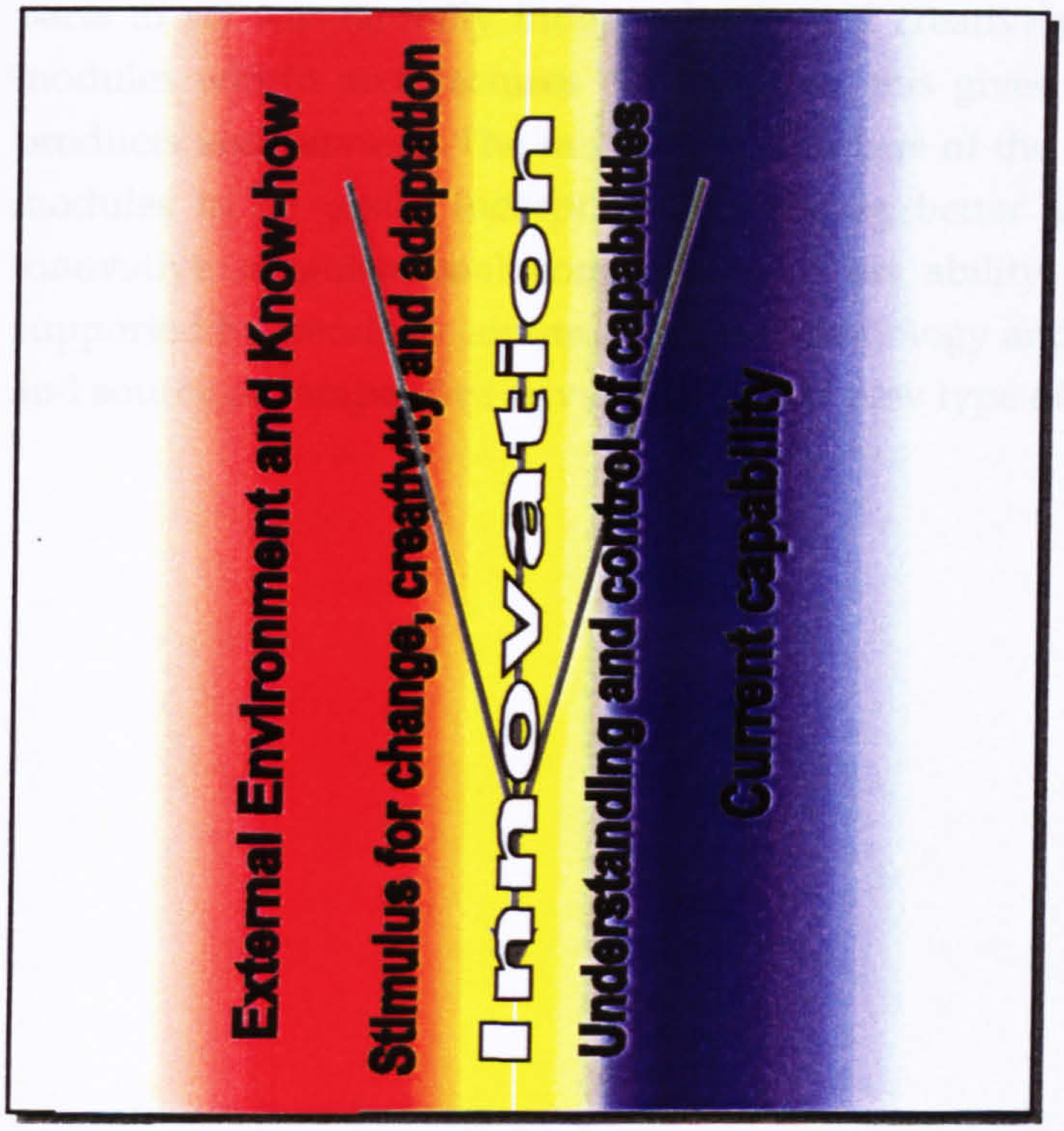

Figure 53 A conceptual view of the design model of the business.

When compared to the organisms explored in evolution, it is clear that the ability to survive is linked to the ability to continually innovate. The author's model of the design process allows the product architecture and modularity to be managed as a part of the business rather than seeing this property from a more limited product perspective. The key mechanisms which allow the organisation to continually innovate and survive are :-

The Brand – a set of values forming the relative relationship between the organisation, the customer, competitors and technology needs. The brand allows the organisation to ***navigate*** confidently in the external environment into the future, without becoming insensitive to the outside world.

Targets – originating from the brand, targets are the means of making visible across the organisation the necessary performance of the product portfolio, products, systems and modules down to each individual. Where the organisation does not currently have the capability of meeting targets, innovation must take place. This is the ***steering*** mechanism of the organisation.

The risk and opportunity management process – which allows the organisation to respond to the targets in a way that takes account of its capabilities and constraints. This is the ***control*** mechanism of the organisation.

The modular hierarchical structure of the organisation – which provides a mechanism for the organisation to be guided as one whole entity, but which provides a mechanism for each of the parts to act substantially independently and creatively within boundaries. Through the reuse of modules within architectures or platforms, this gives new mechanisms to improve efficiency of products and services. The more open structure of the organisation allows new competencies and modules to be easily incorporated, allowing better absorption of more efficient, effective and innovative organisational components. This ability to absorb and ally new competencies is supported by trends in communications technology and globalisation, and provides the ***propellant*** and source of competitive advantage for the new type of enterprise.

5. THE APPLICATION OF THE DESIGN MODEL TO A NON-AUTOMOTIVE DOMAIN

The design model of the business has been explained to allow a wider understanding in previous chapters, and has been shown to be based on universally - applicable theories of the system and the innovation process. However, the application of the model to other than an automotive environment has not so far been shown.

The aim of the work that is reported in this chapter is to demonstrate that the model is applicable in principle to a wider set of domains. The section is laid out in the following way:

5.1 Choice of the domain
5.2 Characteristics of the chosen domain
5.3 Application of the design model to the domain
5.4 Evaluation and conclusions

5.1 THE CHOICE OF A NON-AUTOMOTIVE DOMAIN – HEALTH CARE

To meet the objectives of the research, the domain to which the model should be applied needs to meet a number of criteria. Ideally, the domain should be far-removed from the author's domain of research, involving neither manufacturing nor the automotive industry. It should present sufficient complexity to be non-trivial, and should be sufficiently open to obtain detailed information. The subject should, for the purposes of building confidence in the design model, be well enough understood to allow critical assessment of the findings. To allow the author's work to be more generally useful, an area should be chosen where the application of the model could have wider beneficial effects.

The domain chosen is that of cancer care. A manual of standards and performance indicators has recently been published (NHS 2000) which fixes the structure of national and regional cancer services and sets measures and standards for the treatment of patients in cancer centres and units. The information published is sufficiently transparent to allow insights to be gained, but has no associated visual models to assist the comprehension of the healthcare professional or the external observer.

The domain chosen constitutes an acceptable test of the design model to the requirements laid out. Section 5.2 lays out the characteristics of the domain in the next section.

5.2 CHARACTERISTICS OF THE CHOSEN DOMAIN

Every year in the UK, over 200,000 people are diagnosed for cancer in the UK and 120,000 die from the condition. One in three people are diagnosed with cancer at some time in their lives, and one in four of the population dies from it. Recently, there has been unfavourable comment on the quality and national variability of cancer services in the UK – the 'post-code lottery' (NHS 2000b). There are also higher cancer death rates of manual workers compared to professionals, a factor of five to one due to higher rates of smoking. Survival rates and standards of care also vary for different cancer types – in some instances much lower than for many European countries. Some of the reasons are the uncertainty of patients as to whether to bring symptoms to a GPs attention, variability in GP's recognition of cancers, hospital equipment which is out of date and inadequate, a shortage of cancer professionals, and long waiting lists for hospital diagnosis and treatment. The quality of communication between healthcare professionals and patients and their carers has also been variable, leading to distress and difficulty of making appropriate decisions.

Recognising these shortfalls, the UK government NHS Cancer Plan (NHS 2000b) has focused additional spending and reforms to offer 'fast, convenient, high quality care, with patients at the centre'. The plan covers all aspects of cancer care, including broad epidemiology, primary (first contact) care, secondary healthcare (the referral services of consultants), tertiary treatment (at specialised hospitals or units), hospice and homecare – as well as the work of voluntary groups and government departments. Objectives and actions have been set for improved cancer prevention, earlier detection, and a guarantee of effective treatment and care. These aim to lower the death rate, improve prospects for survival and improve quality of life for those affected by cancer.

The main points of the plan are the following: -

- A Cancer Plan focus of patient-centred care, with objectives for quality of communication and range of support throughout the 'cancer journey'.
- A reliance on evidence-based treatment in particular areas such as palliative care.
- The establishment of National Networks, each covering all involved services for a population of 1-2 million people, and the clear definition and scope of the work to be done in the cancer centres and units to facilitate the optimum delivery of services within the network.
- The establishment of Network Site Specific Groups (NSSGs), specialist groups for specific (types of) cancers across each network, each agreeing specific policies and pathways for the delivery of treatment and care.
- Cancer centres and units, which are the functional organisations designated to facilitate the optimum delivery of services, and onward referral of cases. Each has clear leadership, with a lead clinician, lead nurse and lead centre or unit manager, and adequate support.
- The formation of multidisciplinary teams for each of the main site-specific cancers (breast, colo-rectal, lung and gynaecological) and a non-specific team. These are responsible for :
    - Decisions regarding all aspects of diagnosis, treatment and care of individual patients and decisions regarding the team's operational policies are multidisciplinary decisions.
    - To ensure that care is given according to recognised guidelines with appropriate information being collected
    - To ensure that mechanisms are in place to support entry of eligible patients into clinical trials,

- The setting of roles, staffing and qualifications and training for each of the teams
- The setting of standards for response times and measures for patient levels, treatment effectiveness and times.
- The redesign of processes to cut waits and improve patient experience.
- The setting of roles, responsibilities and standards of qualification, training and practice for each of the specialist functions. The specialist functions include imaging and pathology, non-surgical oncology support, chemotherapy, radiotherapy, specialist palliative care, education, training and professional development, and communication. Other specialists in the extended team could include psychiatrist, social worker and others, depending on the team and needs.

5.3 APPLICATION OF THE DESIGN MODEL TO THE DOMAIN

From the information in the national standard, it has been possible to organise the information against the framework of the author's design model of the business. While some of the terms would need to be changed, many of the concepts are portable across the domains. The main points considered in assessing the compatibility of the case study with the design model were the following: -

<u>The focus of cancer care.</u> The object, or project centre, of the work is clearly intended to be the individual patient in this case. This fits the philosophy embodied in the design model, which focuses on the success of the project outcome (the patient in this case) as the means by which the success of the organisation is judged. The project is also the object on which the innovation of the organisation is focused, again consistent with the cancer care model.

<u>The use of 'Brand Values'.</u> While brand values are not mentioned, the image and real underlying performance of cancer care in the UK is being targeted. The image that the NHS wishes to be projected to the patient, and to the public more generally, is for the effectiveness and speed of treatment, and the psychological values of 'knowing what's happening' and a sense of support for the whole 'cancer journey.' This is the equivalent of a product organisation's use of the brand.

<u>The central use of targets</u>. Measures are established for population incidence, referral rates and times, improvement goals, unit capability and capacity. These allow the comparison at the whole network level with other networks, the improvement across time within the network, the efficiency and effectiveness within centres and units down to the individual specialisms. This again conforms to the author's model.

<u>The use and meaning of decisions.</u> There are a number of clear points where irrevocable decisions are made in the process. A list of clinical trials is decided as being mandatory across a particular network. A diagnosis is made, with any evidence necessary to support this being generated through the use of a therapeutic operation if necessary. A treatment decision is made by the multidisciplinary team.

A systematic approach. All networks are structured in the same way. The Network Group covers all the cancer care groups in its area. NSSGs are subordinate groups to the Network Group, and recommend policies and pathways for treatment and care across the range of health providers. Cancer Centres and Units are responsible to the network, and work within a formal definition and scope of the work they will do. Individual multidisciplinary teams form the 'project teams' for the major types of cancer site. Within the project teams are equivalent functional specialisms forming the teams.

Clear roles and responsibilities. Individual nominated persons are responsible for leadership and standards are set out for qualifications, training and roles within the Network Groups, Cancer Centre and Unit leadership, Multidisciplinary Groups, and functional specialisms.

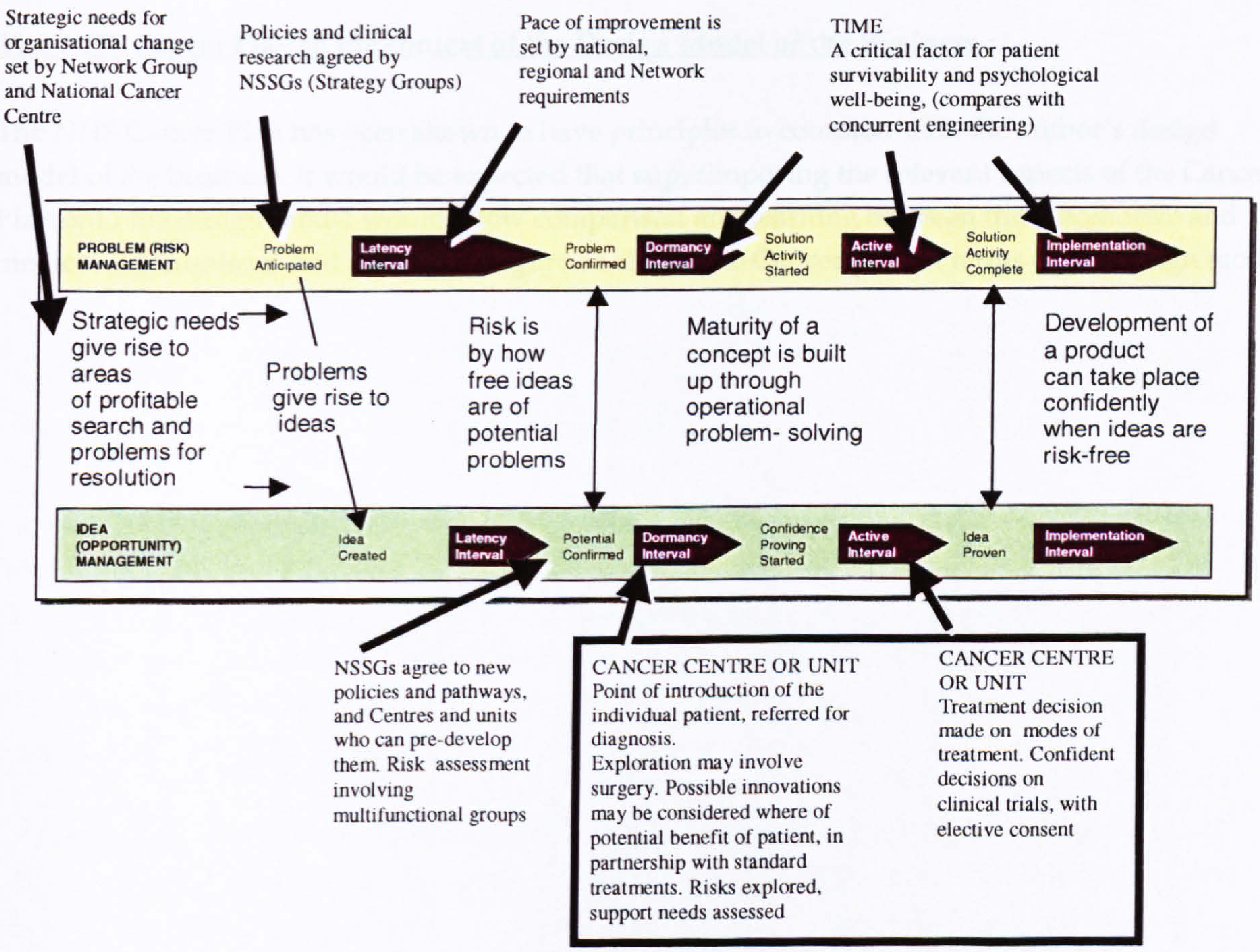

Figure 54 A comparison of risk and opportunity processes with the NHS Cancer Plan.

A modular approach. The mandatory structure of groups and their measures across all networks allows the comparison of performance and the rapid sharing of best practice. Their equivalence allows learning to be made on optimum resources, and for the results of clinical trials to gain better acceptability.

A compatible approach for opportunities, problem management and concurrent engineering.
The same approach described in section 2.10.2 for the interaction of problems and opportunities is valid in this case. Figure 55 shows how targets for organisational strategic innovation are set, and how new clinical research and policies are originated, assessed and developed against these needs and opportunities arising from the NSSGs, which are composed from the Cancer Centre and Unit specialists. When new policies or clinical procedures are proven in principle, it is presumed that specialists can consider whether or not to apply these to individual patients on an elective basis. This is considered at diagnosis, and confirmed at the treatment decision, following the agreement of all multidisciplinary parties, and of course, the patient.

The importance of time and evidence-based decision confidence is an important factor, as with the automotive domain. The use of multidisciplinary teams is adopted, as with concurrent engineering.

The NHS Cancer Plan in the context of the Design Model of the Business

The NHS Cancer Plan has been shown to have principles in common with the author's design model of the business. It would be expected that superimposing the relevant aspects of the Cancer Plan onto the design model would allow comparison and learning between the automotive and medical organisations and processes. Figure 55 shows the Cancer plan in terms of the design model.

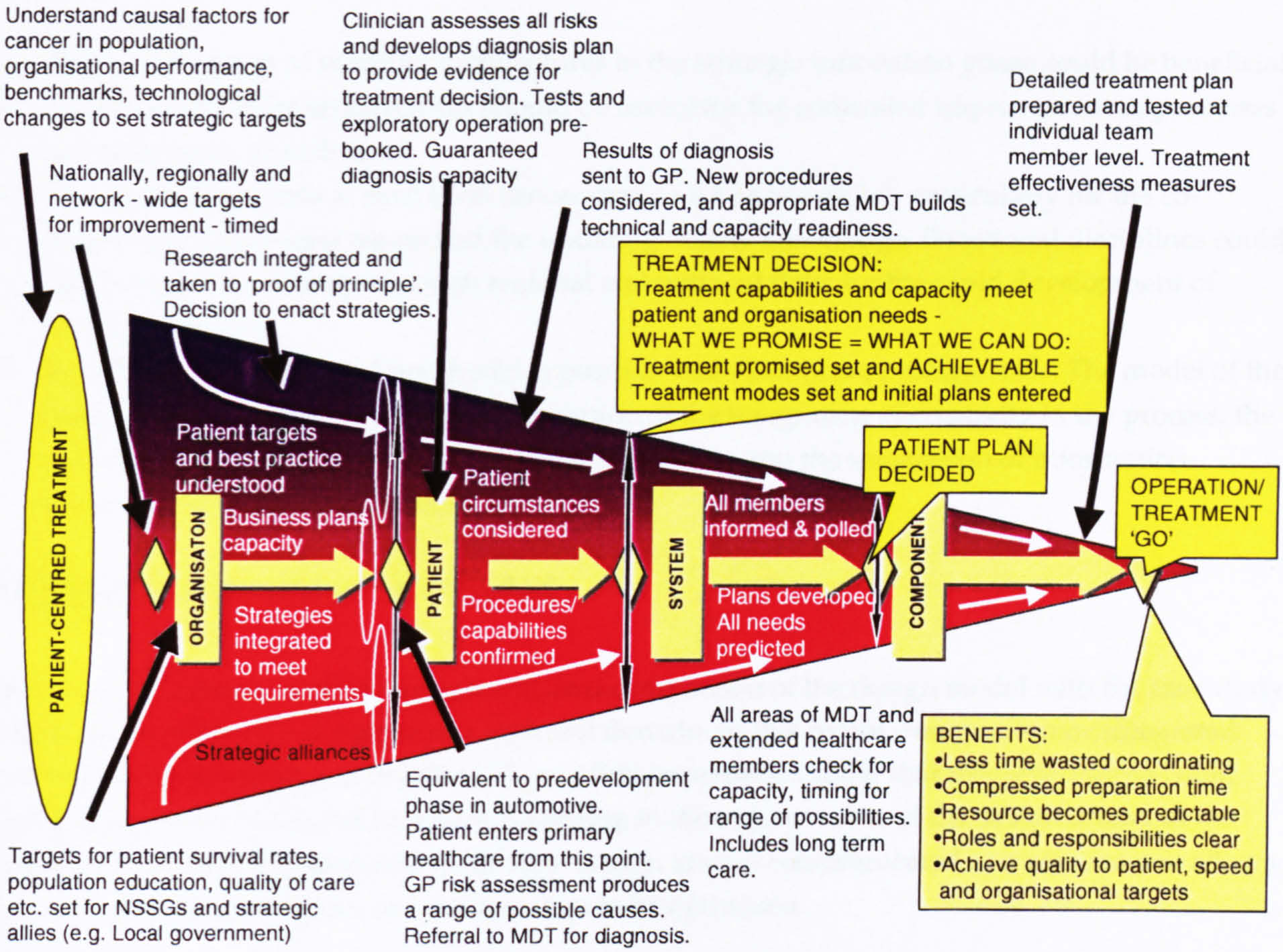

Figure 55. The design model of the business for Cancer Care. Internal and external know-how and creativity, and the feed-back of hierarchical capability are not included to allow clarity

The design model of the business integrates the national and network requirements with clinical and network improvement, and then the care of the individual patient through the treatment 'design process' up to the point of commitment to treatment. A few points must be noted in this comparison:

- Many of the concepts are comparable to the model for automotive project. The medical case appears to be better developed in some instances than the automotive – in the setting of long term targets for the organisation, for example.
- The overall speed of the design process is much faster in the cancer care example than in the automotive domain. Elapsed time targets for start of treatment from referral are as low as 48 hours. Some techniques could be beneficial to the automotive world.
- Concepts that could be transportable from the author's innovations could include innovation tools, competency development, set-based targeting and risk assessment. Depending on the decision-making culture in the NHS and associated partners, changes in behaviour may also be needed to make the model work satisfactorily. The quality of decision points cannot be properly

assessed by the author, as these would need to be further investigated by a medical professional.

- The consideration of modular architectures in the strategic innovation phase could be beneficial.
- The use of modular architectures should be useful for the controlled improvement of processes and treatments at each level.
- The use of IT systems at each level cancer care could be beneficial, particularly for the co-ordination of extended teams and the updating of new knowledge. Functional disciplines could also benefit from linkage through regional and national links for the rapid development of excellent practice.
- Evaluation of the Cancer Care model is possible with healthcare professionals. The model of the design process would suggest an examination of the integration of creativity in the process, the recording and use of internal and external know-how and the integration of information associated with each hierarchical level.

5.4 EVALUATION AND CONCLUSIONS

The above assessment shows through an initial comparison of the design model with the case study that it can be applied in principle to a different domain. In this recent example, a new integrated process has been introduced into the UK, and first impressions show that the new process could bring significant benefits if it functions according to the requirements of the design model of the business. Currently, the elements of the new system are not communicated in a manner that allows its benefits to be understood, or for the system to be optimised.

Further potential benefits exist for developing the case study further with healthcare professionals, a project to be pursued at a later date with the Peterborough National Health Trust.

6. CONCLUSIONS

This research began with two objectives. The first of these was to find the causes of strategic inflexibility in an organisation, and the second to find solutions for addressing these problems. The research benefited by investigating strategic inflexibility, rather than initially seeking new solutions that could compound previously existing problems. Not only have causes of strategic inflexibility been understood, but also a framework for strategic flexibility has been developed from this, and implemented through tools and processes. The following conclusions can be drawn from this work:

STRATEGIC INFLEXIBILITY HAS BEEN FOUND TO HAVE A BEHAVIOURAL CAUSE, WHICH CAN BE OVERCOME THROUGH CATALYSING HIGH QUALITY DECISION-MAKING

1. **A causal factor for strategic inflexibility is a behavioural dysfunction in individuals that produces a system-wide effect.**

A systems model of the decision-making culture has been developed, which provides a behavioural explanation of strategic inflexibility. The principles identified in the model have been found to explain the wider consequences of individual behaviour in complex organisations. A dysfunctional decision-making component of an organisation, whether an individual or a group, causes a disconnection between the external world and the organisation's response. The beneficial behaviours necessary are; to adequately recognise goals and challenges important to the organisation's future; to use a rigorous approach in setting goals and making decisions; to fully consider the external environment and alternative futures when making decisions, and being fully open to constraints and opportunities. Any deficiency in these traits leads to some level of strategic inflexibility, with a dysfunctional individual or decision-making group being at least partly prevented from responding to external threats, alternative solutions, internal limitations and opportunities. Dysfunctional behaviours exhibited high in a decision-making hierarchy also influence hierarchies below them to adapt to, and reinforce this behaviour. The choice of leaders in an organisation is therefore highly significant to the operation of an organisation, as it colours the quality of behaviour below it. The model tends to support the popular disenchantment of 'top-down' methods of management, which rely on decision-making individuals using internal value models, internal sources of expertise, and internal creativity to drive an organisation. While highly skilled individuals would perform adequately in simple environments and less knowledge-intensive organisations, at the very least such behaviour prevents lower levels of the organisation from becoming proficient and contributing their creativity, know-how and professional judgement. It also puts management hierarchies under increasing levels of stress when faced with greater levels of complexity. This indicates also the difficulties of moving from top-down to more collaborative working, in that learned behaviours in subordinate hierarchies do not immediately unlearn previous behaviours, making a transition to a more open style of decision-making less likely to succeed.

2. A model of decision-making behaviour has been developed, which identifies the areas of individual and group decision-making behaviour that affect strategic flexibility, and their consequences. The same model also provides the basis for the evaluation and improvement of such behaviours, and has led to the development of processes and tools to catalyse the adoption of high quality decision-making cultures.

Making the mechanism visible has also provided an understanding of how behaviours might be changed to overcome the human element of strategic inflexibility. A fundamental change to individuals' and groups' decision-making behaviour is essential in the areas described above. However, behaviours are unlikely to change unless there are catalysts to reduce the high levels of effort required from all participants in a decision hierarchy. The model has proved useful in making dysfunctional behaviours visible, but has also provided guidance in the development of processes and tools to overcome collective dysfunctional behaviour. These principles have been applied both to the governance of an organisation and project hierarchies. The tools are also more generally applicable. The research has met the objective of describing the systematic model of decision-making culture, its potential dysfunctions, and the approaches available to correct these.

A DESIGN MODEL OF THE BUSINESS HAS BEEN DEVELOPED TO HELP ORGANISATIONS MANAGE STRATEGIC FLEXIBILITY

3. A design model of the business has been developed which relies on appropriate decision-making behaviour to effectively employ the intellectual and physical assets of an organisation to meet its goals. Organisations based on the design model would intrinsically manage strategic flexibility as they would continually prepare for potential future threats and opportunities to ensure evolutionary fitness.

THE PARTS OF THE DESIGN MODEL HAVE BEEN DEFINED

4. In the design model of the business, the goals of the organisation are met through the lifecycles of the products and services produced. The organisation is integrated through a focus on the value generated by these products and services, and the competencies and resources to produce that value.

5. Individual innovations in organisational processes and tools have been implemented which have been central to the development and introduction of the design model. These are in the areas of innovation management, organisational and product targeting and target agreement, and have been described to allow their wider application.

Guidelines and individual tools and processes have been created and applied. These include the following:

- Methods of managing the research and technology needs in an organisation
- A process for managing technology issues.
- A trendline process for agreeing future product targets and technology needs.
- A process for converting brands into targets at all levels of an organisation.
- A tool for communicating customer needs to spur innovation.
- A tool for identifying required future capabilities and their sourcing.
- A model defining the 'fuzzy front end' of product development.

Many of these are associated with target-setting and target agreement, identified as being an essential support for decision-making where the product or service is complex, and many people are involved in its design. The main innovations that are broadly applicable have been described.

6. The concept of brand has been shown to be an essential means of optimising the organisation's relationship with the marketplace in the long term, medium and short term. Because the values of a brand connect to long-lived human values, they provide stability for long term planning and can readily communicate internal decision-making values throughout an organisation.

A major finding in the research was the utility and universality of the brand concept. As a basis for product values, decision-making culture, core competencies and innovation, the brand provides a method for guiding an organisation for longer-term survivability. The methods and tools used have been described in the body of the research, and successfully applied and generally applicable methodologies have been shown.

THE DESIGN MODEL IS GENERALLY APPLICABLE TO A WIDE RANGE OF ORGANISATIONS

7. The model of the business is applicable to a wide range of organisational cultures, and is compatible with and integrates recent trends in organisational thinking. The model has been explained to allow its wider application.

The design model of the business has been developed as a tool to simplify a complex interaction of hierarchies, while not losing the qualities that govern beneficial complex behaviour. It has proven to be of benefit in diagnosing the problems of businesses in the manufacturing domain, and in identifying the potential solutions for improved strategic flexibility. The principles on which the model is based are compatible with emerging thinking on innovation, complex behaviour, competency and knowledge management, which imply that a much broader application of the model should be possible than for the four automotive cultures examined in the body of the research. A healthcare case study has shown that the model is applicable to very different organisational circumstances also, providing confidence that a much wider application can be gained.

8. The design model of the business is suited to the integration of both single organisations and collections of co-operating entities. This will become an increasingly important area of growth as competition and technological change becomes more intense.

The design model will facilitate the virtual business, an assembly of individuals and organisations forming an integrated enterprise for a limited time, and more likely to be tied together electronically than by geography. The rules and behaviours discussed in this research will support the surer formation of such organisations, whether for profit or non-profit. A vision of the future is that of fast evolving groups of entities at every level, binding together briefly in time to take their part in new ventures, and rapidly reforming with other bodies to produce new organisations. The result will be more efficient and fuller exploitation of know-how and creativity to stimulate market needs with new value, and doing this at lower costs overall. The overall result is likely to be that economic growth is better served by such organisations, and the human and environmental benefits are likely to be substantial.

A NEW CONFORMATION OF ORGANISATION HAS BEEN FOUND NECESSARY TO ALLOW CONTINUOUS INNOVATION AND ORGANISATIONAL LONGEVITY

9. Organisations, products and processes must be partitioned in contiguous modules to meet the simultaneous requirements of design speed, knowledge reuse and appropriate decision-making behaviour at the lowest possible level of the organisation. This allows the ready integration of external partners into the organisation, making it responsive to a changing environment. While modularity in a traditional organisation could lead to decay and loss of strategic flexibility, its integration within the design model framework leads to a dynamically unstable, but continuously innovative and long-lived organisation.

One of the effects of a systematic approach to decision-making and design in an organisation is to allow its modularisation into cells that semi-independently manage themselves to design, produce and market products and services. The benefits for speed of innovation, creativity and cost are potentially extremely important, not only for economic entities, but potentially also for social ones. 'Organisms' can improve quickly to benefit the customer in achieving the goal implied by the 'brand.' In competitive organisations, there are concerns that increasing modularity could destroy the ability of the organisation to innovate new product or service architectures. The model of the design process has a relevance to this question. It shows that the organisation needs a long-term attractor on which to base its acquisition of competencies in the continuous search for mutual benefit with its customers and allies. Without this, the organism is unfocused, or focused only tactically through individual, short-lived, personalities, and will eventually run out of energy to innovate, and die. While a strategy for achieving rapid and more efficient innovation is achieved through modularisation, a tendency for long term loss of competitiveness can be overcome through the integration of this strategy within the design model framework.

The design model of the business brings together high quality decision-making behaviour with a modular structure of organisation, process and product. This combines the efficiency, ease of competence structuring and speed of modularity with the drive for effectiveness, coherent integration and creativity produced by the design model. The result is an architecturally stable, yet continuously changing, innovative and long-lived organisation, more responsive and fitter for survival than are its evolutionary predecessors.

7. CONTINUATION OF THE WORK

A number of aspects have been identified as being central to the design model of the business in the conclusions of the previous chapter. The main findings and innovations shown as capitalised text in chapter 6 are paraphrased below, and each is examined to identify continuing and further work needed in the author's business, and to organisations in general.

1. The need to catalyse high quality decision-making to overcome the behavioural causes of strategic inflexibility

- *Internal to Land Rover*

From being an employee of Rover Group at the beginning of this research, the author's business was bought and managed by BMW from 1994. In the year 2000, the Land Rover part of Rover Group was sold to Ford, where the author is now employed as a strategist in Product and Cycle Planning. The author's current work includes developing and introducing mechanisms for the corporate governance of the company that supports an 'ideal' culture for decision-making. The focus of work in this area is the application of techniques to speed the flow and quality of decision-making through:

- The adaptation and standardisation of a decision support process (Product Direction Letters) to raise awareness of constraints and to communicate business decisions on products and strategies deeply within the organisation.
- The introduction of parametric estimation techniques to support rapid decision-making.
- The improvement of individual decision-making behaviour through explicit implementation of the escalation process explained in section 4.1.2.

While Land Rover is mentioned specifically, routes for the dissemination of the work to the much wider Ford organisation is also under consideration.

- *External and further work*

Literature and direct contact with personnel in other companies and organisations shows that dysfunctional decision-making cultures are still common. There is a need for visibility of the model and the strategies developed by the author to promote correct decision-making. Part of the dissemination is taking place through collaborative research programmes with other sectors such as construction, healthcare and pharmaceutical.

The potential exists for the model to form the basis of a broader model of decision-making and its associated corrective strategies.

2. A design model of the business has been developed to help organisations manage strategic flexibility

- *Internal to Land Rover*

The author is using the design model of the business to act as a focus in the development of new processes, including: -

- The development and introduction of the 'Business Phase' discussed in section 2.10.3.1 to form the change requirements of the Land Rover organisation in the context of a range of future scenarios.
- The development and introduction of a process to synchronise the product, financial and technological concepts of new products and services in the Business and Strategic Innovation phases discussed in section 4.2.

- *External and future work*

The potential for the future dissemination of the design model of the business is considerable, and is likely, initially, to take the form of teaching and individual organisational applications. The model's form and level of information could be improved with further developments to aid clarity and visualisation.

3. The definition of the individual parts of the design model

- *Internal to Land Rover*

The processes developed during the course of this research are not exclusive, and are undergoing constant evolution as they are adopted and adapted to new organisational entities, circumstances and new channels of communication. Beneficial processes such as automated workflows for product decision-making also being recognised and introduced from other businesses in Ford.

- *External and Further Work*

New processes serving the goals of various sections of the design model would improve the utility of the design model, as long as the boundaries and entities of the model are respected and they improved on the methods described in some way. There is no reason why alternative methods could not coexist for various parts of the model to cope with the different organisational needs.

4. The applicability of the design model to a wide range of organisations

The automotive application has already been well described. The application of the model to a wider range of sectors has been described, but its operational application is outside of the scope of this work. Clearly, the expansion of applications by the author and other workers is needed to further prove the applicability of the model.

5. The need for a new conformation of organisation to allow continuous innovation and organisational longevity

- *Internal to Land Rover*

The application of modular organisations, processes and product architectures are being developed and implemented from the strategic down to the component level. The concepts outlined in this work are being actively applied to co-ordinate the responsiveness and efficiency of future products and services in the corporate long-range plan.

- *External and future work*

While the benefits of modular organisations are becoming recognised (as described in chapter 4), their practical adoption into new sectors has a high risk of failure unless the critical interacting elements of a successful modular organisation are understood. This implies the need for a significant amount of dissemination and assistance to organisations wishing to move to the future paradigm. Related groups of organisations (e.g. suppliers and business allies) could reap substantial advantages by becoming first movers in a sector, nation or region. While the author's organisation should be the first to benefit from this work, the unfolding of the design model, from whatever source, will have significant implications on competitive and organisational structures.

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Appendix A

REVIEW OF LITERATURE AFFECTING 'THE DESIGN MODEL OF THE BUSINESS'

REVIEW OF LITERATURE AFFECTING 'THE DESIGN MODEL OF THE BUSINESS

1. INTRODUCTION

This document places the author's 'design model of the business' into the context of relevant areas of learning. As the design model was conceived towards the beginning of this research, more recent and references from wider fields are used. Section 2 overviews the main features of the design model of the business, and then goes on to identify the main bodies of knowledge that can be applied. These areas are overviewed in section 3, and the model placed in context. Overall conclusions are drawn in section 4 that state the points of agreement and differences between the literature and the design model of the business.

2. DESCRIPTION OF THE DESIGN MODEL OF THE BUSINESS

The 'Design Model of the Business' is the author's decision-making framework for the new product introduction process. By making visible consecutive hierarchies of the product process, it is able to connect together each level of the design process from the decision-making process of the portfolio of all products, though to an individual component and its assembly into an individual product. Each of the hierarchical levels is responsible for making decisions within its scope of authority that binds all levels below it. Figure 1 shows an overview of the model, with a number of features marked by the use of arrowed boxes.

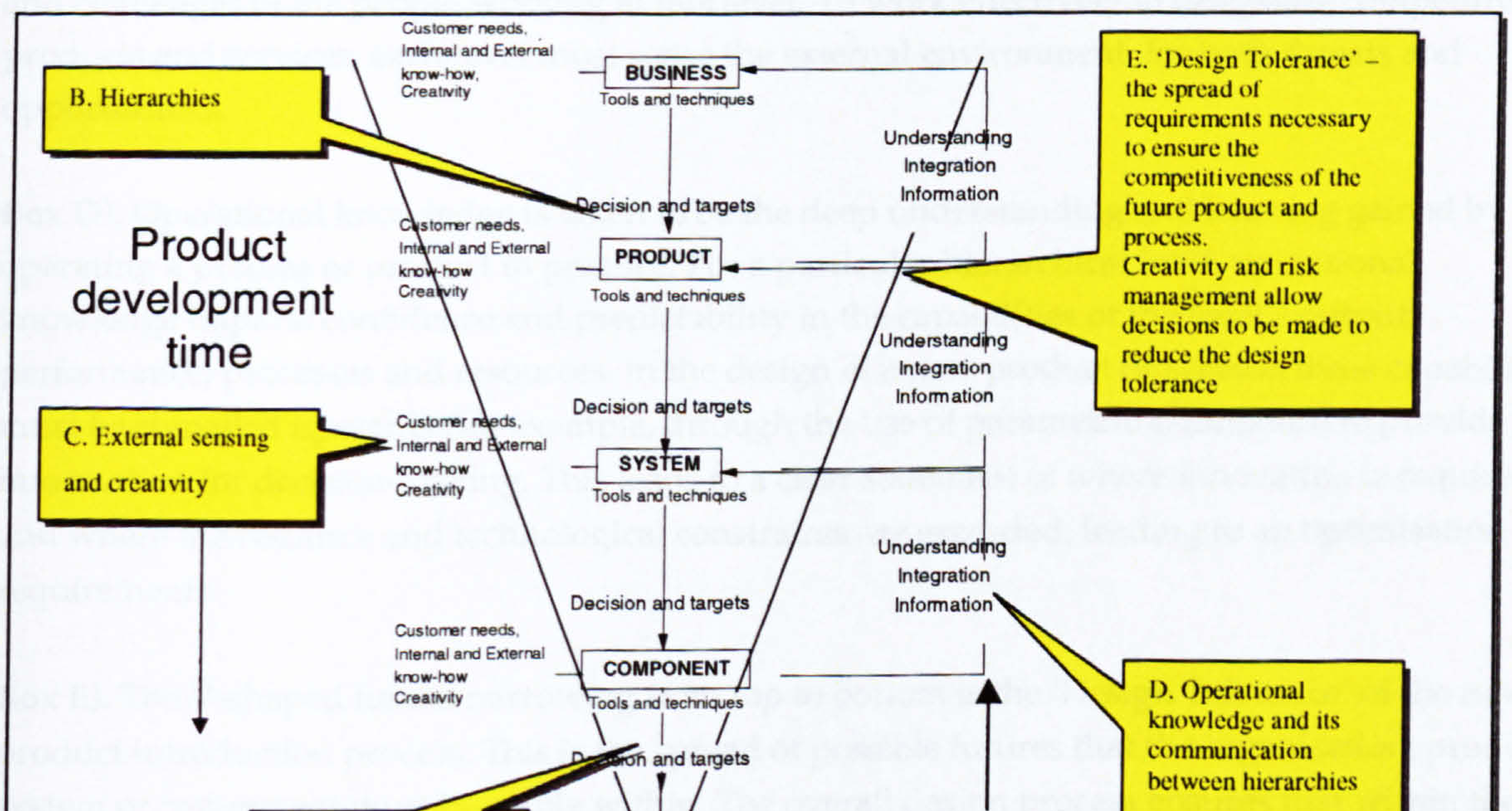

Figure A1. The design model of the business

The arrowed boxes are explained below:

Box A). The central flow of decision-making progresses the design of a product or service through to manufacture and sale over its lifetime. Decisions are made and targets are set for the product and its manufacture, which are irrevocable unless replaced by a new decision by the same hierarchical level.

Box B). The hierarchies of the organisation are nested so that a higher level has appropriate organisational, product and process decision ownership over the next level. Figure A1 shows a product organisation structure ranging from business to product to system to component levels. The business level makes decisions affecting each product that forms the business. The product level represents the management for an individual product within the product portfolio. Within the product is a set of systems, which collectively make up the product. The individual systems may be further subdivided into subsystems before reaching the component level. Each hierarchical level is responsible for all aspects of the entities under its control – examples being cost, performance, timing, investment and manufacturability. The decision process (equivalent to the innovation process) is run to involve all concerned parties so that the decisions made at the end of each part, or *phase*, are robust from the point of view of each part of the enterprise.

Box C). Each hierarchical level has a unique creativity arising from the particular skills, knowledge and challenges of the people working at this level. To work effectively in designing competitive products and services, each level must sense the external environment, for both threats and opportunities.

Box D). Operational knowledge is taken to be the deep understanding and learning gained by operating a process or product in practice. For a particular hierarchical level, operational knowledge imparts confidence and predictability in the capabilities of the level's outputs performance, processes and resources. In the design of a new product or service, these capabilities must be signalled upwards (for example, through the use of parametric estimation) to provide good information for decision-making. This leads to a clear statement of where innovation is required and where the resource and technological constraints are exceeded, leading to an optimisation of requirements.

Box E). The V-shaped funnel narrowing from top to bottom is the 'Design Tolerance' of the new product introduction process. This is the spread of possible futures that the organisation, product, system or component must be viable within. The overall design process ensures that within the spread of possible futures, a decision never has to be abandoned or repeated, but will always succeed in meeting its objectives. To achieve this, the span of unknown futures is covered by a series of optional solutions or a single, flexible, solution at each level of the hierarchy. The solutions are developed sufficiently to give confidence that one or more options are sufficiently mature to succeed in meeting the targets set.

The areas of knowledge that are particularly appropriate to compare with the design model of the business are the following:

1. New Product Introduction Frameworks

The design model of the business is itself a framework covering the overall business, product portfolio and new product introduction. Other conceptual models are available that describe all or part of this process. Such models are used to compare different innovation processes and to describe how a process should operate.

2. Business Innovation Frameworks

Business innovation frameworks are used as models to visualise the business in its competitive environment. The design model of the business has a role to play here, as it not only forms a framework for internal innovation, but also a framework for placing each aspect of the business against its external allies and competitors.

3. Strategic Innovation

This area of knowledge covers the philosophies that are used to navigate businesses through changes to make them fitter against the external world. The structure of the design model of the business has embedded within it an approach to organisational renewal, and so it is relevant to compare this against recent learning in the field.

4. Concurrent Engineering

The process of design and decision-making in the author's design model is equivalent to product design and development. The practice of concurrent engineering is widely recognised as best practice in this field, and a survey of how the author's model compares to this is necessary.

5. New product introduction effectiveness and efficiency techniques.

For the design model of the business to form a valid framework for product development requires that it is compatible with, or can replace, detailed tools and techniques for product design and development. The main techniques for focusing a product programme are examined to test their compatibility.

6. Individual and group behaviour

The author's findings on the behaviour of groups and individuals in the decision-making process form the basis for correct functioning of the design model of the business. Areas of behavioural study affecting the design and development process and organisational behaviour are reviewed to assess whether their findings are compatible.

Strategies for flexibility and innovation

Various techniques and strategies have been adopted during the research to allow the organisation to leverage changes in the business. Recent thinking in this area has progressed rapidly and is examined and compared to the model.

Integration through systems, cybernetics and complexity

A systems approach has been adopted consistently in the development of the design model of the business. However, related areas include the fields of cybernetics and complexity, which are relevant to the control and organisation of complex organisations and organisms. Their relationship and significance to the author's work is examined.

An overview of the individual authors and their concepts relevant to the design model of the business is referred to in figure A2. Each area of knowledge numbered around the inner circle is overviewed and examined in section 3.

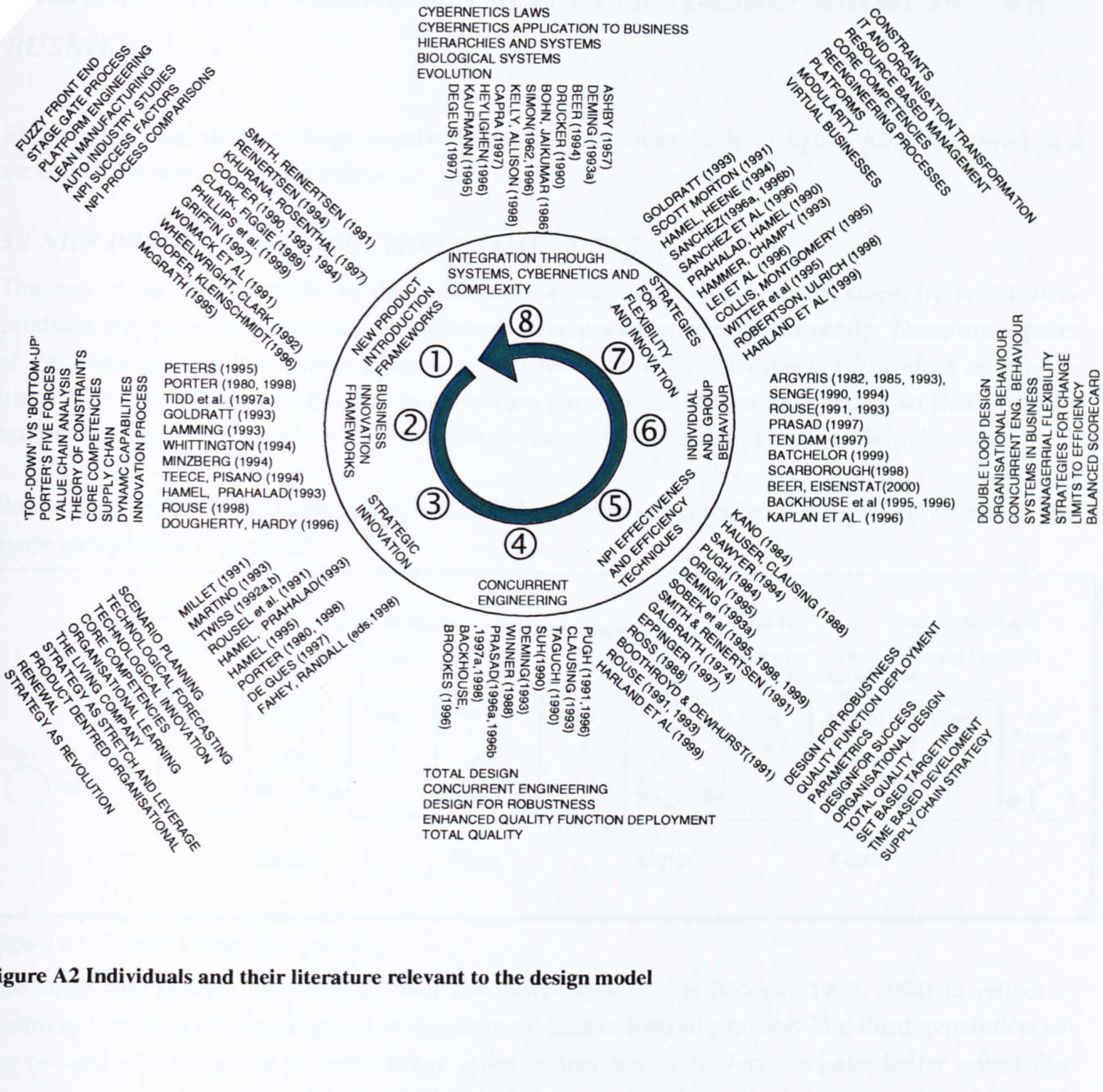

Figure A2 Individuals and their literature relevant to the design model

3. REVIEW OF KNOWLEDGE AFFECTING THE DESIGN MODEL OF THE BUSINESS

Each of the areas of knowledge numbered around the inner circle of figure A2 is reviewed in a section in the same sequence below.

3.1 NEW PRODUCT INTRODUCTION FRAMEWORKS

The core of the design model of the business is a framework of sequential steps, by which new products and the organisation are co-ordinated to achieve maturity concurrently. These are aspects of the more general innovation process, which focus on different aspects of product or service innovation. The purpose of these is to generalise parts of the innovation process so that different businesses can be compared, or that best practice can be visualised and more widely shared.

Robert Cooper (1993) has provided an influential model of new product development known as the stage-gate process (figure A2).

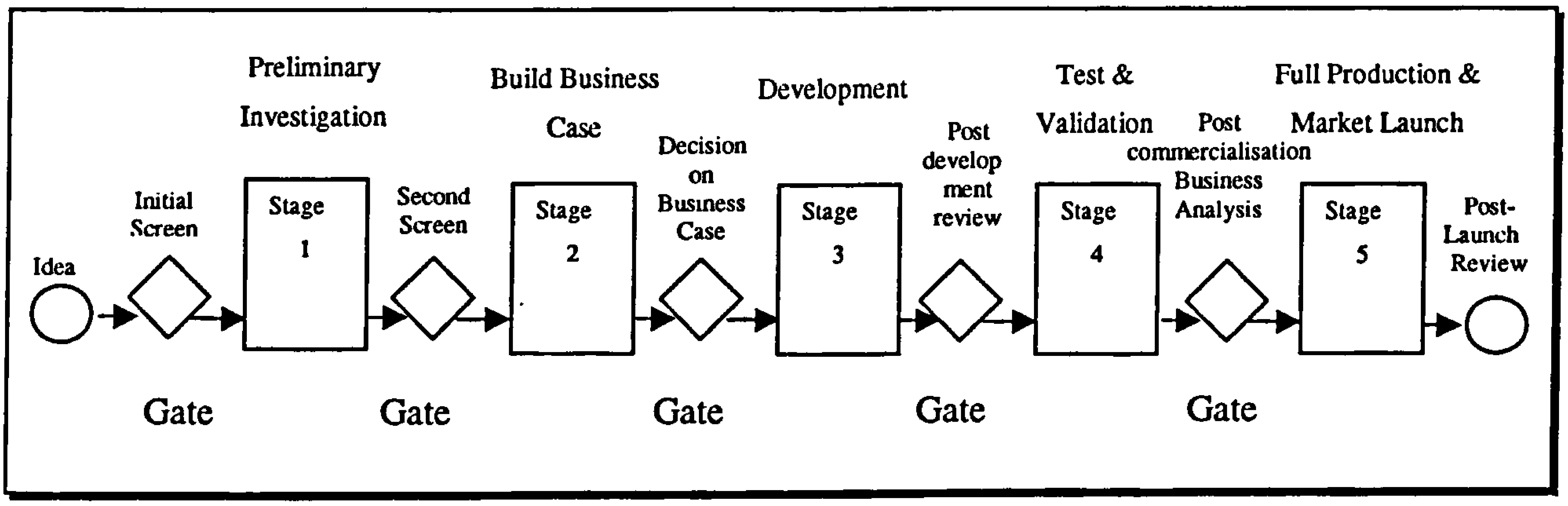

Figure A3. Cooper's stage-gate process

The stage-gate process has evolved over successive generations (Cooper 1990, 1994) to reflect a common language for learning and to disseminate best industrial practice. The third generation of the process admits the use of more 'fuzzy' gates, where go/no go decision gates better reflect the more concurrent approach being adopted in industry. Surveys have shown a strong correlation of successful product innovations with the use of stage-gate processes (Griffin, 1997), although this factor is insufficient on its own to account for this success. The practice has been taken on widely in new product introduction processes, with different numbers of stages being used in practice, dependent on industry and team organisation (Phillips et al., 1999). The more recent models acknowledge concurrent working, where all necessary players in the design process work in parallel to achieve a level of new product maturity in sequential stages of a 'game plan'. The criteria for a successful process are: -

- Quality of execution for all activities, ensuring the key steps are carried out without omission, proficient execution of these, and focus on pivotal steps, notably those that are up-front and market oriented.

- Sharp focus on selecting a portfolio of projects within the organisation's resources, good prioritisation, sharp project evaluation and tough Go/Kill decisions. Inconsistent or capricious decision-making is rejected. The gates are the quality control gates with metrics and criteria for passing economic, process quality, timing and next phase planning criteria.
- Fast-paced parallel processing, rather than a relay of ownership between functions.
- Multifunctional teams at all stages of the design and development process passing information backward and forwards, to meet stage-gate requirements.
- A strong market orientation, executing the key marketing activities in a quality fashion; preliminary assessment, market research for user needs and wants, competitive analysis, concept testing, customer reaction during development, field trials and quality launch activities.
- Good up-front homework to manage technical and market risk.

The balance between risk and uncertainty is an important one for Cooper, where the process 'buys' reduction in uncertainty by spending development money through the process. This allows project ideas to be 'killed' as early as possible if a positive business case cannot be achieved. The author's process, as explained in section 2, investigates a range of solutions to cover the range of requirements and risks, and proceeds to select and hybridise successful concepts from these.

The early stages before formal development have been termed the 'fuzzy front end' (Smith and Reinertsen, 1991;Reinertsen, 1994; Khurana and Rosenthal, 1997) and this has been addressed in some more detailed models of this part of the design process. This is the period from where a company (or an aggressive competitor) could start working on a product opportunity up to the point where the first dollar is spent in the development cycle. Figure A4 shows Reinertsen's (1991) model of the NPD process overall, a useful if simple overview. This recognises the speed of response to external or internal challenges as being important to a business.

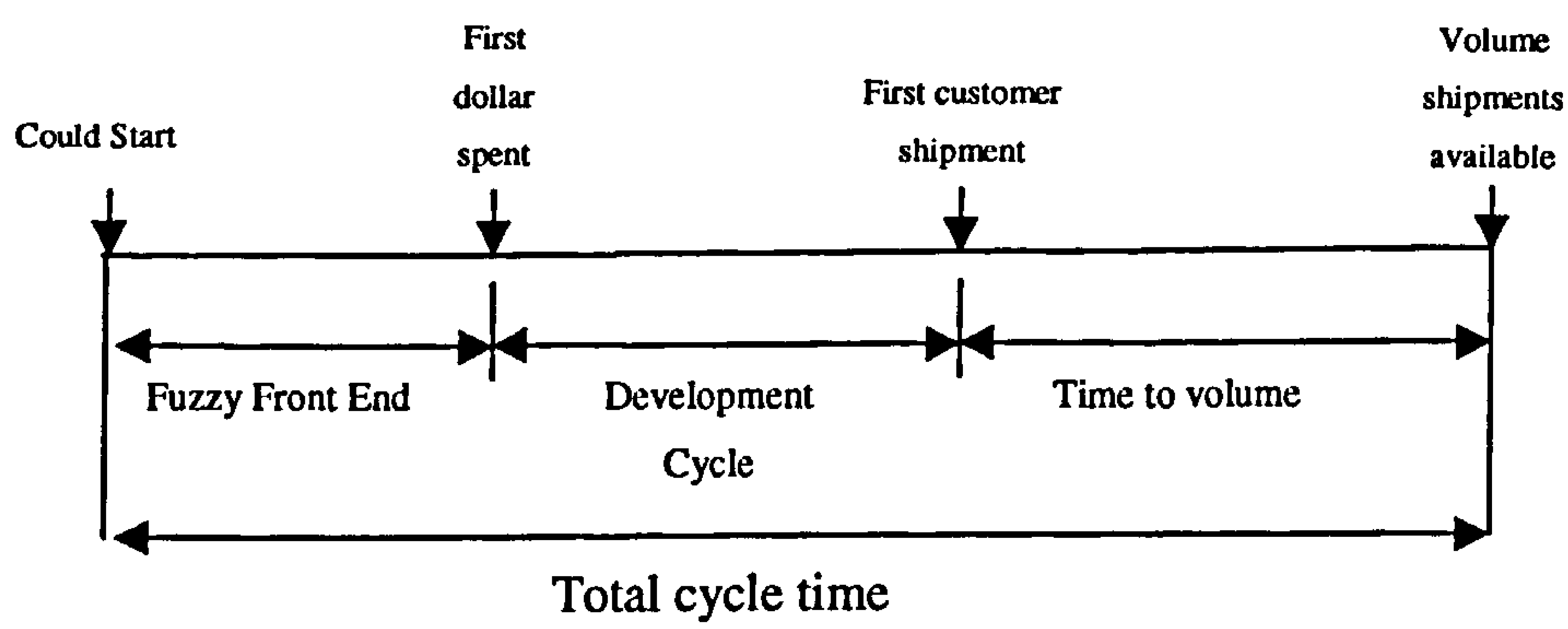

Figure A4. Reinertsen's measurement model of the development programme (Reinertsen 1991)

Khurana and Rosenthal (1997) pointed to the foundation and project-specific elements of a product project as being the main elements of the fuzzy front end. Front-end decisions were found to become ineffective without the foundation elements. They indicated overall that to fail to integrate.......

- a product strategy,

- a well-planned product portfolio,
- a facilitating organisation structure with clearly identified customer needs, and
- a well-defined product concept and a project plan

.....could severely hamper new product development.

McGrath (1995) described the product strategy in terms of four sequential processes, in hierarchical order, as strategic vision, product-platform strategy, product-line strategy and individual projects. Khurana and Rosenthal (1997) point out that, although this platform approach has merit, the independent levels could benefit from being incorporated into the systems approach, shown in figure A5. They state this is due to the growing amount of empirical evidence of the need to co-ordinate overall product strategy (foundation) with project relevant input consisting of product ideas, market analysis and technology options. Understanding the interrelationships between the activities was seen to be as important as the activities themselves. This has been the author's view also and the requirement has been taken account of in the author's design model at a more detailed level.

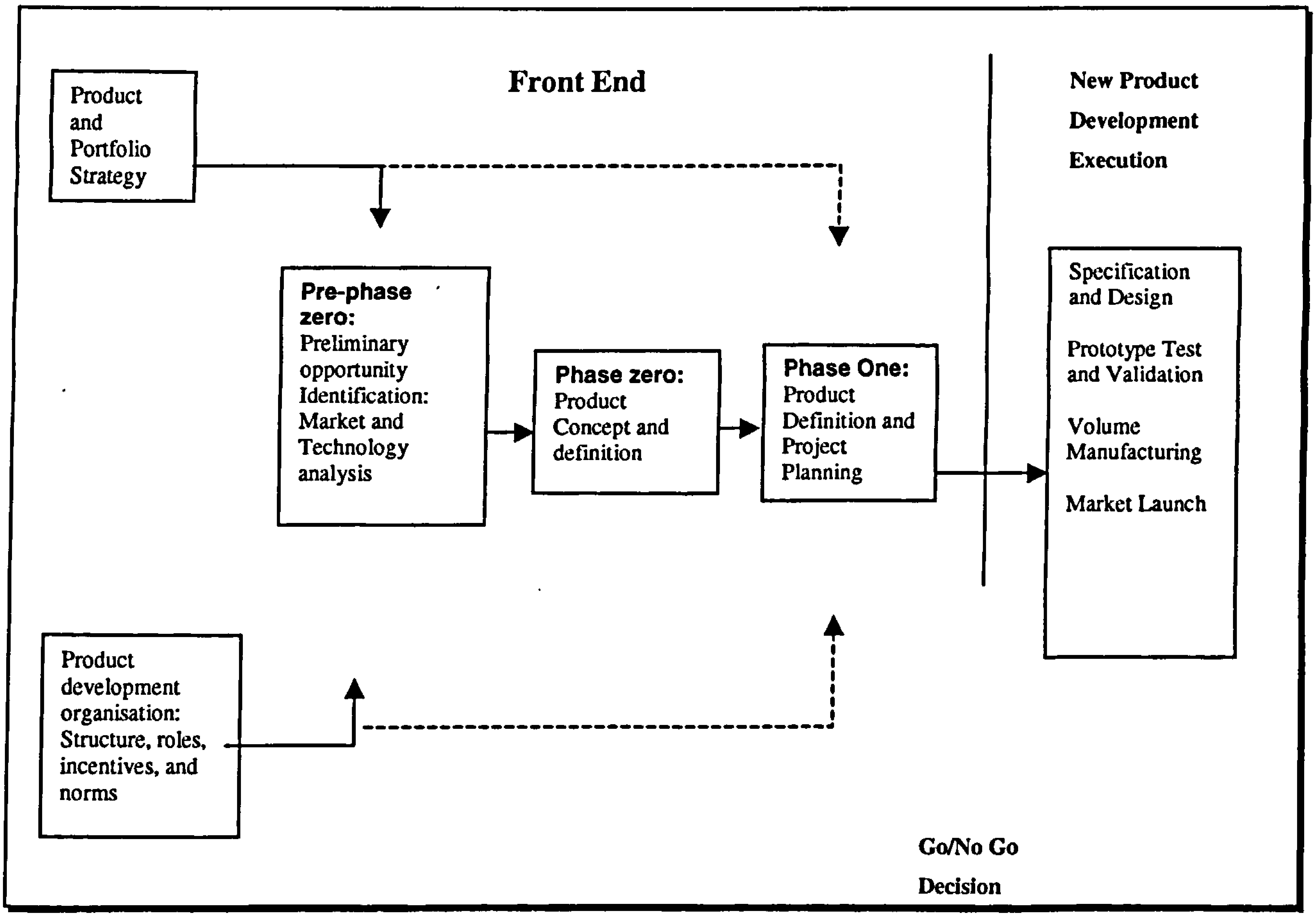

Figure A5. Khurana and Rosenthal's (1997) model of the New Product Development Front End

A number of studies have been conducted, many using the frameworks discussed above, to identify behaviours in new product introduction that promote success or failure. A selection of these is reported below: -

• Clark and Figgie in 1989 reported on the characteristics of the NPD process overall in the automotive industry that allowed successful organisations to meet the requirements of speed, responsiveness, high productivity and a new design quality :-

"What really sets out the outstanding companies from those that are average is putting it all together - - from the foundation-laying process, through engineering problem solving, to the organisational structure and leadership - - in a way that is coherent and works well to achieve effective, efficient, rapid development."

They focused on downstream groups participating in integrated problem solving, which required an appropriate set of communication structures in framing and solving problems, attitudes and communication, philosophies and attitudes for joint responsibility, team work, customer orientation, and capabilities. This approach was proposed as being far more effective in terms of speed, efficiency and design effectiveness.

• Cooper and Kleinschmidt (1998) identified four key drivers of performance. Although resource availability (money and people) and R&D spending levels were strongly related to development performance, they did not drive profitability. However, a high quality, rigorous new product process, that emphasised up-front homework, tough go/no go decision points, sharp early product definition, quality of execution and flexibility was most strongly related to profitability. The factors driving performance are shown in figure A6.

THE CORNERSTONES OF NEW PRODUCT PERFORMANCE

1. ***A high-quality new product process***, meaning:
- An emphasis on up-front homework – both market and technical assessments – before projects move into the development phase.
- Sharp, early product definition, before development work begins.
- Tough go/Kill decision points in the process, where projects really get killed.
- A focus on quality of execution, where activities in new product projects are carried out in a quality fashion.
- A complete and thorough process, where every needed activity is carried out without hasty corner cutting.
- A flexible process, where stages and decision points can be skipped and combined, as dictated by the nature and risk of the project.
2. ***A clearly-defined new product strategy for the business unit***, which means:
- There are goals and objectives for the business's total new product effort (e.g. what sales, profits etc. new products should contribute to the business).
- The role of new products in achieving business goals is clearly communicated to all.
- There are clearly defined areas of strategic focus – strategic arenas – to give direction to the business's total new product effort.
3. ***Adequate new product resources***, meaning:
- Committing the necessary people
- Allowing them sufficient time
- Providing an adequate R&D budget.

Figure A6. Strongest drivers of successful new product performance (Cooper and Kleinschmidt 1998)

Just the presence of a formal product development process had no impact at all. NPD (new product development) performance was also strongly correlated with a well-communicated and effective new product strategy for the business unit, as was the quality of teams. The use of cross-functional teams alone by contrast did not have the expected dramatic impact on performance.

This suggests the need for a systematic model for the early phases that better makes visible successful behaviours. A reengineering of the NPD process is strongly urged to embed the above drivers into the NPD process. Both aspects are included in the author's model, and have caused techniques to be developed in support of the model.

3.2 INNOVATION FRAMEWORKS

Some of the best-described innovation processes in literature are those for the product innovation, as overviewed in the previous section. These are economically important processes that begin with the specification of a need and chart an orderly flow of activity through to the production of a product or service. However, while these models are capable of communicating detail, they are constrained in the sources from which they are drawn to narrow industrial sectors. They also less capable of describing the overall process which includes strategic and research activities, due to the formats and operations used being more suitable for product development. Various other views, less constrained to product development, have been examined below and the thinking behind them incorporated into the author's model.

One of the best known models describing the strategic environment of an organisation that of Porter's five forces (Porter 1980). This seeks to provide a basis for thinking about industry and business relationships between competitors, new entrants, suppliers, buyers and substitutes. Porter's value chain analysis also provides a broad model for developing competitive advantage. As a framework for perceiving the position of an industry or organisation and related potential threats and opportunities it is has had few competitors, and has been extremely influential. Porter admits however (Porter 1998), that the five forces model does not eliminate the need for creativity in finding new ways of competing in industry. Criticism has been made that Porter's approach (Tidd et al. 1997b) to defend a firm's position or to influence factors in the businesses or industry's favour underestimates the power of new technology to transform industry structures, and overestimates the power of managers to decide and implement innovation strategies. The individual company's limitations for change (theory of constraints, as developed by Goldratt 1993) generally disables businesses from making the scale of adjustment necessary that may be needed to compete in the desired way. Businesses or industries no longer have the same level of monopoly on technology, and new technological opportunities can cause not only the break-up of industry structures, but can also give rise to new opportunities in mature industries. In addition, the 'bargaining' model used by Porter does not take into account constructive relationships between suppliers and customers as shown by Lamming (1993) and the role that industrial collaboration is increasingly playing. Teece and Pisano (1994) present a more dynamic model by integrating the three dimensions of competitive markets, firm-specific technologies and organisational competencies into a 'dynamic capabilities' approach. This approach allows for a better balance than the long-time struggle (Whittington 1993) between the strategy theorist Ansoff, who advocates a 'top-down' strategic approach and that of Mintzberg who supports a more incremental, 'start from where we are' approach.

Tidd et al. (1997a) support the idea that learned management 'routines' are the processes by which lessons for innovation are learned and repeated. While successful routines are reinforced and repeated, these can become 'core rigidities', which prevent beneficial change in changed circumstances. This is a finding explored in depth by Rouse (Rouse 1998), a collaborator in some of the author's work. Such a routine was discovered in the doctorate project submissions (Saje 1999a, 1999b). An overall model of the innovation process proposed by (Tidd et al. 1997) is shown in figure A7.

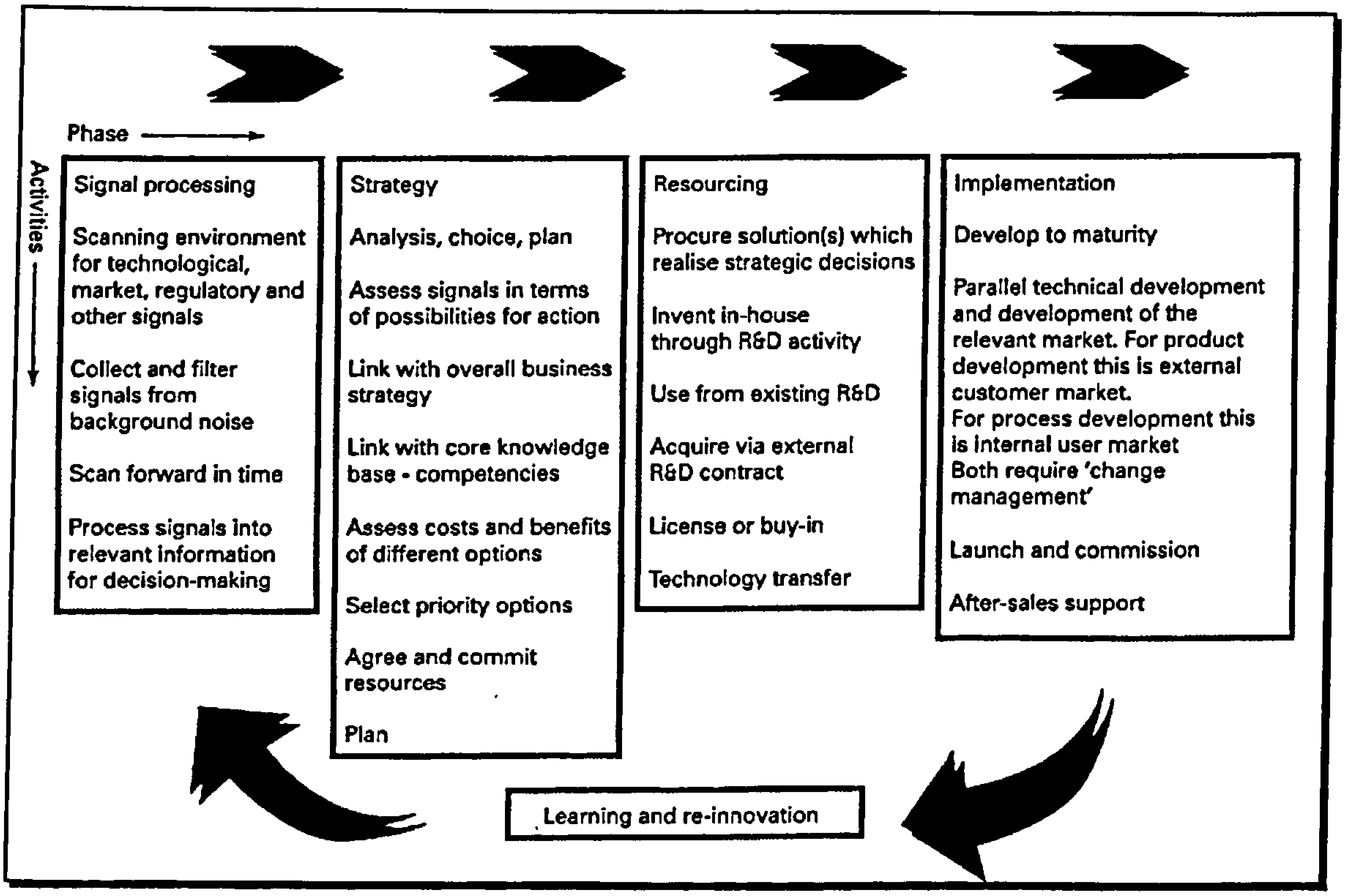

Figure A7. Model of innovation used by Tidd, Bessant and Pavitt (1997a) (page 41)

The incorporation of this and other relevant concepts such as the 'R' process for technology maturity development and trendline planning into the author's framework were developed in previous submissions (Saje 1999c, 2000). The benefit of these in particular is the incorporation of scanning, core competence, business strategy, research/technology resourcing and organisational learning concepts with the otherwise limited product development framework.

3.3 STRATEGIC PLANNING FRAMEWORKS

The conceptual frameworks for incorporating the strategic planning process into the innovation process have been discussed in the previous section, therefore the scope of this section will be limited. However, the means by which these concepts can be implemented in practice is also critical to the author's model. The main influences are described here.

The author has jointly developed an approach for the process of inclusive scenario planning. The methodology developed covers the integration of signal processing with the activity labelled as 'strategy' shown in figure A7. As described in section 3.2, 'core rigidities' that can be brought about through the reuse of the learned, but inappropriate, management decision routines. One of the needs to overcome such routines is to develop and present information having high levels of confidence, within a process that orchestrates the evidence and alternative solutions to make good decisions. Technological forecasting provides one useful methodology to this requirement, as reported by Twiss (1992). Here, the role and methods of the forecaster are stated, with the need of the forecaster always to aim to provide sufficient confidence to the decision-maker to allow them to...

- make decisions to deploy resource (effectiveness)
- make decisions on how well a company uses resource (efficiency)

...by communicating effectively the future potential of opportunities, threats and capabilities faced by the organisation. Ideally, the decision-maker is the best person to develop forecasts, as they will gather just sufficient information to make a confident decision. However, decision-makers rarely have sufficient available time to develop forecasts themselves, and the forecaster must be particularly sensitive to the needs of the decision-maker. Porter (1980) examines and describes the role of industry scenario planning and its role in reducing uncertainty in competitive strategy. A strong focus for organisational renewal is the product plan of the organisation, as described by Dougherty (1992) has been Millett (1991) describes the tools of scenario planning and Martino (1993) covers forecasting methodology, tools and their application. These basic approaches to strategic decision making and technology forecasting are compatible, and were discussed in project 2 of the author's research. The signal processing, scenario planning and 'SWOT' (strengths, weaknesses, opportunities, threats) approaches of Twiss were found particularly appropriate to the needs of technology planning. The 'Open Door' strategic planning approach applied by the author's department (Project number 5) took into account these techniques when originating and assessing future strategies. More recent work by Perrottet and others (Fahey and Randall (eds), 1998) adds further methods and experiences in scenario planning.

Royal Dutch Shell has used scenario planning extensively to reduce market and technological risk throughout the organisation by ensuring contingency planning takes place at many levels of the organisation. The head of strategy, Arie De Geus, describes a view that integrates scenario-planning approaches with the concepts of learning, organisational persona and company evolution (DeGeus, 1997). These ideas have been the basis for significant trends in organisational governance, and have taken root as organisational learning (Senge 1994). The systematic causes of organisational problems are understood through the development of diagrammatic and computational models that allow the development of undesirable organisational traits to be understood. The author has used this approach to develop an understanding of a systematic dysfunction in organisational decision-making behaviour, and to assist in the identification of processes and techniques to overcome this. The techniques have been incorporated in the more detailed applications of the design model.

De Gues' views the business as a living entity, supporting these arguments with examples from his extensive experience with Shell and with scientific views of biological organisms. A consideration of this view is reflected later in this report.

3.4 CONCURRENT ENGINEERING

An overview of the discipline of concurrent engineering and the relevance to the author's model are presented below.

Cooper provides a framework for the new product introduction process that is common across a wide range of concurrent engineering processes. This has been discussed in section 3.1. While Cooper (1990, 1993, 1994) lays out the fundamental stages, gates, and successful behaviours of new product introduction, other workers describe the detailed processes and techniques within. Concurrent Engineering is a relatively recent development of design and development practice that evolved from its earliest first definitions during the late 1980's. The most commonly referred to definition of Concurrent Engineering is that of Winner (1988) who defines it as...

'a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers from the outset, to consider all elements of the product lifecycle from conception through to disposal, including quality, cost, schedule and user requirements.'

Most models of concurrent engineering are in agreement with the boundaries described above. A range of the practitioners of concurrent engineering was surveyed in project 6, 'The integrated company'. Pugh (1991), the originator of 'Total Design' brought together an information and decision model and supportive design practices similar in intent to the author's model, but based on boundaries limited to product design. Pugh's staged model (Pugh, 1996) is shown in figure A8.

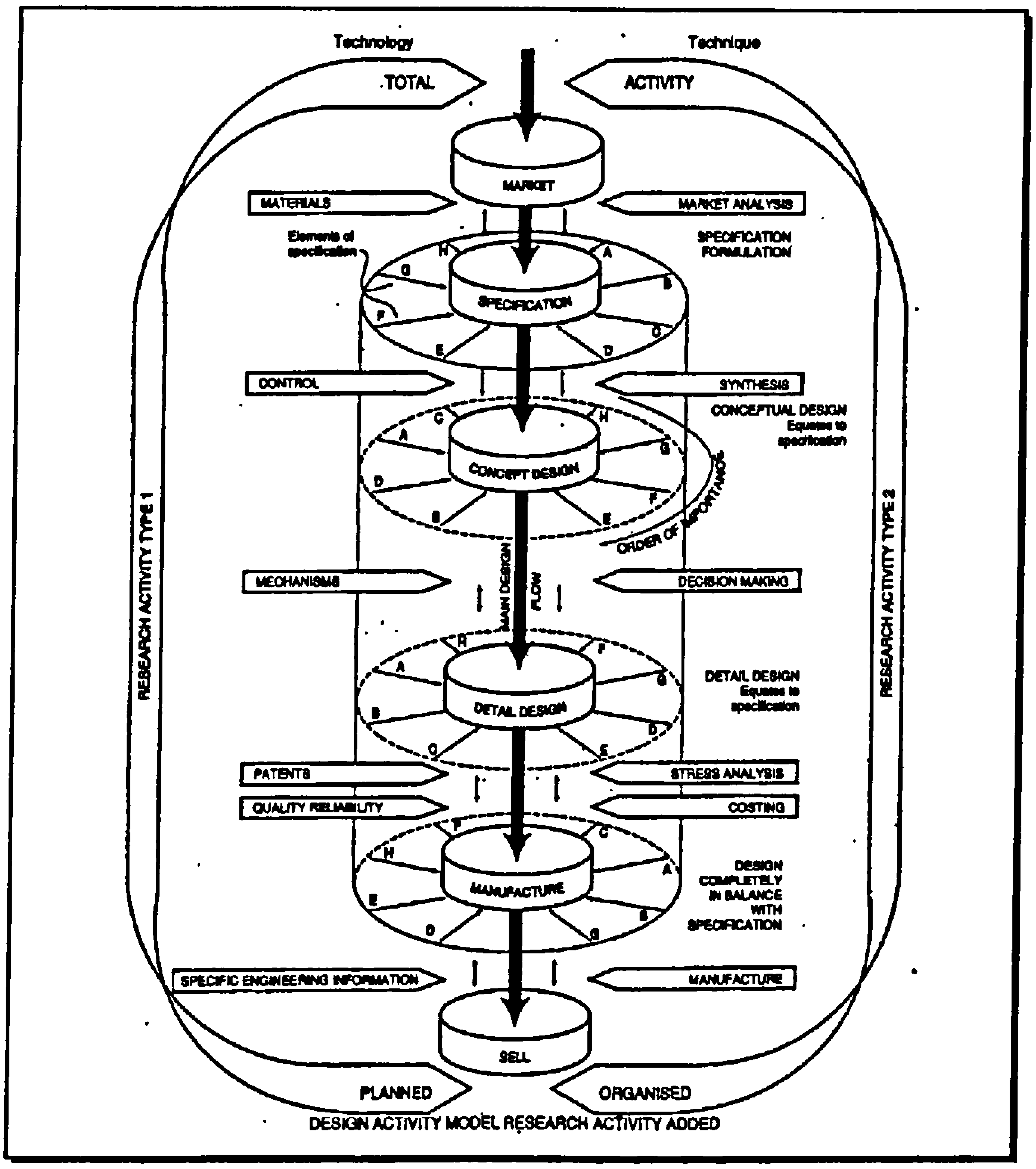

Figure A8 Pugh's model of the Total Design (Pugh, 1991)

While not termed concurrent engineering, this represented a broad and influential rethinking of design practice and behaviour. The model shown in figure A8 covers the simultaneous involvement of all involved functions, the fundamental importance of the design specification and the inclusion of both product and process research. Roles and responsibilities were considered, with the need for personal, product and organisational boundaries to be carefully delineated.

Clausing (1993) in collaboration with Pugh and Taguchi, developed a design practice that provided a repeating model for practitioners to follow, based on a systematic decomposition of the design process. Three basic tools interact to co-ordinate the process through each stage:

1. Quality Function Deployment (Hauser and Clausing, 1988) as the means of identifying customer needs and transmitting these through deeper levels of the business.

2. Pugh's (1996) concept selection process to improve and select the most appropriate concept, and

3. Taguchi's Robust Quality technique (Taguchi and Clausing, 1990) identifying product parameters from the concept selected, identifying process parameters to control these in manufacture through tolerance design.

The form of concurrent engineering described has been defined symbolically by Prasad (1996) as: -

CE/Total Design ⇔ [Paralleling of (life-cycle functions) + alternative concept selection + (co-operative organisation, personal and product boundaries) + consensus decision-making] + design for cost + robust design]

More recently, a system of concurrent engineering (CE) has been published by Prasad (1996, 1997a) and is supported by further consistent work (Prasad, 1996b, 1997b, 1998) The frameworks covered can be described by the following definition of concurrent engineering:

CE ⇔ [Paralleling of activities or simultaneous actions in product development + integrated, highly co-operative, team-oriented work-groups + Computer-supported tools communicating on the network]

The first definition shows that various conceptual tools, behaviours and frameworks have been integrated in Clausing's model, which in combination achieve a step-change in product development quality. By comparison, Prasad's texts already assume most of the toolsets and concepts specified by Clausing. Prasads' concurrent definition concentrates on speeding workflow through the use of co-operative work-groups communicating information and decisions using computer-networked tools. This has taken concurrent engineering closer to a 'product factory' (Reinertsen, 1997), where the tools of design 'manufacture' are well-understood, and the concentration is on achieving efficiency and speed in their application.

The author's work, however, is centred more on the application of concurrent engineering techniques to the earlier processes of organisational direction, strategy and resourcing, where the principles of the earlier definition of concurrent engineering have not yet been generally adopted. Therefore, of interest are the behaviours necessary to succeed at concurrent engineering. These are similar and complimentary to those identified by Clausing (1993) in successful new product introduction processes: -

1. Start all tasks as early as possible.
2. Utilise all relevant information as early as possible.
3. Empower individuals and teams to participate in defining the objectives of their work.
4. Achieve operational understanding for all relevant information (i.e. to have a high level of confidence in the information)
5. Adhere to decisions and utilise all previous relevant work.
6. Make decisions in a single trade-off design space: - that is, treat design, production, and field support as a single system within which trade-offs can be made.

7. Make lasting decisions, overcoming the tendency to be quick and novel.
8. Develop trust among team-mates.
9. Strive for team consensus.
10. Use a visible concurrent process.

Neither business strategy nor technology management is integrated into Clausing's framework, except that a sound business strategy and product portfolio are prerequisites, and that mature technologies are selected from a 'pool' of options.

Several concepts described by Prasad support the author's view that this represents the state of the art reached in concurrent engineering. A broader, more complex version of QFD called enterprise function deployment is used as the fundamental target setting process. Other features are:-

- The design and development process as a set of transformations with inputs, outputs, requirements and constraints.

- The concept of the pursuit of requirements and constraints through transformation loops to meet goals and objectives (Figure A9).

- The uncoupling of the complex system (project) through decomposition into hierarchies of the enterprise, product, system of product/process/organisation and hierarchy of work structure. The uncoupling of the product and work structure is a prerequisite for tasks and requirements to be broken out in such a way that the outputs of each transformation do not interfere with others, which meets Suh's first axiom of design (Suh, 1990). Product and business requirements must also be broken down so as to be independent of others (orthogonal) to meet Suh's second axiom of design, which is that the information content of the design should be minimised. This allows the requirements of the project to be clearly stated and measurable across the product team. For example, a vehicle fuel module design team required to perform the operation 'detail design of the fuel system to achieve weight v, cost w, investment x, dimensions y, properties z' may do this with minimal effects on earlier decisions in the design process or other teams working in parallel.

- The benefits of the near decomposition of product and organisational processes, coupled with advances in information technology and communication, allow the effective use of geographically distributed teams.

The points above give rise to a less fixed set of gates and stages, as shown in figure A10. Cooper's third generation stage-gate process (Cooper, 1995) shows each gate as being indistinct, the implication being that the stage-gate model is now unable to cope explicitly with the new dimension introduced. The main features in the concurrent process are a set of transformation loops that involve various parts of the organisation in collaborating to synthesise solutions that meet requirements and satisfy constraints. Each transformation loop takes account of appropriate knowledge, constraints and goals as shown in figure A11.

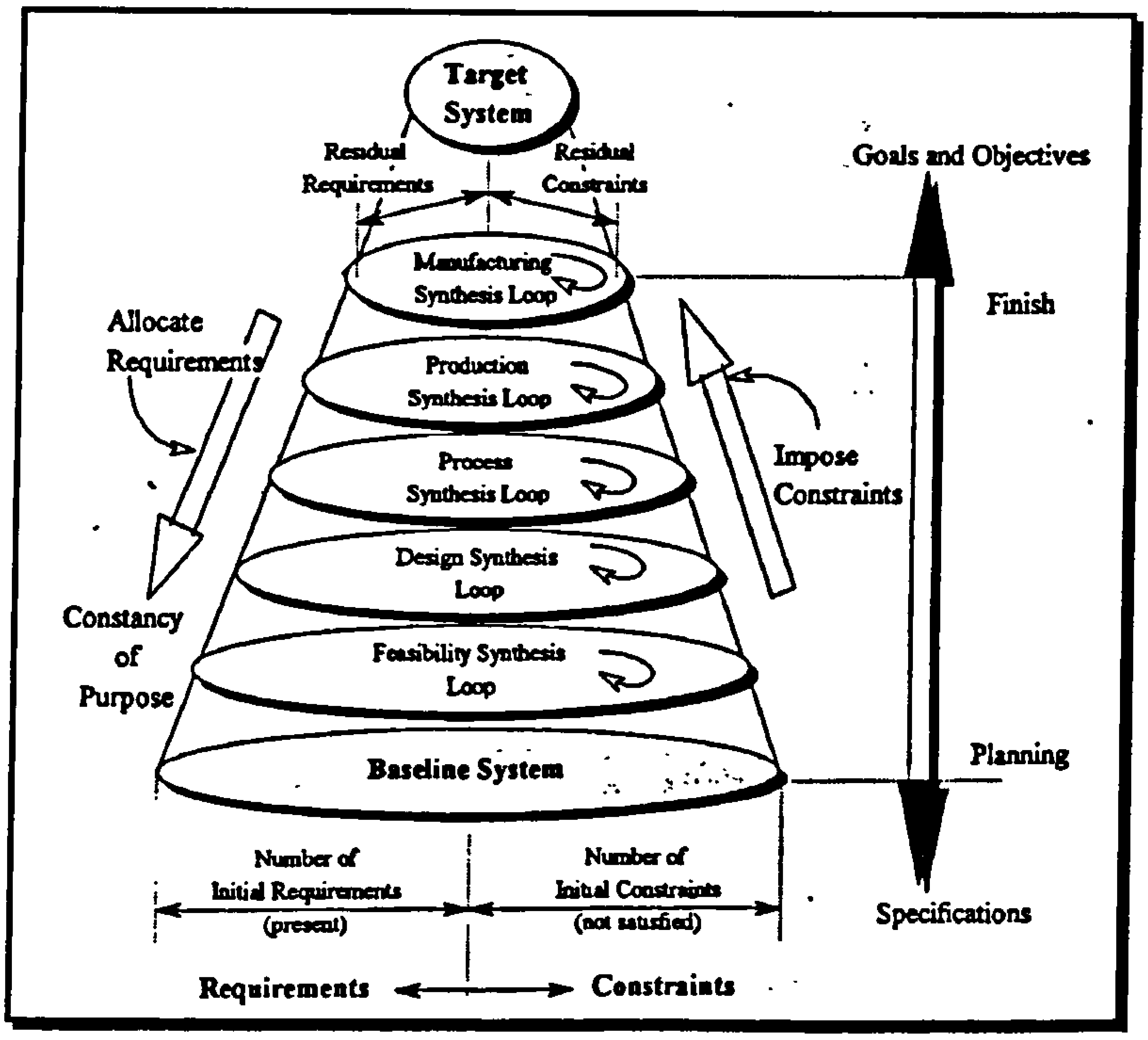

Figure A9. Prasad's (1996a) model of the concurrent engineering process. Note the similarities to the author's 'funnel model'.

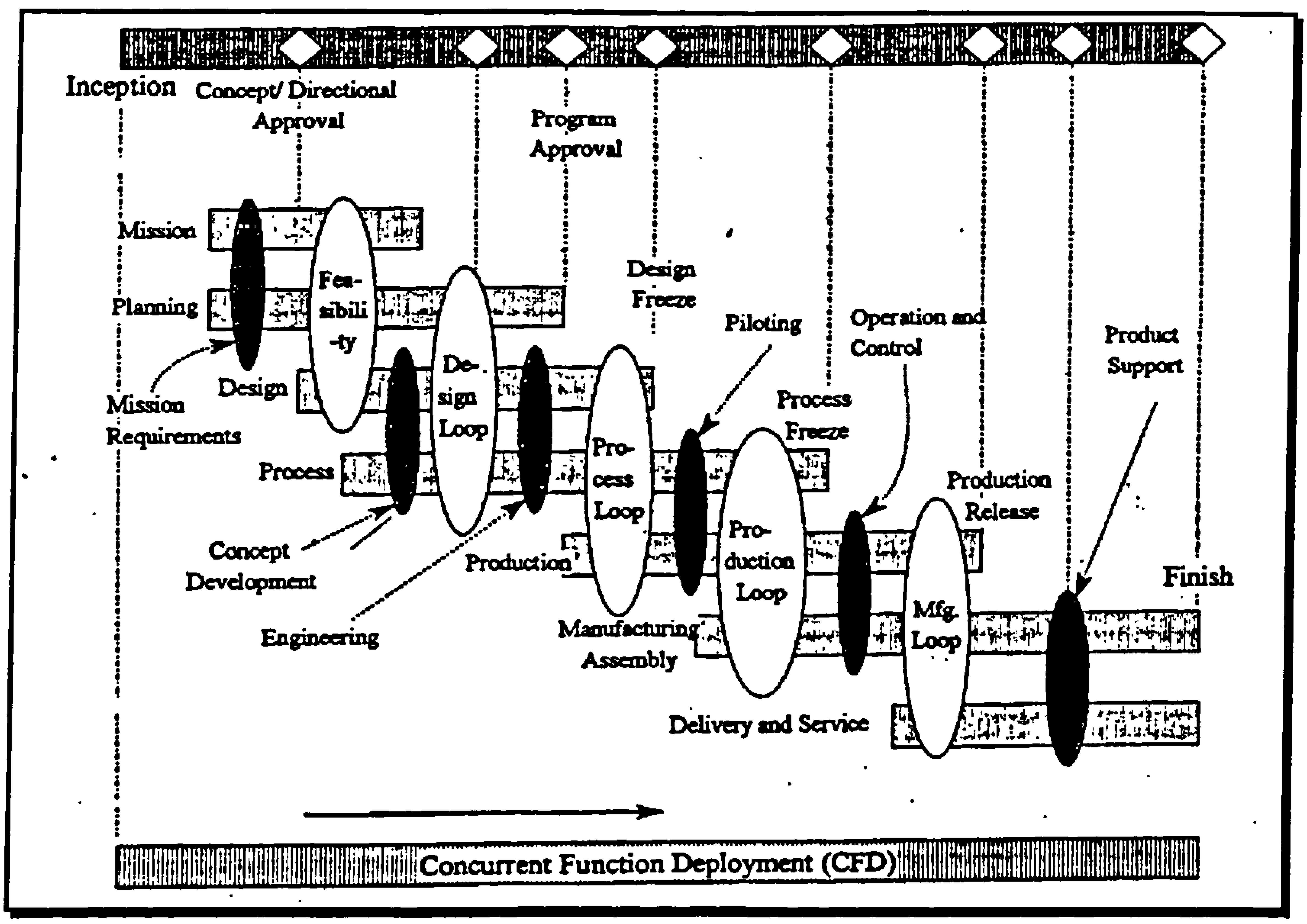

Figure A10. Concurrent engineering process as a set of transformational loops involving functional responsibilities, driven by a version of QFD. (Prasad 1996a)

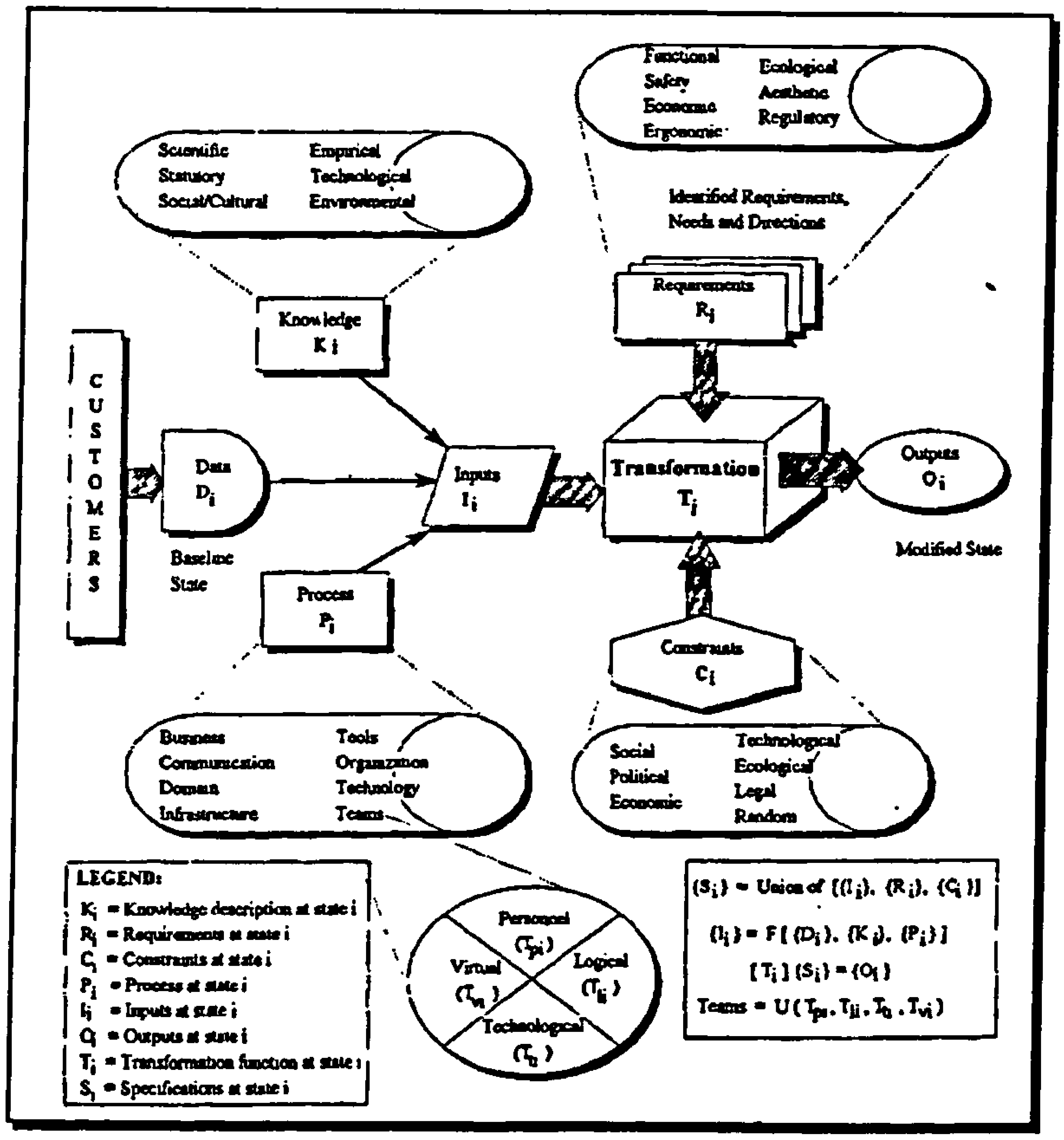

Figure A11. The general transformation process in design (Prasad 1996a)

The concepts of Prasad are compatible with the author's model described in section 2, as each of the segments of decision flow of the author's model essentially represent a transformation process, or loop. There is a similarity between Prasad's (1996a) loops and reduction of remaining requirements to the funnel of the author's model of the design process. However, the funnel in the latter case represents the degree of uncertainty in the final design specifications and the retention of a multiplicity of conceptual designs at an appropriate level to cover the uncertainty.

A particular focus of the author has been the operational understanding of techniques and tools to ensure that they are valid, acceptable and viable in application. Outside of the author's direct experience, confidence in many of the methods and techniques described in literature lack the tacit information needed to gain confidence in their effectiveness. Pugh has an advantage in this respect over Prasad, as the methodologies and human aspects are well-enough described to gain operational confidence. Specific, comparative case studies on the introduction of concurrent applications also have significant value. Backhouse and Brookes (eds. 1996) have assembled a set of experiences over a range of business types. These provide a number of insights into good practice. Particularly relevant to the author's portfolio of work are a number of general points emerging from multiple applications of concurrent engineering across various types of organisation: -

- The recognition that core competencies in a company strategy influence the quality of product ideas generated, and hence must be considered in preparing for the application of concurrent engineering.

- The concurrent engineering process must be tailored to suit internal product structure complexity and the variety required of the product-user interface.

- The interaction of product structure, process, tools, people and control is essential in any form of new product introduction process.

- Changes needed in the culture of working practices must be recognised and carefully handled, as the focus of different organisations will vary (Backhouse et al. 1995).

- The new product introduction process will need to be tailored of to meet the specific needs of focus, efficiency, proficiency, radical innovation and incremental innovation

In general, the author's work is compatible with the discipline of concurrent engineering, and embraces this. While the author has innovated in the practice of concurrent engineering, the major innovation is the application of these principles with other techniques in the early business mechanism, which includes research, business strategy, operational functions and marketing, with product design and development being only one element of the whole system.

3.5 NPI EFFECTIVENESS AND EFFICIENCY TECHNIQUES

Within the framework of new product introduction a number of techniques have become central to the organisation and focusing of the process. A number of these have been mentioned;

- Quality Function Deployment (Hauser and Clausing, 1988).
- Systems engineering (Sawyer, 1994) that appropriately decomposes and classifies distribution of tasks.
- The separation of the tasks, the product and the organisation into nearly decomposable systems (Deming, 1993; Simon, 1996).
- Concept selection and hybridisation (Pugh, 1996).

Additional core concepts which are closely associated with general behaviour in product design processes include Total Quality Management (which covers continuous process improvement, project management, QFD (Hartley 1992) and organisational design (Galbraith, 1974). These techniques are generally applicable to the whole design team, whereas technology tools such as Design for Manufacture/ Assembly, Taguchi's Robust Design (Ross, 1998), Product Information Management (PIM) and Computer-Aided systems (Cax) provide the recording of data and methodologies for collaborative working.

A number of specialised techniques and principles have been found particularly relevant to the development of the design model. Smith and Reinertsen (1991) recognise the effect of scarcity of critical resources as a cause of slow product development and propose strategies to overcome these. This has helped in the recognition and development of new professions in the design model. The use of parametric design estimation (Pugh, 1984; Origin, 1995) from the design and estimating communities has also provided a starting point to bring the 'voice of the expert' into the model. The originators of the Design for Manufacture and Assembly (Boothroyd and Dewhurst, 1991) and similar 'Design for X' techniques recognised the need to employ the technique at a very early stage of the design process where decisions have the greatest effect at the lowest cost. The author aims to provide a general solution to the dilemma on how early to begin the use of such techniques in the design process, where design accuracy and precision are often traded off against design speed and resource saving.

The latter techniques mentioned aim to improve design efficiency, the speed of development and cost of the product and its manufacture. Two further specific sources have been important in developing the effectiveness of the design model. Lamming (1993) has developed a model of the integration of suppliers and other external organisations as partners in the supply chain rather than adversaries. This is now extensively recognised but rarely well practised (Harland et al. 1999). Without such an approach, the business must rely completely on its internal resources for strategic insights and innovation. Close co-operation with business allies is a requirement of the author's model and coincides with findings from Toyota practice, as described in project 4 of the author's portfolio.

The other insight making a large difference to the effectiveness of the model is that of the scenario planning (Twiss, 1991, Millet, 1991; Fahey and Randall, 1998) and set-based targeting (Sobek et al., 1995, 1998, and 1999). These are complementary approaches for ensuring that the organisation's goals recognise that the future is precisely unpredictable and that it values adaptability within a range of future worlds. Without such flexibility, there is little incentive to invest resources in 'up-front' work on market understanding or to develop potential solutions for the future. These approaches will tend to require that the solutions derived be hybridised or 'modularised' to be flexible against future requirements.

3.6 INDIVIDUAL AND GROUP BEHAVIOUR

Argyris (1982,1985, 1993) and Senge (1990, 1994) are recognised as the founders of the 'double-loop' research methodology used for general systems understanding of problems in the business. The approach models complex systems in a way that makes broad behaviours visible, and hence allows a measure of understanding and control.

Such techniques are needed when new methods are introduced into organisations that work in theory, but fall foul of human and institutional barriers when applied in a real situation. Here the invisible framework of needs, belief and perceptions, not only of individuals, but also of larger groupings of teams, bodies of professional and customer groups becomes highly relevant to the adoption of a design. The work of Rouse has been valuable in building value models of stakeholders (Rouse 1991), which acted as a basis for brand, product and service values to be measured, and for understanding resistance to change in groups (Rouse, 1993) using the needs, beliefs and perceptions model. The model, which shows the relationships between the factors influencing the decisions of the individual or a larger coherent group, is shown in figure A12.

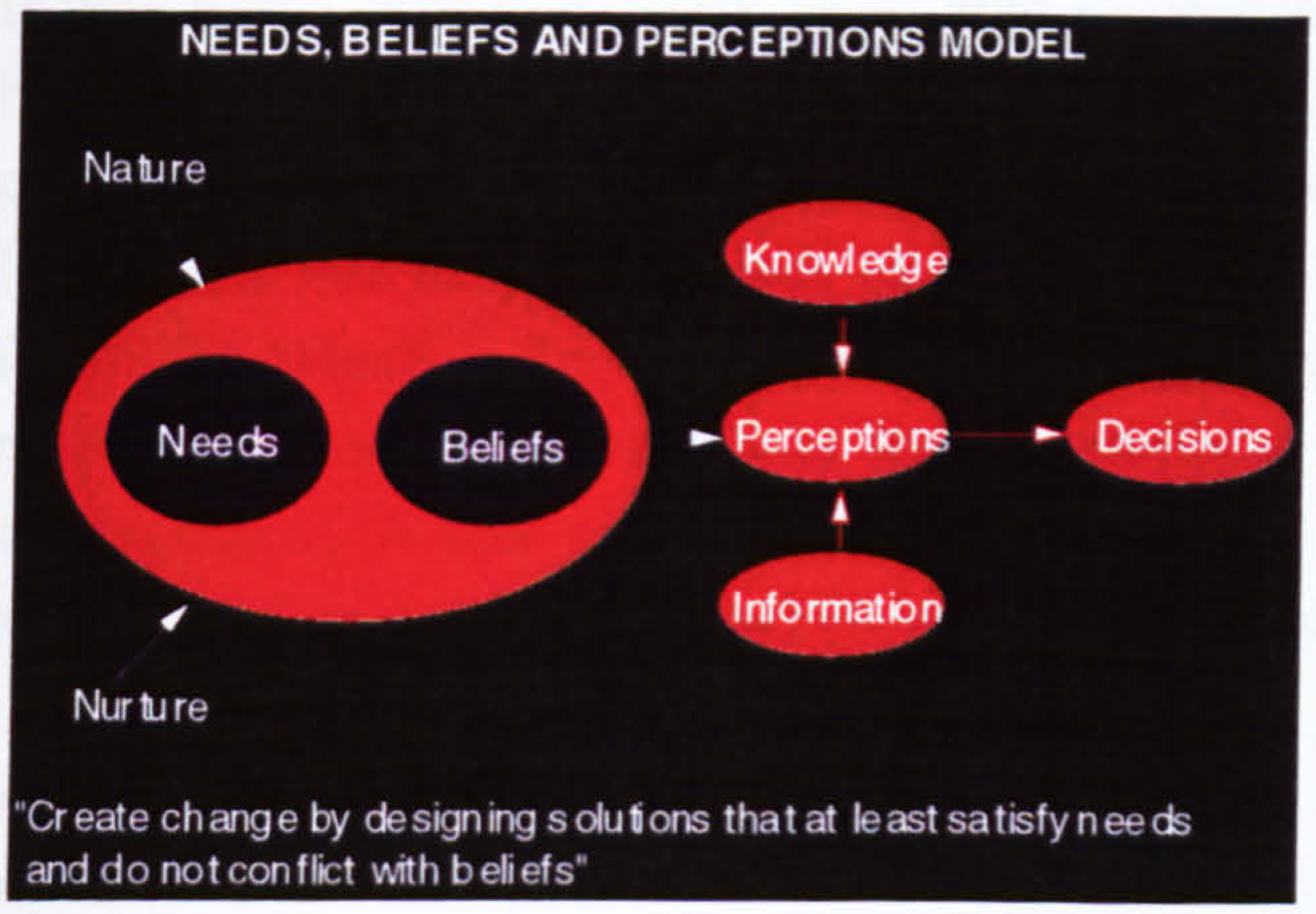

Figure A12. Providing a framework of knowledge and information is not sufficient to bring about change. Underlying needs and beliefs must be respected also (Rouse, 1993).

Argyris (1993) has identified two types of behaviours that are related to functional and dysfunctional businesses. Model I behaviour for individuals is seen world-wide at any age group. Its governing values are to achieve the individual's intended purpose, to maximise winning and minimise losing, to suppress negative feelings and behave according to what is considered rational. It leads individuals to craft their positions, evaluations and attributions in ways that inhibit enquiries into them, and tests of them with other's logic (Argyris 1982, 1985). Argyris states that this behaviour leads to Model OI behavioural worlds in organisations that reward limited organisational learning, inhibit double-loop learning, and overprotect the individuals and the organisation. Such a set of behaviours was found at the outset of the author's study.

By comparison, the governing values of Model II, are those of valid information, informed choice and vigilant monitoring of the choice in order to detect and correct error. Here, individuals openly illustrate how they reached their evaluations and attributions and how they crafted them to encourage inquiry and testing by others. These form OII-type learning systems where embarrassment and threat are not covered up but engaged. This is a situation where organisational learning is created and persists. Type OII organisational behaviour is recognised as that needed to make the author's design model operate.

Beer and Eisenstat (2000), also recognise a range of management barriers to strategy implementation and learning, and provide principles for engaging them. These include the factors of: -

- Top-down or laissez faire senior management style
- Unclear strategy and conflicting priorities

- An ineffective senior management team
- Poor vertical communication
- Poor co-ordination among functions, businesses or business allies
- Inadequate down-the-line leadership skills and development

It was noted that that CEOs were able to overcome these routines, but that these practices also broke down with the leader leaving. This reinforces the author's finding on the dysfunctional decision-making process that senior management unwillingness to confront these issues openly leads to a loss of performance in the business. Ten Dam (Ten Dam 1987) found that strategic flexibility, which is the ability to adapt to changing environments, to open new environments and to pursue new objectives, is at least partially a state of mind. This is revealed at all levels of management. A case study investigation showed that successful individuals combined common-sense with innovative approaches. As a group, flexibility dimensions included:-

- overall repertoire range,
- degree of overlap in capabilities and
- the amount of mutual trust.

The most important factor for cultural flexibility was the willingness of management to discuss challenges and to make real decisions on them. Individual qualities in leaders were found essential to the human aspects of strategic flexibility. These were the personification of a future direction, a sense of mission and similar qualities.

Prasad also examines the management styles necessary for successful product innovation in a concurrent engineering environment (Prasad 1997). He concludes that a directive style, with 'a ragbag of techniques, rituals customs and superstitions' prescribes product needs based on anticipated needs and requirements. The supportive management style, which manages by objectives (MBO) and by results (MBR) (McGrath 1984) and sets a pyramid for reporting, is based on no sound theory of co-operation or system optimisation. Similarly, with the approach of 'managing by facts', a team is individually better informed and targeted to manage towards customer needs, each area becomes an individual profit centre. This leads to inter-group competition and the destruction of the system. The third style proposed is a 'Constancy-of-Purpose' management style, where goals are supportive of other goals. This leads to the integration of the workforce as one co-operative unit. All members of the various teams owe their allegiance to the strategic business unit's goals. The obligation of management is to support the unit so that it can contribute its best to system goals. Team training is directed towards 'agreeing a mission, whether goals, the role of each individual, work-group, team, department, management, processes of getting things done, including a communication plan'. In this approach, management rejects decisions detrimental to the company's goals, even if this is supportive of product or team goals. Compromise is accepted when the overall result is permissible and a better result is achieved overall. These activities are stated to be ineffective unless team commitment, convergence and collaborative thinking, team recognition and deep common understanding are achieved.

3.7 STRATEGIES FOR FLEXIBILITY AND INNOVATION

The methods for strategic planning have undergone radical change since the 1980's. The activities of mission and vision crafting, bottom-up financial forecasting, narrow competitor tracking, annualised strategy development, Boston Squares portfolio management and narrow preoccupation with analytical data has been shown to provide service to a business only in a limited range of competitive situations (Simpson, 1998). Large multi-business corporations suffered massive set-backs (IBM, Digital, GM, Westinghouse) arising from not perceiving or controlling their businesses using appropriate models.

Since this time, waves of new approaches have aimed to make visible the new basis of competition and provide corporate controls. 'In Search of Excellence' (Peters, 1995), Total Quality Management, Reengineering, Core Competence (Prahalad and Hamel, 1990), 'competing on capabilities' and 'the Learning Organisation' (Senge, 1990) have swept through businesses, but without any reference to each other in a consistent framework. However, a resource-based strategy takes account of the many assets of a business, and provides a view that integrates these factors (Collis and Montgomery, 1995). This aims to build a set of unique resources and capabilities, but 'with a sharp eye on the dynamic industry context and competitive situation, rigorously applying market tests to these resources'. In order to achieve the value potential of these resources and avoid being undervalued, firms must apply leverage to utilise these resources – in other words, to make as much of themselves as possible.

Based on similar principles to the resource based competition described by Montgomery, the whole area of integrated business and technology management has developed as competence-based competition (Hamel and Heene, 1994; Sanchez et al. eds., 1996). This involves a wider set of principles than described by Montgomery, which particularly include the principles of modularity in products, organisations and processes, and recognises the application of the science of complexity to organisations. There are wide implications but a major benefit is that of increasing strategic flexibility for a business. To gain strategic flexibility, firms in a number of markets are beginning to use modular, flexible designs to generate unprecedented levels of variety and change. The exercising of strategic options creates new flows of resources and forms a virtuous circle, giving rise to more strategic flexibility (Sanchez , 1995).

The enablers and drivers of new product strategies giving strategic flexibility are the concepts of modularity in products and organisations. Modularity allows the de-coupling of processes for developing new products, enabling these processes to become fast, concurrent, autonomous and distributed (Sanchez, 1996). This requires an intentional and disciplined de-coupling of technology development and product development, as described by (Witter et al., 1995). This also requires new concepts for strategically managing knowledge. As technology and process are de-coupled, particular areas of knowledge can be better managed:

- **'know why'** (theory of the system to allow the adaptation or development of significant new product variations),
- **'know-how'** (understanding of current products and how to make them) and
- **'know-what'** (strategic understanding of the purposes to which know-why and know-how may be applied to competition.)

This approach allows a business to collaborate extensively with other businesses by sharing know-how (e.g. drawings), yet still retain its critical know-why (architectural design knowledge) and know-what (concept application to market knowledge). The interfaces between the modules are facilitated by the lines of communication which allow joint goals, functional, geometric and system signals to pass. However, modularization is constrained by complexity, where some aspects of the business are too complex to de-couple effectively (Scarborough 1998). Here, organisational boundaries, skills and information systems must chosen appropriately to allow rapid experimental learning within complex systems and still keep stable external interfaces. This allows a framework to be formed that gives an appropriate balance of planning (where the system is understood and predictable) and emergent approaches (where the system emerges by theory and experimentation). The areas of complexity that could defy beneficial modularization could be logistical, technological (product or process), organisational or environmental.

A means of managing modularity to give product variety efficiently is the platform concept (Robertson and Ulrich, 1998). This is a system of product planning taking into account a range of desired products, their differentiating attributes and then maximising common hardware process and knowledge. This conserves research, development and production resources. Platforms are a concept consistent with the concept of evolutionary architectures (Rouse, 1991), where the basic architecture of a product is maintained, and those parts (modules) improved through time so that work is only applied to add differentiation.

The author's scheme was originally aimed at providing flexibility through the use of a modular and platform approach, individual modules and platforms providing the framework for the retention and management of parametric, external understanding and detailed operational knowledge. The scheme and the goals of competence-based management are in alignment with the model.

Making the best use of possibilities within a strategic framework requires a mechanism for bringing together external knowledge, internal constraints and possibilities. IT, in particular, is a special case as it deals with information, the automation of tasks and reconfiguration of businesses. An appropriate framework has been devised arising from the 'Management in the 1990's' Research Program (Scott Morton (ed.), 1991). This recommends triangles of strategy alignments, where one strategy, the domain anchor, provides the 'anvil' that the second strategy (the domain pivot, or hammer) confirms and improves. The third strategy, the impacted domain, is the component affected by any changes to the domain pivot, and may be a major constraint of the changes that can be adopted by the domain pivot. Figure A13 shows the overall process, which first uses IT strategy as the hammer, business strategy as the 'anvil' and organisational infrastructure complying and providing constraints. The process continues around the loop anticlockwise for one or two cycles until the strategies are aligned and deliverable.

In the author's opinion, the process could be used for any strategic driver that offers significant opportunities for a business, and not only IT.

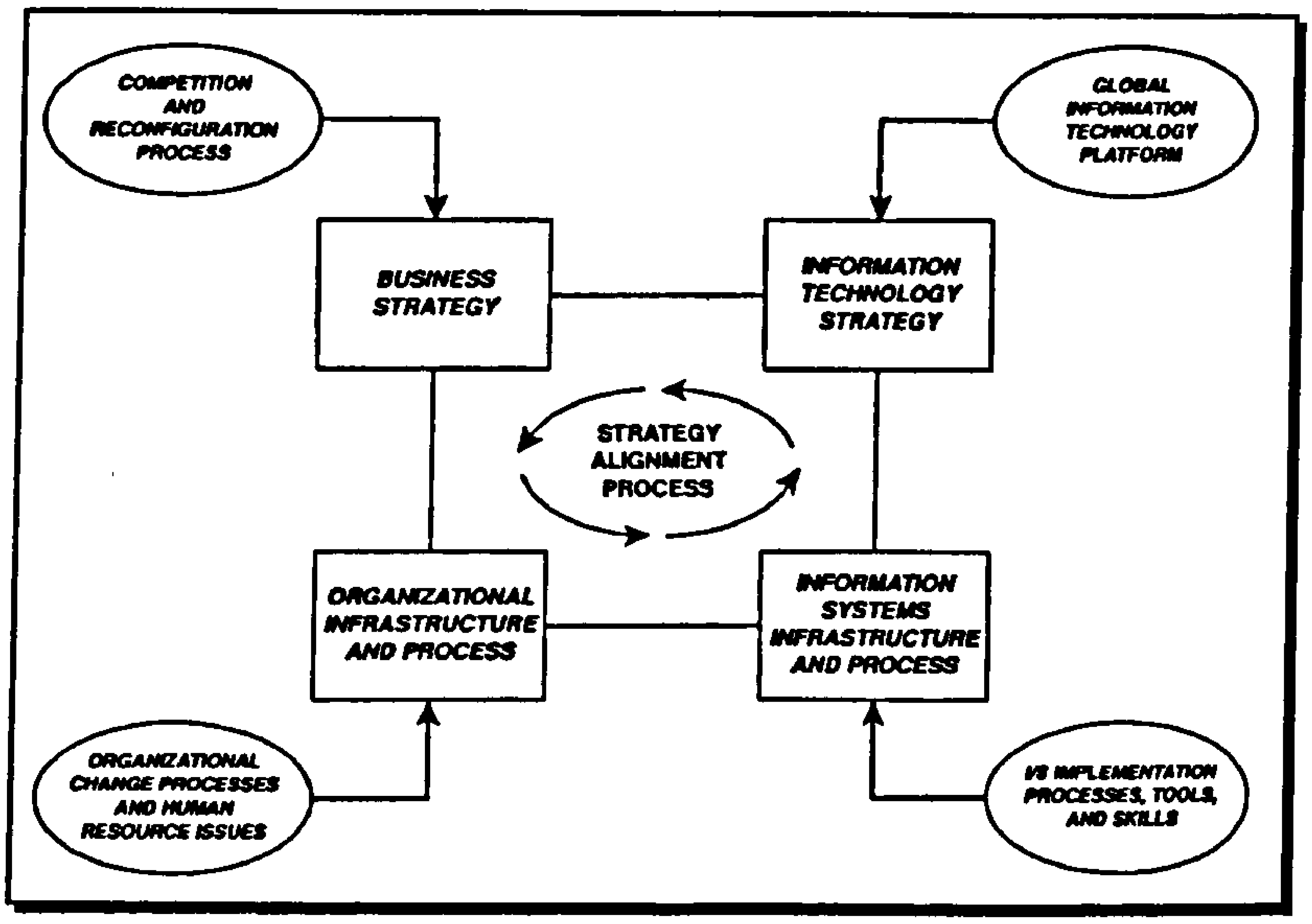

Figure A13 Strategy Alignment Process (Scott Morton, 1991)

The aims of a business strategy itself are governed by the values of the organisation. While most businesses generate mission and vision statements that profess building value for the customer in different ways, the guiding principle often observed in practice is that of financial return.

However De Geus (1997) proposes that, ***"Like all organisms, the living company exists primarily for its own survival and improvement: to fulfil its potential and to become as great as it can be".*** In contrast, Deming (1993) proposes that an organisation should aim for everybody involved with the business as a system to gain (win/win). This approach allows a joint working to common goals that encourage synergistic working within the organisation, and between the organisation, its external partners and customers.

The author has identified a solution to this dilemma. Sanchez in 'Management at the Point of Inflexion'(Sanchez, 1997) points to the need for ***"relatively simple rules for ordering complex stocks and flows of resources in ways that act as attractors".*** The findings of the author's work are compatible with these in that the most potent attractor (the quasi-stable set of values that provide survivability for firms in different kinds of competitive environments) is the brand. This allows a simple contract to exist between customer and the firm, giving a common value system for target setting and decision-making, a bond between firm and employees, firm and supply chain. This finding is compatible with the structure and brand targeting processes developed by the author for the design model of the business, and is also consistent with the need for a 'Constancy of Purpose' style of management advocated by Prasad as essential for successful concurrent engineering.

3.8 INTEGRATION THROUGH SYSTEMS, CYBERNETICS AND COMPLEXITY

Drucker (1990) suggests that complexity, uncertainty and ambiguity are likely to be the hallmarks of tomorrow's production and business systems. As technologies and organisations become more complex, so learning becomes a more important mechanism than top-down control (Bohn and Jaikumar, 1985). This is not only relevant for manufacturing, but also R&D, business management and product and process development (Khurana, 1999). The systematisation of an organisation allows the interaction of relatively simple and largely autonomous parts to form a complex and 'intelligent' whole. Deming (1993) focused post-war Japanese industry on co-operation (win/win) and learning within a system, whether the system was the business or a group of businesses, with its well-known results. De Geus sees the business as a system also, applying the implications of working and learning in a system to the behaviours needed to make this work. His work led to the formation of the body of knowledge known as the 'learning organisation', brought together by Senge (1990, 1994).

Some of the most instructive work in the understanding of complex systems has arisen through the 'new' sciences of cybernetics (Weiner 1985) and complexity. Ashby (1957) developed a mathematical treatment of the science of control and feedback in biological and human systems – initially intended to help medical and biological research. This shows how the organism survives if it is able to maintain a set of critical parameters stable internally (homeostasis). The 'fitness' of the organism is judged by the probability of survival against a set of external disturbances, the system shown in figure A14.

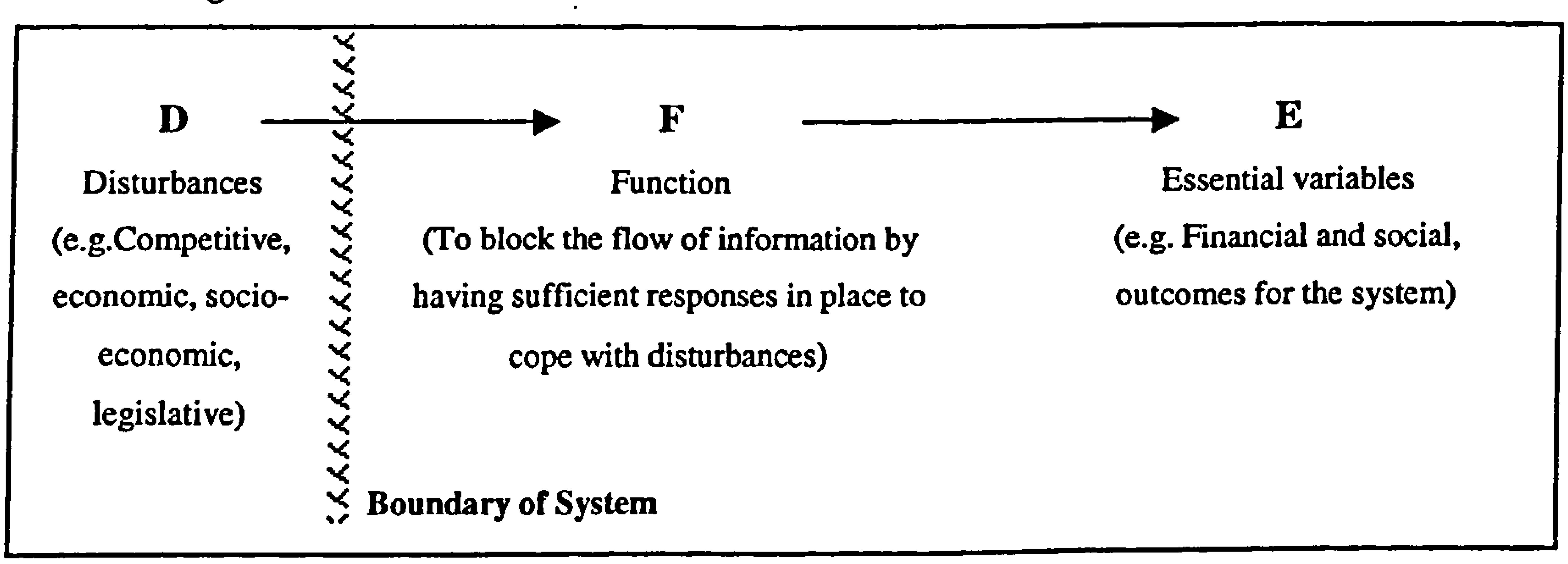

Figure A14 Model of a dynamic system. To survive it must protect its essential variables from external disturbances.

Ashby's law of requisite variety states that, for an open system (i.e. one that interacts with its environment):

"To achieve control, the variety of actions a control system is able to execute must be at least as great as the variety of environmental perturbations that need to be compensated. The larger the

variety of available counteractions, the larger the set of disturbances that can be corrected, and the larger the domain of potential environmental situations the control systems can survive."

This principle has two points of contact with the author's work. The first is the need to use scenarios and set-based targeting to prepare business responses for a range of possible competitive environments. The second is in the need to identify and measure sufficient attributes that allow the important customer needs to be measured in 'Engineering the Brand' (project number 7), and wider project target setting. In a quote from Churchill, "The invisible must be made visible". In the author's words, in order to engineer something, the engineer must first see the metric, understand it and then be able to measure it.

Beer (1994), Simon (1992) and others have applied and extended the work of Weiner and Ashby (1962) further into business, psychological and computing applications. Beer has applied cybernetics in a series of rules and processes to reinforce the viability of organisations (Beer 1994) and a number of these have resonance with the author's findings. Simon (1962) explored the system of hierarchies, an essential part of the model of the design process. Forrester is well-known for understanding the destructive interaction between non-communicating systems, and the dynamic modelling of systems. The development of cybernetic models has been taken further for biological systems (Dawkins, 1974) and has assisted in explaining the evolution of both living and non-living systems (Heylighen, Aerts (eds.), 1996).

A further body of work, closely connected with cybernetics and systems theory, is the study of chaos and complexity (Kaufmann, 1995). The core of this work is the principle of self-organisation of individuals into networks. Seen in mathematical form in the well-known Mandlebrot series, the basic principles are that there is a natural tendency for simple units with particular properties to self-organise into networks giving rise to complex behaviours (Capra, 1997). 'Complex' in this sense means having a variety of responses to external perturbations to maintain the viability of the organism. The Santa Fe Institute was set up by Murray Gellman to explore the common applications of mathematics to complex systems. Studies at the Santa Fe Institute (SFI) explore complexity in natural systems and its links to biology and business, examples being the understanding of biological immunity mechanisms and evolutionary virus searching algorithms. A membership list of the SFI business network (Table1) shows a wide and recent corporate interest in complexity.

A recent work (Kelly and Allison, 1998), reports the lessons of complexity as applied to the Citicorp business. The authors have identified the following necessary behaviours for individuals to achieve a self-organising system:

- Trust information from others – if they have a process and follow it, respect the results these give. Believe people when they identify risks, better to help solve these before it happens - don't just expect people to bring solutions or you will never hear the problems until it's too late.

Company	Company type	Location	Member since
1992 2 new members			
Citigroup	Banking	New York, NY	June 1992
Deere & Company	Manufacturing	Moline, IL	September 1992
1993 2 new members			
Legg Mason Mutual Funds	Finance	Baltimore, MD	April 1993
Sencorp	Plastics and packaging	Newport, KY	September 1993
1995 5 new members			
McKinsey and Company	Consultancy	New York, NY	January 1995
Hewlett-Packard Company	Electronics	Palo Alto, CA	June 1995
Marine Corps Combat Development Command	Military	Washington, D.C.	September 1995
Unilever Research	Consumer goods	Merseyside, UK	September 1995
Ernst & Young	Consultancy	Boston, MA	October 1995
1996 4 new members			
Intel	Electronics	Hillsboro, OR	October 1996
Kozo Keikaku Engineering, Inc.	Engineering	Tokyo, Japan	October 1996
Honda R & D	Auto manufacture	Torrance, CA	November 1996
Office of Naval Research	Military	Arlington, VA	November 1996
1997 13 new members			
CNO - Strategic Studies Group	Military	Newport, RI	January 1997
MITRE CAASD	Aviation R&D	McLean, VA	January 1997
Solectron	Electronics	Milpitas, CA	January 1997
Motorola University	Electronics	Schaumberg, IL	February 1997
Joint Warfare Analysis Center	Military	Dahlgren, VA	June 1997
Bios Group LP	Biotechnology	Santa Fe, NM	September 1997
British Telecom Laboratories	Telecommunications	Ipswich, UK	September 1997
Boeing	Aircraft manufacture	Seattle, WA	October 1997
Credit Suisse First Boston	Finance	New York, NY	October 1997
Toyota Motor Corporation	Auto manufacture	Aichi, JAPAN	October 1997
Hakuhodo Inc.	Advertising	Tokyo, Japan	December 1997
HRL Laboratories	Electronics R&D	Malibu, CA	December 1997
SUN Microsystems	Computing	Palo Alto, CA	December 1997
1998 6 new members			
Pioneer Hi-Bred International	Electronics	Des Moines, IA	March 1998
Arthur Andersen	Consultancy	Houston, TX	April 1998
Dentsu	Advertising	Tokyo, Japan	October 1998
Ford Motor Company	Auto manufacturer	Dearborn, MI	December 1998
Lilly Research Laboratories	Pharmeceutical	Indianapolis, IN	December 1998
Procter & Gamble	Chemical	Cincinnati, OH	December, 1998
1999 11 new members			
The Abernathy Group	Consultancy	New York, NY	January 1999
World Bank	Finance	Washington, D.C.	June 1999
Agilent Laboratories	Instrumentation	Palo Alto, CA	July 1999
Davis Selected Advisers, L.P.	Financial	New York, NY	July 1999
America Online, Inc.	Internet provider	Dulles, VA	September 1999
Warburg Dillon Read	Finance	Chicago, IL	September 1999
State Farm Insurance Companies	Finance	Bloomington, IL	October 1999
Lazard Asset Management	Finance	New York, NY	November 1999
Merrill Lynch Asset Management	Finance	Plainsboro, NJ	November 1999
Cisco Systems	Telecom electronics	San Jose, CA	December 1999
EBay	E-business	San Jose, CA	December 1999
2000 (Part) 5 new members			
TRW Systems & Information Technology Group	IT	Albuquerque, NM	March 2000
ZEFER	Internet consultancy	Boston, MA	March 2000
Argonne National Laboratory	Government research	Argonne, IL	April 2000
Captial Research & Management Group	Finance	Los Angeles, CA	May 2000
Janus Funds	Finance	Denver, CO	May 2000
CommerceNet	Finance	Cupertino, CA	July 2000
Trilogy Advisors	Consultancy	New York, NY	September 2000

Table 1 List of corporate members of the Santa Fe Institute (September 2000)

- Share information – speak out when there is disagreement or a lack of listening, this is the basis of learning, particularly important when organisational weaknesses are challenged.

- Align choices: Deep commitment – make sure that plans that are drawn up are real and committed and not ignored.
- Co-ordinate co-evolution: Responsible interaction – Creating one or more scenarios for potential action and then acting according to the one they select allows a team to co-ordinate their action. Effective use of group scenario building – before proceeding – mentally tests the projected consequences of potential actions.

A series of steps are then proposed to make the most of an organisation using this behaviour.

The findings arising from the engineering doctorate work are in alignment with those of the above, particularly in the behaviour necessary for natural self-organisation of the system to emerge. Where the author's work is distinct is in its inclusion of brand values, product operational processes, organisation guidelines and technological approaches. These provide guidelines for overall organisational and technological change in addition to the vitally necessary human dimension.

4. *CONCLUSIONS*

This review set out to show the level of agreement and distinctiveness of the design model against published literature. The following points of distinction and agreement can be made against each area of learning reviewed.

1. (New product introduction frameworks). A systematic framework is needed to cover the early phases of the new product introduction process. The author's model provides a means of integrating the early phases.

The role of the author's model in the literature is to define the maturation of confidence, by which means a successful, responsive, integrated new product introduction may be achieved. Other models in general map the <u>activities</u> that take place, rather than mapping the interaction of these activities. The properties required for speed, responsiveness and high productivity are co-ordination (Clarke and Figgie 1989) and up-front planning (McGrath 1995). The need for a systematic model of the early phases, such as the author's, to show a general means of making these behaviours visible has been stated (Khurana and Rosenthal 1997).

2. (Innovation Frameworks). Innovation frameworks provide a means of covering the wider concept of innovation beyond product innovation. Where the author's model is innovative is in integrating a mechanism to respond to alternative futures, core competencies, and a motivation for the organisation to seek continuous innovation.

The author's model represents a process of sensing the outside world, consciously setting a span of possible futures, understanding the requirements of these against its competencies and technologies and then maturing its options through to delivery. The innovation of the model is in integrating these, and providing a motivation for continuous, rather than sporadic innovation, through the organisation. It is proposed that the brand concept is a long-term driver for this, which keeps the organisation on a true course in the marketplace.

3. (Strategic Innovation Frameworks). Product innovation is identified as a strong basis for organisational renewal, which is the basis of the Design Model of the Business. scenario planning, strategy and product decision-making processes have been adapted by the author to allow the organisation to renew itself around the portfolio of products.

Product innovation has been identified as a primary means of organisational renewal, supporting the author's use of the whole product lifecycle as the basis of the design model of the business. The design model requires the use of a technique such as scenario planning to make visible an explicit range of futures, and the organisational responses to these. Processes have been developed and improved in concept to support the visibility of competitive futures, and the development of new options against these.

4. (Concurrent Engineering). The design model of the business uses principles compatible with and similar to concurrent engineering, but in addition applies these to the early organisational

and product design prior to product development. The flexibility of the design model to adapt for different product structures and complexities suggests that it is more broadly applicable than to just the automotive industry.

The principles and application of concurrent engineering have been found to be compatible with the author's model. Where the design model is innovative is that it applies these principles for the early phases of design and development, which include portfolio planning, business strategy formulation, and strategic innovation. Concurrent engineering models cover product design and development and not these early phases. Lessons from the application of concurrent engineering to a variety of organisations show that hierarchical breakdowns of product, process and organisation should be influenced by the structure of the product and the organisation's level of complexity (Backhouse and Brookes 1991, 1996; Backhouse et al 1995). The flexibility of the author's model to different product structures and complexity suggests that it should be capable of applicability across a range of organisational types.

5. (NPI effectiveness and efficiency techniques) The main design tools for New Product Introduction have been found compatible with the design model, which provides a framework for their effective deployment.

The potential complexity of dealing with a range of possible targets emerging from scenario planning and set-based targeting (Sobek et al. 1995, 1998, 1999) can be simplified by embedding these into a range of product options. In the Design Model, these options are then hybridised at stages during their development using Pugh's concept selection technique (Pugh 1996). Various levels of supplier integration have been found compatible with the author's Design Model, and have been observed in industrial practice. None of the 'Design for X' approaches have been invalidated by the author's model, but their effective introduction into the design process is facilitated through the author's development of the early phases of a reengineered new product introduction process.

6. (Individual and group behaviour) The design model of the business takes into account lessons in the literature on appropriate decision-making behaviour, and aims to form a basis for the integration of the workforce as one co-operative unit.

The model of a dysfunctional decision-making culture found in the author's research is consistent with that identified by Argyris (1982, 1985, 1993). The design model of the business, its processes and principles has been purposely developed to support appropriate decision making with valid, transparent targets and good evidence for confident decisions.

7. (Strategies for flexibility and innovation). A modular, platform approach allows an organisation to be strategically flexible in technological terms, but needs to avoid stagnation by continuously renewing its differentiating competencies. The brand concept can provide the focus for continuous renewal.

Leading edge strategy planning concepts call for strategic flexibility through the use of a modular and platform approach to organisations and their products. The author's design model was originally aimed at providing flexibility through a modular and platform approach, and is closely aligned to the needs of a strategically flexible organisation. From the author's research, a means of guiding a business can be provided by using the concept of the brand. This is the entity in the author's model that drives the innovation process and defines competencies, products and decision values in the organisation.

8. (Integration through Systems, Cybernetics and Complexity). Complexity and cybernetics provides rules for the behaviour of individual elements to allow their co-ordination into an evolutionary fit, self-organising group, and is an area of growing relevance to corporate bodies. The author's work is in alignment with the principles and provides models and tools for their deployment.

The author's work agrees with the principles of cybernetics and complexity. Many of the features of the design model of the business coincide with the need for systematic hierarchies, a central requirement for loosely coupled, self-organising systems. The goal of targeting and environmental scanning is to identify potential disturbances for an organisation to provide a response before the disturbance happens. Where the author's work is in advance of that published are the models, tools and processes developed to support an organisation to be strategically flexible.

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