A GREENFIELD SITE SELECTION MODEL FOR SME's 
BASED WITHIN THE RAPID PRODUCT 
DEVELOPMENT SECTOR

LEE EDWARD JAN STYGER

A thesis submitted in fulfillment of the requirements of the De Montfort 
University for the degree of Doctor of Philosophy

January 2001
ACKNOWLEDGMENTS

I would like to acknowledge all of the people at Styles RPD, ARRK and indeed all of those connected with the Rapid Product Development sector who gave me the drive to complete this work.

I would especially like to express my sincere thanks to Phill Dickens for his guidance and encouragement during the research. Phill made the whole process of study a pleasure and not a chore.

I would like to thank Nick Longford for showing me that statistical analysis need not be a black art best kept to mathematicians. Also Michelle Young for disclosing the intricacies of Excel.

Tom Pongpanich deserves special mention for providing me with good exchange and encouragement at the early stages of this work. As do the entire staff and board of the Institution of Engineering Designers for their support.

I would like to finally thank my wife Alison, who has always encouraged and supported my every endeavor.

This work is dedicated to my daughters Monica and Rozlyn in the hope that they always maintain their current thirst for knowledge.
DECLARATION

I declare that all the work described in this report was undertaken by myself (unless otherwise acknowledged in the text) and that none of the work has been previously submitted for an academic degree. All sources of quoted information have been acknowledged by means of references.

Lee Edward Jan Styger

1st January 2001
SYNOPSIS

This work has been undertaken to research and determine a robust site selection model for small to medium sized enterprises based in the European Rapid Product Development sector.

Site selection is a complex, multi-level decision-making problem that combines issues such as market forces, provision of finance, availability of workforce etc., with the actual site selection requirements. The process of site selection must be undertaken in a near as possible neutral decision-making environment. The decision model must be able to deliver an outcome that is compatible to the demands of the "real world problem".

Typical decision-making models are either limited and therefore do not provide sufficient clarity, or are over complex and rely on mathematically perfect solutions that may have no real value in actual decision-making processes. Most decision-making models are matrix based and rely on the principle of first past the post, where the highest score provides the "winner" or outcome. Overall the matrix system is robust but typically limited.

This work shows that a two-stage decision model should be adopted that incorporates decision cells to enable profiles of the target location to be mapped and analysed against that of the optimum desired outcome. This work also shows that it should be possible to portray the whole site selection project (inward investment process) as a stage gate model where each stage is logically presented and analysed in relation to the corporate needs.
KEY WORDS

- DFI - Direct Foreign Investment
- DTI - Department for Trade and Industry
- EMU - European Monetary Union
- EU - European Union, defined as the fifteen member states that were incorporated fully into the European Union (EU) on 1st January 1999.
- GDP - Gross Domestic Product
- JIT - Just In Time
- NAFTA - North American Free Trade Agreement
- OEM - Original Equipment Manufacturer consisting of a company or organisation larger than 250 employees or with a turnover greater than £35m.
- RDA - Regional Development Agency
- ROI - Return on Investment
- RPD - Rapid Product Development
- RTO - Research & Technology Organisation
- SME's - Small to Medium Sized Enterprise consisting of a company or organisation not larger than 250 employees with a turnover greater than 40mecu, balance sheet total of less than 27mecu and is not more than 25% owned by another organisation.
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CHAPTER ONE – INTRODUCTION TO THE WORK
1.0 Introduction and Terms of Reference of the Scope of Work

This work has been undertaken to research and determine a robust site selection model for small to medium sized enterprises (SME's) based in the European (EU) Rapid Product Development sector (RPD). The work is based on the assumption of greenfield site development, however, the final model is flexible enough to cater for locations that offer existing facilities. It has been necessary to cover a number of areas in order to determine the proposed decision-making model, these are:

1. Provide contextual information relevant to the scope of work
2. Provide relevant industrial case studies for analysis and comparison
3. Define the process of inward investment
4. Review the opportunity cost of inward investment for the SME's
5. Define a structured decision making process relevant to the scope of work
6. Provide an analysis and discussion of the case study with reference to the area of work
7. Review the main issues arising from the industrial case study with reference to the comparative work and research
8. Review the importance of the site selection model within the context of a holistic site selection and site development project
9. Propose the theoretical site selection model
10. Undertake a functional trial of the new site selection model
11. Provide conclusions to the research
12. List further work that has arisen as a result of this research
1.1 Background to the Problem

Commercial success is dependent on a successful marriage of corporate strategy and local conditions. Strategic decisions are typically complex and made up of conflicting criteria (Story 1999). The outcomes of complex decisions should therefore not be arrived at lightly or by "shooting from the hip" (Wild 1989). This is especially true when related to subjects that have major economic implications such as investment in new site locations.

The inward investment process ranks high in importance in terms of economic growth for regions throughout the European Union. However, the whole process of investment and the optimum criteria for site selection remains the most unpredictable mechanisms of economic growth (Hirschman 1958 and Arnold & Quelch 1988).

The site selection process is complex, the outcome is typically influenced by corporate culture and politics. For example, Potter & Tackey (1992) state that larger companies typically emphasis the importance of incentives, labour and site, whereas high-technology companies will specify integration with other similar organisations (i.e. the "Cambridge Phenomenon", or "Silicon Valley"). Service companies hoping to establish centres will usually prefer capital cities.

To date, little work has been undertaken to determine the optimum site selection procedure for SME’s based in the Rapid Product Development sector.
1.2 Definition of Problem

Inward investment is the process by which a company moves or expands from its original geographic market place into a new geographical market place.

The process of inward investment will continue to be a major factor in the development of the European economy for some considerable time (Owen 1999). The inward investment process will necessitate the need for companies to select new sites for their operations within the proposed location. Therefore, a robust model for site selection is necessary if companies (specifically Rapid Product Development) are to move into new geographical markets with the minimum of risk.

Current site selection models typically fall into two camps, these are:

1. Simple matrix models that deliver an outcome based on highest score or first past the post principles
2. Computational matrix models that are reliant on complex mathematical formula to deliver an outcome typically based on first past the post principles

Most site selection models are typically too rigid and as such do not favour "real world" decision-making processes and outcomes. Also most of the current models have tended to be developed for service and logistics based operations. Less research has been undertaken into developing models for manufacturing, engineering and specifically Rapid Product Development operations where the dynamics of the business place different requirements

Much has been written regarding the process of inward investment, however, there is little recorded work on the unique challenges faced by SME’s that wish to embark on such a project. Christodoulou (1996) suggests that this may be due to certain evidence that indicates that most SME’s who enter into the process of inward investment typically move less than thirty miles from their original point of origin.

1.3 Hypothesis

Typically a criteria based selection matrix model offers a good method of delivering an outcome or value for a complex decision (Badri 1996, Jayaraman 1999). Good criteria selection models can remove potential error and emotional biases (heuristics) associated with a decision-making process (Arntzen et al 1995). Finch and Luebbe (1995) and Müller and Schimmel (1999) propose a system based on the principle of “highest score wins” (first past the post). However, the reliance on the first past the post principle may not deliver the best overall decision. This is because there may be a large variance between the criteria values of optimum desired outcome (i.e. the theoretical maximum score from the criteria matrix) and those of the actual outcome (Longford 1999, Vause 1999). For example, there may be no workable “real world” solution if labour was considered to be the most important criterion, yet the highest score from the ranking model was derived from maximising all criteria except labour.
Furthermore Müller and Schimmel (1999) suggest that decision models should have a maximum of twenty criteria for fear of "the overall picture of the problem" becoming lost in the detail of the decision-making process. This work has however shown that site selection is a multi facetted problem typically incorporating many more criteria than Müller and Schimmel would allow.

It is therefore suggested that a process based on the analysis of the outcomes of individual decision-cells plotted against those of the optimum desired outcome may offer a more robust method of delivering a real world solution for site selection. Also a matrix selection model that incorporates a number of detailed selection levels may allow highly complex decisions to be made without losing the overall picture of the problem and may also offer a higher degree of transparency.
CHAPTER TWO – THE RAPID PRODUCT DEVELOPMENT SECTOR
2.0 Introduction

The measurement of value and contribution of this work is based against the research and delivery of a novel site selection model that enables users to determine the optimum selection criteria for greenfield site selection for companies within the European Rapid Product Development (RPD) sector. The case studies and benchmarks are included in order to provide a common reference point for the research and understanding for the provision of weightings and rankings for the selection model (Codling 1998).

This Chapter provides:

1. A definition of an SME
2. A definition of the European Union
3. A definition of the EU RPD sector, industry trends and sector growth
4. Analysis of the EU RPD sector during the period of study
5. Methodology of data gathering for the RPD company case studies
6. The main case study – Styles Precision Components
7. Other comparable RPD company case studies

2.1 Definition of an SME

In February 1996, the European Commission adopted a single definition of an SME (Anon [c] 1998). The definition was applied across the European Union on the 1st January 1998 and is outlined in the table below.
### Table 2.1 - European Commission Definition of an SME

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Micro</th>
<th>Small</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Number of employees</td>
<td>10</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>Max. annual turnover</td>
<td>-</td>
<td>7mecu</td>
<td>40mecu</td>
</tr>
<tr>
<td>Max. annual balance sheet total</td>
<td>-</td>
<td>5mecu</td>
<td>27mecu</td>
</tr>
<tr>
<td>Max % owned by one, or jointly by several enterprise(s) not satisfying the criteria</td>
<td>-</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Note: to qualify as an SME'S, both the employees and the independence must be satisfied and either turnover or the balance sheet total criteria


#### 2.2 Definition of the European Union

Within the scope of this work, European Union is defined as the fifteen member states that were incorporated fully into the EU on 1\textsuperscript{st} January 1999. The member states are shown in the table below along with key data.
Bennett (1997) describes the European market being dominated by the “golden triangle” (the area defined within Liverpool, Cologne and Paris) that contains over half of the entire EU population in a landmass smaller than that of the UK. The north/south divide within Europe is of more concern, whereby the northern states dominate the industrial and financial growth of the whole of the EU (Peel 1999, The Economist May 27th 2000).
2.3 A Definition of the European Rapid Product Development Sector, Industry Trends and Sector Growth

2.3.1 Definition of the European Rapid Product Development Sector

Product development is more usually but incorrectly confused with research (Vernon 1966). Product development companies do not usually become involved in contract research. Lancaster and Reynolds (1999) state that all companies develop products to enter new markets to return a profit. The European Rapid Product Development sector is collectively an engineering based service sector defined as those companies that are providing services involving the rapid design and development of products for a third party manufacturing organisation. The sector may include organisations practicing, any and/or all, of the following activities:

- Conceptual design
- Engineering design
- Test and analysis
- Modelmaking
- Prototyping
- Short-run or bridge production
- Value-added/niche manufacture, etc.

The distinguishing features of a "Rapid Product Development service provider" are:
• Rapid and responsive
• Customer focused
• Fast and efficient electronic communication

2.3.2 A Brief History of the European Rapid Product Development Sector

The origins of the RPD sector can be traced back to the late '80's. The RPD sector evolved primarily as a business process (supported by advanced technology) for designing and developing products rapidly (Cooper 1999). The key to the sector was the ability to "productionise" craft skills brought together from traditionally isolated specialist services such as engineering design, drafting, model and patternmaking and toolmaking etc.

Much time has been given to the technical aspects of RPD. It is however sufficient to state that the core driver for the RPD sector is CAE technology.

2.3.2.1 Unique Business Dynamics

The EU RPD sector has some unique business dynamics. For example order books are typically short, debtor days (payment after delivery to the client) are long. Accurate business predictions are therefore impossible and the management of cashflow is primary. There is always a major conflict between workshop capacity and cyclic nature of the marketplace. There is typically little understanding for the management of this type of business outside of the sector.
2.3.3 Sector Trends

Most EU RPD service supplier companies are SME's that typically provide products and services to most of the OEMs and first and second tier suppliers throughout the EU. The client base is now demanding that RPD service companies offer a total service combining the major process and technical elements of product development (i.e. an "all under one roof service").

The new demands being placed upon the sector is forcing a change in operational paradigm that includes:

- New business processes
- New skills
- New technologies

Traditionally the RPD sector has placed great reliance on leading edge technologies. It is however the considered opinion of industry that the business process of RPD and most importantly people and skills are the key factors to future success of the sector (Styger 1999 [a]).

Barlow (2000) commented that the UK toolmaking industry (a sub-sector of the RPD sector) was in "terminal decline". If we make a comparison between the old and new paradigms of product development it is easy to understand why the comments were made because this particular faction has tended to be under capitalised for many years. A comparison between the old and the new paradigms of product development is shown in table 2.3.
Table 2.3 - A Comparison Between the Old and New Paradigms of Product Development

<table>
<thead>
<tr>
<th>Old Paradigm</th>
<th>New Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly fragmented industry</td>
<td>All under one 'roof'</td>
</tr>
<tr>
<td>No urgency or project management skills</td>
<td>High project management</td>
</tr>
<tr>
<td>A craft industry</td>
<td>Productionised manufacture</td>
</tr>
<tr>
<td>Little or no investment and development</td>
<td>Investment at a 'critical' scale</td>
</tr>
<tr>
<td>2D Specifications</td>
<td>Paperless - 3D Solid Model CAE</td>
</tr>
<tr>
<td>The 'Black Art' of product development</td>
<td>Measured and audited procedures</td>
</tr>
<tr>
<td>Slow response times and culture</td>
<td>'Rapid' response time and culture</td>
</tr>
<tr>
<td>Outdated technology</td>
<td>State-of-the-art technology</td>
</tr>
<tr>
<td>Little communication internally or externally</td>
<td>Continual communication internally and externally</td>
</tr>
</tbody>
</table>

2.3.4 Statistics of the EU Rapid Product Development Sector

In 1998, the EU RPD sector was valued at over £30bn (Clouston 1998, Anon [a] 1998). A breakdown and comparison of the available global and EU figures for the RPD sector is shown in table 2.4.

Table 2.4 - Breakdown and Comparison of Available Global and EU Figures for the RPD Sector

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Global toolmaking market</td>
<td>£41bn</td>
</tr>
<tr>
<td>Global technical moulding</td>
<td>&gt;£100bn</td>
</tr>
<tr>
<td>European toolmaking</td>
<td>£10bn</td>
</tr>
<tr>
<td>European precision moulding</td>
<td>£20bn</td>
</tr>
<tr>
<td>European RP market</td>
<td>£150m</td>
</tr>
<tr>
<td>European RPD Market</td>
<td>£30bn +</td>
</tr>
</tbody>
</table>
2.3.5 Predicted Growth of the EU Rapid Product Development Sector

During the period of study, government estimates predicted that the market value of the sector would double from £30bn to £60bn by 2003 (Spencer 1998).

Although there is no definitive work relating to the number of people currently employed in the EU RPD sector, an estimate of 2.6million high-skilled professionals (i.e. people with formal higher-educational qualifications) was provided by the STARpd Consortium in 1999 (Anon [b] 1999). It was predicted that the EU RPD practitioner base would rise to 4million to coincide with the market expansion. A formulation for the estimate of the number of skilled, high-value jobs in the EU RPD sector is shown in table 2.5.

<table>
<thead>
<tr>
<th>Table 2.5 - Formulation for the Estimate of the Number of Skilled, High-Value Jobs in the EU RPD Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are approximately 200k CAE seats in the UK [assume 1 operator per-seat that compensates for the number of seats in OEMs and typically three shift working] (Ballard 1999)</td>
</tr>
<tr>
<td>There are approximately 1200 toolmaking companies in the UK. Each company has an average of 40 employees, therefore 1200 X 40 = 48k</td>
</tr>
<tr>
<td>Note this does not include any other portion of the RPD sector. However, let us assume that there are only 250k skilled people employed in the UK RPD sector (a probable gross underestimate).</td>
</tr>
<tr>
<td>The German market size is 2.5 times that of the UK</td>
</tr>
<tr>
<td>Therefore we may assume that there are approximately 625k employed in the German RPD sector</td>
</tr>
<tr>
<td>We may assume that the rest of the EU is approximately 3 times the UK and German totals</td>
</tr>
<tr>
<td>(i.e. 3 X 875)</td>
</tr>
<tr>
<td>Therefore the current number of high-value jobs within the EU RPD sector is:</td>
</tr>
<tr>
<td>2.625m</td>
</tr>
<tr>
<td>Note: this number is prior to any addition to cover the predicted doubling of the market size</td>
</tr>
</tbody>
</table>

Note: the above figures do not include all of the test, engineering and management professionals associated with the sector.
There are concerns that there will be a chronic shortage of practitioners entering the sector with the right level of skills and qualifications. The lack of a skilled workforce will cause some companies to look further afield for expansion opportunities (Styger 1999 [b]), hence the need for a robust site selection model specific to the Sector.

2.3.6 Differential in Revenue Generation

Within the RPD sector, more revenue is usually generated from activities that are further along the process chain. Activities early in the process chain however allow client capture and feed the “productionised” functions that typically generate more revenue.

Figure 2.1 illustrates the typical revenue differentials for the RPD sector, where one unit value of conceptual design work will generate one thousand units of value added manufacturing work when the product is developed along the RPD process chain.
Figure 2.1 - The Typical Revenue Differentials for the RPD Sector

Figure 2.2 illustrates the key monetary values of the EU RPD sector.
Despite the high monetary value of the RPD sector, there is a general lack of sector visibility throughout the EU. The sector is therefore fragmented and undervalued by the customer base (Eyles 2000).

2.3.7 The Differentiating Factors of the Rapid Product Development Company

The EU RPD sector is not typical, traditional business models and management techniques do not always apply. For example, most RPD companies earn revenue and profit by producing complex components in low-volume (i.e. batches of one). There is high dependency on capital intensive equipment and a highly skilled workforce. Typically there is less need for low-
cost materials and labour. There is also a tendency to have small vertically integrated production units.

2.4 Analysis of the European Rapid Product Development Sector During the Period of Study

During the period of study, the EU Rapid Product Development sector had some unique market features. The market features are discussed below.

2.4.1 A Fragmented and Immature Service Sector (The Bureaux)

During the period of study, the rapid product development sector was comparatively young in terms of definition and visibility within the global market place. External perceptions of the industry were, at the time, based around a limited number of specialist technologies that were (as is common with an emerging market) competing for maximum market share. Park (1998) claimed that the market place was proliferated with small “garage industries” that focused on one particular service or technology. He predicted that the market would mature and witness a rationalisation of service providers.

2.4.2 A Misinformed Customer Base

The emerging nature of the Rapid Product Development market inevitably led to confusion relating to the capabilities and benefits of the products and services on offer. This had the net effect of slowing the predicted industrial take-up and marginalising the sector further (Wohlers 1999 and Culley 1999).
2.4.3 The Global Shift in Customer Expectations

The emerging nature of the market place and confusion of the customer base placed further demands on the sector in terms of shifting requirements and expectations (Martensson et al 1998). During the period of study, the customer base was beginning to demand a fuller rapid product development service that included all technical services under one corporate umbrella (Wohlers 1998).

2.4.4 The “Grey Market”

The industrially commissioned “Royle Report” (1998) highlighted a unique trend in the rapid product development market, where 50% of the service capacity was housed within OEMs, universities and RTOs. This had the effect of converting much of the available business from a high-value-added service into a commodity product (Sarwar and Hackney 1998 and Dickens 1999).

2.4.5 Global Influence and Over Capacity of Low-Value “Out Of The Box” Services

The global demand for rapid prototyping services did not meet the general predictions of the industry. This led to an over capacity in low-value “out of the box” services that reduced the profit margins of higher-value service providers. As a result, most of the valued-added companies had to reduce prices to generate some gross contribution (Anon [d]).
In the fourth quarter of 1998, Plynetics Inc. (the premier North American RPD service provider) had entered into receivership. Within the UK market, Formation Ltd. followed a similar strategy to that of Plynetics Inc. The low-price strategy failed and administrative receivers were appointed on the 20th January 1999. It is claimed that the Company was over extended (debt/equity ratio of 8:1) and had focused their expansion strategy on new production tooling activities at the experience of their core rapid prototyping business (Birchall 1999). These case studies highlight the importance of opportunity cost and the holistic site selection process, both of which are discussed in Chapters Four and Eight respectively.

2.5 Methodology of Data Gathering for the Rapid Product Development Company Case Studies

Typically most researchers use questionnaires to gather inter-personal data. Questionnaires are adequate for general information gathering if they are designed well and correctly executed. However, face-to-face interviews are more productive if specialist and/or in depth information is required (Ryan 1984, Kotler 1994, Christopher and MacDonald 1995). There are typically four advantages for using interview processes for in depth data gathering, these are:

1. Complex questions may be asked and complex issues explored more closely
2. New areas may be investigated and new lines of thought followed
3. The status and level of the respondent is assured, therefore the quality of the information is higher
4. A higher percentage of responses are more likely to be forthcoming, therefore the overall sample group is likely to be of higher quality.

Bayliss (1989) and Lancaster and Reynolds (1999), state that a degree of structure must however be maintained and the number of questions kept to a minimum if an interview is to return quality unambiguous data. The structure should include:

- Personal information (i.e. name, company, position in company)
- General market information (i.e. size of company, number of employees)
- Target questions (i.e. have you expanded to a new or second site).
- Specific questions (i.e. why did you move, what was the key criteria, was the move successful)

These recommendations were followed in the data gathering process for all of the case study companies discussed below.

2.6 The Main Case Study – Styles Precision Components

2.6.1 A Brief Business History of Styles Precision Components

Styles Precision Components (Styles) was founded originally in 1946 as a precision engineering company. New management took control of the Company in 1988.

Regional economic decline coupled with limited product portfolio undermined the stability of the Organisation. In an attempt to overcome the decline in
business faced in the late 1980's, Styles evaluated a number of alternative business opportunities in the hope that new business would lead to profitably and thus transforming the Companies circumstances.

In November 1993 a £250,000 venture capital deal was negotiated with 3i. In 1994 Styles re-evolved into a rapid prototyping company, specialising in the manufacture of plastic prototype components by exploiting new rapid prototyping technologies.

The re-focused company prospered and moved to a new 10,000ft² facility (located on the same industrial estate) in May 1996. Styles expanded again in 1998 and took occupancy of a second larger unit (15,000ft²) adjacent to the former one.

Styles was acknowledged as the UK market leader in rapid prototyping and was widely acclaimed as the European exemplar for this industry. The high standards of Styles was exemplified by several business and industry awards including:

- Teesside Small Business of the Year
- Barclays Bank Business Achievers Award
- BT Internet Award for Innovation & Manufacturing
- Teesside Business Executive of the Year
- IJKE Host Company
- ISO 9002 holder

The Company achieved an unprecedented delivery performance of 96% on-time delivery. In order to achieve the performance figures, Styles invested
heavily in training and also in advanced manufacturing techniques such as Kaizen, time-compression and cellular-manufacture.

Styles policy of advanced and sustained "people" improvement matches well with the now more widely accepted view of the controlling principles of a rapid response organisation (Willson 1998 and Anon [e] 1998). Likewise the claim of Styles (in their 1998 business plan) to develop so called "technical entrepreneurs" and "productionise" craft based processes is supported in the works of Smith & Reinertsen (1991), Reinertsen (1997), Pugh (1991) and the UK Government White Paper on Competitiveness (Anon [f]1998).

2.6.2 Styles General Financial Performance during the Period of Study

At the time of study, the general performance of Styles was good. Despite heavy competition (see rational of UK market below) the Company increased consistently its sales and profitability to reach £4.2m of sales by 1999.

Despite the pressures from competitors in the market place, Gross Profit also increased annually as a percentage, as the Company became more efficient. This was achieved within a strategic principle of high levels of re-investment in preference to high dividends.

Figures 2.3 and 2.4 illustrate the financial performance of the Styles business during the period of study.
Note: Despite an overall 50% drop in sales price due to market dynamics, Styles managed to increase gross margins through improved productivity and working practices.
2.6.3 Styles Expansion Strategies

Originally the executive team of Styles estimated that the Company had a UK market share 16% in terms of revenue. The Royle Report (1998) later challenged the figure and claimed that Styles had only 9.13% by capacity. Importantly Styles estimated that their share of the high-value-added customers was greater than 50% i.e. a significant proportion of the key market.

The Company reasoned that to increase sales further it would either have to displace well-entrenched competitors within high-value-added clients or
proceed "down-market" which would have eroded margins and de-valued its services and products.

The internal Styles Strategy Framework 1998 - 2003 document (Anon [g] 1998) stated that new geographical markets may have offered further growth potential, however, entry was considered difficult without a wider product portfolio i.e. the fully integrated services of Rapid Product Development.

2.6.3.1 Proposal for Strategic Operational Clusters

Styles proposed a series of "Rapid Product Development Clusters", that would contain the full portfolio of products, both existing within the structure of the Organisation and targeted for introduction within the future business plan. The Clusters were to be targeted at the high-value-added sector of plastic production, for example the development of housings for the consumer electronics market.

The Executives of Styles reasoned that the rapid prototyping activity (one of the functions of rapid product development) would act as the distribution route for higher value-added products such as rapid parts in real material or rapid tooling. The company considered that this strategy would overcome the cyclic nature of tooling and moulding contracts, because the Cluster would be able to call on extra work from the prototyping cell early enough to maintain a constant flow through the other cells.

The original Cluster was to be split between the UK and Germany. Once established, each site would develop into a full independent Cluster. Both of the independent clusters would prove the concept and strategy.
original Clusters had been proven, Styles wished to replicate the clusters around the European Union.

2.6.3.2 Rational of the Deployment of Operating Clusters

The rational of Styles was based on analysis of the global market dynamics of the rapid product development industry and was confirmed in an internal document entitled the "Audit Trail"(Anon [h] 1998). The basic rational to extend the product portfolio was not radical for example Griffiths (1998) claimed that a new generation of toolmakers would evolve from companies that were currently operating in the rapid prototyping sector. Smith (1998) proposed that the technologist's view of time compression was not necessarily that of the business manager who considered total development time-scales not isolated technological solutions.

Styles Executives also considered that they had an opportunity to command a significant European share of the market if they could replicate their operation near to a major center of high-value-added manufacturing activity. This would require a move into another European state.

The Styles corporate strategy broadly aligned with Bartlett and Ghoshal's (1989) theory of "the transnational organisation" and the Canadian World Product Mandate (Etemad and Seguin Dulude 1986). Bartlett and Ghoshal's theory suggests that local subsidiaries become global players by becoming the corporate supplier of a particular product or service group (i.e. Styles UK rapid prototyping and rapid parts in real materials and Styles Germany rapid tooling and technical moulding). The Canadian World Product Mandate provides a concept by which a subsidiary is given global responsibility for the supply of certain products and services.
2.6.4 Selection of the Critical First Site

Styles' first site location project was crucial, because Styles wanted to be able to target robust Western-European markets along with emerging Eastern-European markets. This aspect of the corporate strategy had particular emphasis when related to findings published later than the 1998 Technology Foresight Workshops on Plastics Sector Research by the DTI (Spencer 1998 and Anon [i] 1998). The data generated from workshops indicated that Eastern European economies were capitalising on state-of-the-art processing equipment in a bid to grow local economies and that organisations based in Western-Europe would only be able to compete by moving into higher value-added products and services (such as design and development).

Styles chose Döbeln (located between Dresden and Leipzig) in the German state of Saxony as the first target site for expansion. The location was supported by significant Federal grants (50%) and had a high-skilled generic workforce that was available for employment.

A more detailed analysis of the Styles site selection procedure and model is provided in Chapter Six.

2.7 Other Comparable Rapid Product Development Company Case Studies

It is fair to say that many companies in the EU RPD sector have undertaken relocation programmes (for example Kruz in Stuttgart, who moved into new purpose built premises across the road from the original site). However, few
companies have undertaken greenfield selection and development any distance away from the original location.

The following data was gathered from RPD companies who had undertaken site selection and development projects some distance away from their original location. The data was generated from a process of meetings and interviews with the senior executives of the organisations concerned. The data gathered from Companies A-G was undertaken to provide a benchmark of historical trends to map against the main case study (H). The table of the case study interviews dates and locations is recorded in Appendix One and a list of the key interview questions is reproduced in Appendix Two.

2.7.1 Company A

Company A, is a Japanese owned RPD company operating as a self directed and self financed organisation within the European sector. At the time of study, the Company employed 90 people and had its main operating base in the South West of the UK. The turnover was approximately £4.5m and profit before tax of approximately £250k. Company A had a unique benefit of a global network of sister RPD companies where co-operation was encouraged but not mandated.

The customer base of Company A was split approximately 60% in the UK and 40% in the remainder of Europe.

Company A originally had its manufacturing site based in London. In 1998, the Company looked to move to a new location. This decision to relocate was based on the high operating and overhead costs associated with the London
area. There was also a skills shortage in the London area that made organic growth difficult and also contributed to a high-cost base.

The overall strategy of Company A was developed in 1998. It consisted of looking to strategically acquire a similar RPD company. The actual location was not considered to be particularly important because the Company considered that there was little need for close proximity to the customer base, especially in view of their European coverage. However, the company considered that a skilled workforce was the most important feature of their relocation strategy.

In the spring of 1999, Company A took advantage of acquiring the assets of an RPD company that had gone into receivership. The workforce were retained and augmented by the original team that relocated from London. The overall strategy was considered to be a success.

The Company considered that if the "right acquisition" was not possible then it would have looked to develop a greenfield site. Indeed it considered that further growth across the EU would necessitate this action because further high-value acquisitions would be less likely.

2.7.2 Company B

As a German start up venture originally incorporated in 1996, Company B grew rapidly via strategic acquisitions throughout Germany. The growth was funded by venture capital investment. At the time of study, the Company had seven sites and employed 130 people. The head office was in the South of Germany, however, each satellite was considered to be a "centre of
specialism" and was to some extent self governing. The turnover was approximately £6.3m, however, profit before tax was zero.

The general commercial strategy of the company was to offer all technical services for the development of specific products such as vehicle light clusters. The Company was keen to promote its technical consultancy and project management services within its overall product range.

The customer base of the Company was concentrated in Germany with approximately 5% being other EU States. Company B had an active policy of trying to acquire further RPD companies for expansion. At the time of study, the Company was looking for acquisitions in other EU states. Their main criteria for acquisition were:

- Region and established market penetration
- Alternative technological base
- Skilled workforce

In general terms, Company B considered that their overall plan of strategic acquisition was robust. The process allowed the Company to grow rapidly without excessive management time being devoted to non-profitable activities such as plant and building development. Importantly the strategy enabled the Company to increase turnover by incorporating the revenues of the acquired companies into that of its own. The Company did not in effect experience the traditional "death valley" curve of greenfield development growth (i.e. high initial capital outlay followed by low return on investment (ROI) whilst the market is being developed).
2.7.3 Company C

Company C is an American owned RPD organisation operating within the European RPD sector as a self directed and financed entity. The Company described itself as a “full-service engineering company” (i.e. offering all RPD services under one corporate umbrella). Its products and services were however more specifically focused on the automotive sector with the core activity being the design and development of complete systems, for example powertrain development.

The Company had great experience in site selection, having developed 34 sites globally. The first European site was commissioned in 1995 in the south east of the UK. The second European site was commissioned in the UK midlands in 1999. A third site was planned for 2001 in the north west of Germany. All of the existing and planned sites were greenfield developments.

Company C’s site selection procedure was based entirely on the proximity of the location to a single major client. Other criteria were "never considered". Indeed it was stated during the interview procedure that Company C was “prepared to have a site idle if this satisfied the clients need to see a building in the locality”.

Company C considered that their overall strategy of greenfield development, in close proximity to the client, was robust and worked well. They also claimed that close proximity to the client acted as a barrier to entry to their competition, although there was counter evidence to this from other sources.
2.7.4 Company D

Company D is an American owned RPD organisation operating within the European RPD sector as a self directed and financed entity. In some respects this Organisation was a close a follower to Company C but did not benefit from having preferred tier one supply status.

Company D experienced major overseas growth and then made its debut entry into the European RPD sector with a greenfield development in the south east of the UK in 1998. The Company stated that there were further plans to expand into the UK midlands and north west of Germany in 2001.

The two reasons offered for the site selection strategy were proximity to a single major client and as a reaction to the development strategy of Company C. No other criteria or strategic rationals were offered. The site selection strategy was considered to be successful.

2.7.5 Company E

As a German greenfield start up venture originally incorporated in 1994, Company E grew organically on the original site to employ 50 people. The Company was funded by venture capital investment.

The key site selection criterion was based in the proximity of the location to the founders home in the east of Germany.

In terms of other selection criteria, the availability of a skilled workforce was considered to be important. Interestingly, Company E stated that because
they specialised in a focused technical niche of the RPD sector, their lack of proximity to their key markets (typically southern Germany) was not an issue in their particular case.

2.7.6 Company F

Located in the middle of Germany, Company F was a privately owned RPD company incorporated in 1994. The Company originally specialised in CNC programming and machining. They later moved into modelmaking, rapid prototyping and polymer casting. By the end of 1999, the Company had grown organically to 12 employees with a turnover of £1.3m and pre-tax profitability of £32k.

Company F was the smallest organisation that was interviewed as a part of the study. Due to its size, the Organisation had overcome problems of growth by establishing two joint ventures. The first joint venture was in Germany the second in Poland. Both joint ventures were conducted because Company F could not recruit suitably skilled employees in their locality.

Company F considered their strategy to be a success because they did not have to dilute their equity in the Organisation to raise sufficient finance to fund growth.

2.7.7 Company G

Company G was the first commercial rapid prototyping company in the UK founded in 1991. The Company was originally funded by private capital. The Organisation grew rapidly until competitors began to enter the market place in
the mid 1990's. New market entrants caused a price war and the erosion of
the core business of the Company at which point it looked to expand product
lines in an effort to diversify its cash generating potential. In its final year of
operation, the Company employed 80 people and had a turnover of £3.8m.

The Company needed a larger facility in order to expand their product range.
A greenfield site was located in the vicinity of the original operation. The key
criteria were to be as close to the owner's home as possible. Other criteria
such as client proximity, possible new market areas availability of skilled
workforce or incentives were not considered. This study concurs with
Christodoulou (1996) theory that most SME's do not move more than 30
miles from origination.

It should be noted that the interview was conducted four days after the official
receivers were called into Company G. The Organisation had over geared
their borrowings trying to finance the move and planned expansion.

2.7.9 An Analysis of the Results of the Relocation Strategies of the Case
Studies

Table 2.6 illustrates Vernon's (1966) theory that the motivation of companies
varies greatly beyond the basic cost analysis that is more typical in business
models.

Although all of the companies involved in the study were operating and
competing in the same sector, different expansion strategies were adopted
and (with the exception of Company G) considered to be successful.
<table>
<thead>
<tr>
<th>Company</th>
<th>Employees (Europe)</th>
<th>Turnover (£'000)</th>
<th>Profitability (£'000)</th>
<th>Expansion Strategy</th>
<th>Key Location Factors</th>
<th>Internal Success Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>90</td>
<td>4500</td>
<td>250</td>
<td>Acquisition</td>
<td>Skilled work-force</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>130</td>
<td>6300</td>
<td>0</td>
<td>Acquisition</td>
<td>Skilled work-force, companies with synergy &amp; new markets</td>
<td>Yes</td>
</tr>
<tr>
<td>C</td>
<td>90</td>
<td>Not disclosed</td>
<td>Not disclosed</td>
<td>Greenfield expansion</td>
<td>Proximity to single client</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>Not disclosed</td>
<td>Not disclosed</td>
<td>Greenfield expansion</td>
<td>Proximity to single client, Reaction to competitors expansion</td>
<td>Yes</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>Not disclosed</td>
<td>Not disclosed</td>
<td>Greenfield expansion</td>
<td>Close to founders home, Skilled work-force</td>
<td>Yes</td>
</tr>
<tr>
<td>F</td>
<td>12</td>
<td>1300</td>
<td>32</td>
<td>Joint Venture</td>
<td>Skilled work-force</td>
<td>Yes</td>
</tr>
<tr>
<td>G</td>
<td>80</td>
<td>3800</td>
<td>0</td>
<td>Greenfield expansion</td>
<td>More space in locality</td>
<td>No</td>
</tr>
<tr>
<td>H</td>
<td>73</td>
<td>4200</td>
<td>250</td>
<td>Greenfield expansion</td>
<td>Skilled work-force, New market opportunities Incentives</td>
<td>Yes</td>
</tr>
</tbody>
</table>
CHAPTER THREE – THE PROCESS OF INWARD INVESTMENT
3.0 Introduction

Inward investment and foreign direct investment (FDI) are often used to describe the same process of the transition of capital and/or resources from one location to another. In the context of this work, inward investment is used to describe the actual physical process of transition and the management of the project, whereas foreign direct investment is used to describe the commercial and financial aspects of the transition project.

The principle of the "global factory" has provided low value-added manufacturers (typically the OEMs) with the ability to take advantage of most of the favorable economic factors from a given location (Carson1998 and Anon [j] 2000). Typically suppliers to the OEMs are forced to follow to secure their business. The migration of supply chain companies is not restricted to the mass production orientated component suppliers, but also the high-value-added suppliers such as companies offering RPD services (Dornier etal1998).

With regard to inward investment, there are great differences between countries and regions throughout the EU. Depending on the business sector, a successful match between location and company is not always possible (Potter and Tacky 1992 and Story 1999).

This chapter deals with the following issues:

1. The rational of the process of inward investment projects for SME's
2. Regional investment strategy
3. The lack of a control model for the inward investment process
4. Factors affecting successful inward investment projects
The proposed ideal model of inward investment

3.1 The Rational of the Process of Inward Investment Projects for SME's

In common with larger organisations, SME's can and do compete globally. However, according to Porter (1992) SME's typically focus on export sales strategies with only a modest amount of foreign direct investment. SME's typically enter into inward investment projects because of changing circumstances, market dynamics and the desire to replicate indigenous commercial success abroad in the hope of generating higher return on investment. For example, "customer pull" such as supply chain requirements coupled with the need for companies to deliver locally manufactured products to the OEM (on-line or just in time manufacture). Alternatively companies may have a product or service that is sufficiently differentiated from the competition and may look to expand into other regions to benefit from economies of scale (Dunning 1988, Cohen et.al. 1989, Dunford and Kafkalas 1992, Chan and Mauborgne 1997, Arend 1998).

The restructuring of manufacturing (production) has led to greater flexibility in the workforce and the ability of the OEM to assign further and more complex tasks to external sub-contractors (vertical integration). Pellerin (1996) claims that this process not only reduces manufacturing costs but also encourages changes in social and employment behavior such as an increase in self-employment for the professional classes.
Ferdows (1997) offers insight into the range of tangible and intangible reasons for companies investing in regional sites. Table 3.1 illustrates Ferdows ranking of reasons for companies investing in regional sites.

### Table 3.1 - Table of Tangible and Intangible Reasons For Corporate Investment in Regional Sites

<table>
<thead>
<tr>
<th>Most Tangible</th>
<th>Most Intangible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce direct and indirect costs</td>
<td>Attract talent globally</td>
</tr>
<tr>
<td>Reduce capital costs</td>
<td></td>
</tr>
<tr>
<td>Reduce taxes</td>
<td></td>
</tr>
<tr>
<td>Reduce logistics costs</td>
<td></td>
</tr>
<tr>
<td>Overcome tariff barriers</td>
<td></td>
</tr>
<tr>
<td>Provide better customer service</td>
<td></td>
</tr>
<tr>
<td>Spread foreign exchange risks</td>
<td></td>
</tr>
<tr>
<td>Build attentive supply sources</td>
<td></td>
</tr>
<tr>
<td>Pre-empt potential competitors</td>
<td></td>
</tr>
<tr>
<td>Learn from local suppliers</td>
<td></td>
</tr>
<tr>
<td>Learn from foreign customers</td>
<td></td>
</tr>
<tr>
<td>Learn from competitors</td>
<td></td>
</tr>
<tr>
<td>Learn from foreign research centres</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1.1 Globalization and Inward Investment

Many of the high-profile industrial successes of the EU can be attributed to the process of inward investment and foreign direct investment (Owen 1999). Inward investment is likely to continue and become more important with the continued growth of Globalization (Kopka 1997). There are typically two schools of thought concerning inward investment (developed from macroeconomics) and globalization (developed from management in overseas companies). Govinadarajan and Gupta (1999) consider that both
schools of thought should however be integrated into a single conceptual framework because the implementation of inward investment occurs within the arena of globalization.

European business is changing faster and more radically than at any other time (Cauley De La Sierra 1994 and Bennet 1997). Enlargement of the European Union, moreover, has created the second largest association of industrially developed countries (after NAFTA) in the entire world.

Today's customers are now faced with a growing range of choice in the products and services they can buy (Culture 1994). They are making their choice on the basis of their perception of quality, service and value (Gindy 1999). Regional consumer taste has become homogeneous and markets have moved away from their traditional localised focus. As such, the overall concept of Globalization is not new (Kofman 1996 [b] and Story 1999).

The process of Globalisation brings new challenges to any manufacturing sector. These may be summarised as either greater opportunity in terms of larger market sectors for existing product portfolio or erosion of market share by superior competition entering the existing market place (Boyer 1988 and Jefferson 2000). Gusterson (1993) made reference to geographical trading becoming less defined as international boarders are opened up. Dalby (1996) contributes further by commenting that the utilisation of electronic commerce accelerated the "global market" effectively decentralising the "Central banks" and the local nature of politics.

According to Story (1999) and the World Bank Global Report (Anon [k] 1997) a rise in globalization in the early 1990's constituted four commercial areas, these are:
1. Foreign Direct Investment (FDI)
2. Commercial bank loans
3. Bond purchase
4. Acquisition of entities or shares in companies listed on the stock exchange

3.1.2 Foreign Direct Investment

There are two kinds of long-term private international capital movements (Haymer 1976), these are:

1. Direct investment
2. Portfolio investment

Foreign Direct Investment has had a major and lasting effect on the industrial structure of Europe (Thomsen and Nicolaides 1992). In terms of balance of payments, Foreign Direct Investment represents all capital that transfers between a parent company and any overseas subsidiaries. Therefore, Foreign Direct Investment can occur through:

- Mergers
- Acquisitions
- Minor or majority participation in organisations
- Greenfield investment
- Joint ventures

Foreign Direct Investment allows indigenous companies to spread their portfolio of products and services and thereby capitalise on opportunities not
open to them in their home market (Culem 1988 & Owen 1999). Hoch (1982) and Story (1999) provide a strong case that argues that the whole process of Foreign Direct Investment has left a trail of failed expectations and projects for many companies. Williams et al (1992) and Lovering (1999) further contribute by stating that researchers and politicians have typically placed too much reliance on the “self interested claims of companies” who have been involved in Foreign Direct Investment. The fact remains that Foreign Direct Investment has grown more rapidly than the national average of the economy.

Typically countries and regions have three options concerning Foreign Direct Investment, these are:

1. Favor it
2. Be hostile to it
3. Sponsor international partnerships

Investors typically favour greenfield projects although acquisitions of indigenous companies or joint ventures also offer some opportunity.

Fellner (1954) states that the early stages of economic development generate a unique element of risk that is associated with the slow maturing of an inward investment project. Delayed profitability in such projects can be attributed to three criteria, these are:

1. Economies of scale (internal)
2. Complementary factors (infrastructure, supply chain, market)
3. Technological and organisational progress
Typically once the inward investment project is completed (i.e. the process of site selection, capital raising, recruitment and training etc.) a company is expected to grow and prosper without any further assistance. The "hands off" approach typically introduces an element of long-term risk, whereby some companies become "early leavers" and remove their commitment to a region due to local sectorial difficulty.

3.1.2.1 Statistics of Foreign Direct Investment

In 1997, globally developing countries received $120bn of Foreign Direct Investment in 1997. This represented the greatest source of finance and a five-fold growth on the 1990 figure. The ratio of Foreign Direct Investment to GDP grew from 0.8% to 2.0%. The percentage share of Foreign Direct Investment by developing countries also grew from 21% to 36% in the same period. The real monetary value of Foreign Direct Investment into developing countries also increased by more than 3.5 times (Anon [k]).

Potter and Tackey (1992) report that in 1991 Foreign Direct Investment into Europe was valued at $26bn despite a depressed market. The UK has regularly attracted approximately 30% of the total FDI into the EU. In the first year of operation (1999 - 2000), the UK Regional Development Agencies claimed to have created or saved 35000 jobs (Anon [I] 2000 and Pike 2000). White (2000) claims that Spain accounted for half of the new jobs created in the EU between 1996 and 2000.

According to Culem (1988) and Story (1999), multinational corporations account for 80% of global Foreign Direct Investment. For example in 1995, Japanese companies had invested heavily in 212 manufacturing sites and 96
research and development centres in the UK (Harrington 1994 and Dickens 1995).

The growth can be attributed to greater private investment in services that in- turn free scarce public resources for necessary social improvements. There is however a level of interdependence because governments must in-turn ensure that price and regulatory rules enable service providers to operate on a robust commercial basis. However, continued liberalisation of investment rules will also encourage further Foreign Direct Investment (Anon [k] 1998).

3.1.3 The Transition Process of Economic Development and Its Effect on Inward Investment Strategies

A transition process exists between the level of economic development within a region and the deployed strategy of inward investment (Robock 1971). This may be shown schematically (figure 3.1) with regard to the level of incentives being offered in relation to a region.

**Figure 3.1 - A Schematic of the Transition Process of Economic Development and Its Effect on Inward Investment Strategies**
3.2 Regional Investment Strategy

Support mechanisms for companies tend to be geared towards larger organisations. As such, smaller generic companies are less likely to benefit from the same level of support. However, the European Commission Office responsible for inward investment (DGIV) typically takes a more flexible approach to SME's led projects even outside of assisted areas (Rees and Thomas 1992, Yuill et al 1994).

Aubrey (1951) states that there is a common goal between specific regions and investors into the regions to ensure economic growth and prosperity of the region. Hirschman (1958) and Hoar (2000) state that economic growth is interdependent on many influencing factors, these may include:

- Capital
- Entrepreneurship
- Skills
- Minimum standard of public order
- Law enforcement
- Public administration
- Education
- Health
- Public utilities

In terms of inward investment, many criteria must be fulfilled simultaneously to allow growth to occur. However, the availability of capital acts as a catalyst. According to Hirschman (1958), foreign capital (Foreign Direct Investment) has two roles, these are:
1. To bring with it certain abilities (i.e. skills, know-how etc.)

2. As qua capital that can also be viewed as pressure inducing or pressure relieving

There are many reasons why countries encourage inward investment these may include:

- As an income generator
- As a capital generator
- As a pace setter for further investment

Although in political terms there is a tendency to spread capital over many projects in many regions. Hirschman (1958) states that investment in one time frame attracts further investment in the next. The attraction is repeated more often and becomes easier with each round because the precedence has become set.

3.2.1 The Duel Effect of Inward Investment

There is a suggestion that inward investment has a tendency to widen rather than reduce income disparities between countries, because capital and resource is typically channeled into areas that are already developed and robust. Del Monte and De Luzenberger (1988) provide evidence that many large-scale investment projects fail to stimulate further indigenous growth. It is undeniable that the inward investment process brings a new order to any region. For example, a merger, joint venture or acquisition could introduce a
management team that may not have the tradition of supporting established local supply chains (Buckley and Casson 1991, Styles 1999).

The rationalisation of any supply chain is typically a policy of the multinational looking to gain from economies of scale. However, a region does not have any influence on the migration of a supply chain either politically or financially. This situation was noted during a site visit to Stuttgart in April 1999. The visit was approximately six months after the merger of DaimlerChrysler. At this time, American automotive suppliers were trying to gain market share of every area of the German supply chain. Local reports claimed that many of the companies were not intending to develop and manufacture new products in the region, but rather export any high-value-added work to the USA (Kehrer 1999).

3.2.1.1 Political Necessity

Decisions and policies of government concerning inward investment have become highly emotive and political (Anon [m] 1996, Lorenz 1999, Anon [n] 2000). For example, Fellner (1954) claims that incentives may be considered by some to be a bribe to facilitate a political need that pacifies a (loud) minority to the detriment of a (silent) majority.

3.2.1.2 BMW - A Case Study of Political Necessity

The theory of political necessity may be exemplified by the sale of the BMW owned subsidiary Rover Group in Birmingham during the first quarter of 2000.

Prior to the announcement of the proposed sale, the UK Government and media were promoting heavily e-commerce to the neglect of any other form of
business venture or investment opportunity. Harland and Wolf (Belfast) announced on the 13th March 2000 that they feared the shipyard would have to close because it failed to secure an order. The following day, the UK Government announced that its was providing a grant of £530m to assist BAe Systems develop the next generation of civil aircraft. This announcement removed the interest of the media from Harland and Wolf (political expedient) but was a short-lived success because within twenty-four hours BMW announced that it was disposing of Rover Group and there would be major job losses. The UK Government immediately pledged £123m for local regeneration, whilst attempting to find an alternative purchaser of Rover Group. At the time, Rover Group accounted for 25% of the custom of the UK automotive supply chain. The UK government worried that if the Longbridge plant was to close then the supply chain would deteriorate also and major economic decline would result in the region (Anon [o] 2000, Done et al, 2000, Robinson 2000, Urry and Batchelor 2000, Bush 2000, Guthrie et al, 2000, Anon [p] 2000, Daniel and Peel 2000, Oliver 2000, Wachman 2000, Lorenz and Parsley 2000, Wolf 2000, Burt et al, 2000).

Sources within the Department of Trade and Industry (DTI) had previously stated that "the UK government was not prepared to lose BMW at any cost". Indeed by working the settlement figure backwards, it was considered cheaper to give BMW the high-level assistance than have to support the region over a long period of recovery after closure of the plant (Dallaway and Gillis 1999). The nett effect of the incident was that typically "fashion" investments and industries such as e-commerce were ignored when traditional high-level employers were in trouble regardless of the real value or long-term potential of the business.
Interestingly, this period also witnessed the first serious losses in share value within the world-wide e-commerce (dot.com) sector.

### 3.3 The Lack of a Control Model for the Inward Investment Process (Inward Investment and the SME’s)

Amber and Styles (1998) state that the inward investment process for most SME’s is haphazard. The process is typically a product derived from a mix of the market opportunity and the need (real or otherwise) to expand into other geographical markets. Pongpanich (2000) provides insight into the typical broad decision process of site selection that consists of:

- A Trigger (i.e. the recognition of potential new markets and opportunities)
- First screen (of all opportunities and possible investment locations)
- Second screen (a more in depth study and filtering process)
- Final choice (an outcome based on a full analysis of the opportunity)

The process of location (i.e. the geographical site) is, according to Christodoulou (1996), “inadequately understood with conflicting evidence and a significant random element within it”. This is further expanded to include the proposal that there is no single key requirement to secure a site, but the absence of one element can render a location void or extremely risky.

It is clear that the inward investment process is not as straightforward a process as a “simply picking a location, building a factory and manufacturing the products”. Many factors are presented in a complex matrix of opposing forces that often have a different and sometimes conflicting influence on the
outcome. Some of the influencing factors are unique from the stance of the SME and the RPD sector.

The main influencing factors for an SME may be defined as:

1. General EU economics
2. Global economic influences
3. The migration of markets and larger companies

The main influencing factors are discussed in more detail below.

3.3.1 General EU Economics

An April 1998 communication from the European Union (Anon [q] 1998) stated that entrepreneurs were re-focusing their attention on the EU due to the emergence of the single currency, Union enlargement and because of troubles in the Asian markets.

The communication also stated that the greatest barrier to investment was perceived to be the lack of a single pan-European risk capital fund similar to that available in the US. However, fragmentation, institutional and regulatory taxation, paucity of high-tech SME's, human resources and cultural barriers were also cited as barriers to further growth in inward investment. However, the introduction of European Monetary Union (EMU) in January 1999 provided a significant and crucial factor in the development of a fully integrated European economy (Martin 1998).
It is however doubtful that the EU will be able to sustain a robust low value-added manufacturing base due to global competitors being able to assemble and deliver products at a lower price.

3.3.2 Global Economic Influences

The Asia crashes of late 1990's unsettled the rest of the world. At the same time, the breakup of the old USSR caused many companies to re-think global policy. Both factors were cited as the driving forces behind many companies focusing on the indigenous and comparatively robust EU market place.

3.3.3 The Migration of Markets and Larger Companies

The series of DTI Technology Foresight studies conducted in the early part of 1998, highlighted a general trend of the OEM to migrate to emerging economic nations (such as Poland) in order to establish viable manufacturing businesses. The studies showed that "technological innovation" was not necessarily an obstacle to corporate migration, because technology could be "bought and transported anywhere". Ferdows (1997) concurs by reasoning that it is becoming the norm for companies to manufacture and develop products in many geographical locations instead of concentrating the product development function close to the corporate headquarters.

Tait and Marsh (1998) presented two interesting theories in the Business Locations in Europe Annual Report 1998, these were:

1. Tait stated that Motorola operated fourteen manufacturing sites in Europe. He maintained that Motorola's fundamental reason and investment
rational for entering developed regions was to get closer to the customer base.

2. Marsh claimed that the first and most important factor influencing decisions regarding business location was the degree to which the company can take advantage of its existing strengths tied to its current location (i.e. even adapting the company to play to its local strengths).

3.3.4 An Analysis of Possible Key Decision-making Differences for the SME's & OEM

Key decision-making factors relating to inward investment projects can vary greatly between the SME's and OEM. By undertaking similar SWOT analysis techniques, as those described by Armstrong (1990) and Silberg (1994), it is possible to illustrate the polar differences that a project may encounter depending on the size of organisation concerned. Table 3.2 illustrates some of the key decision-making differences that may occur between the OEM and SME.
Table 3.2 - Table of Site Selection Decision-making Differences Between the OEM and SME

<table>
<thead>
<tr>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM - Decision taken lower down the organisation therefore more clinical and less personal</td>
<td>SME - Likelihood of a personal/emotional decision being made</td>
</tr>
<tr>
<td>SME - Decision taken at top level therefore company is committed</td>
<td>OEM - There may not be final top-level commitment to the project</td>
</tr>
<tr>
<td>SME - Able to make quick decision</td>
<td>OEM - Likely to take some time to make a decision</td>
</tr>
<tr>
<td>SME - Decision of strategic importance to company</td>
<td>OEM - Decision made at local level may not match the long-term plans of the global company</td>
</tr>
<tr>
<td>OEM - Ability to call on large resources and high level &quot;political and business&quot; favors</td>
<td>SME - The organisation does not have the political connections therefore process may be difficult</td>
</tr>
<tr>
<td>SME - Little chance of political involvement</td>
<td>OEM - May have political pressure to select a particular site</td>
</tr>
<tr>
<td>OEM - should be able to fund the project easily</td>
<td>SME - May have difficulty raising funds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Opportunities</strong></th>
<th><strong>Threats</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>SME - Competitor reaction less likely in same local</td>
<td>OEM - Competitor reaction likely and competitive edge may be eroded rapidly</td>
</tr>
<tr>
<td>OEM - Project costs will have minimal effect on corporate performance</td>
<td>SME - Opportunity cost may place company in high-risk situation</td>
</tr>
<tr>
<td>OEM - Easier to recruit and/or relocate human resources</td>
<td>SME - May be hard to recruit high-caliber project team members</td>
</tr>
</tbody>
</table>

3.4 Factors Affecting Successful Inward Investment Projects

The mechanics of the inward investment process should remain constant throughout the EU. There are however major differences and a great deal of fierce competition between regions and countries. Each Regional Development Agency (RDA) (the bureau responsible for attracting inward investors) will have developed its own agenda that is based on, the local demographics, economy, political necessity etc. The most risk adverse solution (for both the SME and the region of proposed investment) will be arrived at only when the profile of the SME matches the criteria of the local area.

This situation was witnessed in the main case study of this work, when it became clear that the West Midlands Development Agency (WMDA) were not interested in the proposed investment. The reason given at the time was that the investment proposal did not fit with the regions political and strategic aims (i.e. that of low-skill base high numbers of jobs). It was further argued that the remaining skills-base in the West Midlands was low and not suited to high-skilled engineering jobs.

The inward investment process is a high-risk procedure. One of the greatest counter measures that an area can offer is the incentive package (i.e. the total value of grant aide being offered to the potential inwardly mobile company). Inward incentive packages are however criticised consistently by those who feel that if the business case is robust then there is no need for an incentive package (Feuerstein 1999). For example between May and August 1998, the Welsh Development Agency was being accused of offering “over-the-top incentives” to attract companies into Wales. However, comparative history showed that there was no guarantee of a successful outcome to inward investment projects, even with “excessive” incentives (in the region of £200k per-job) (Anon [s] 1998).

The parallel case studies of Samsung, Siemens, and Fujitsu, in the North-East of England are of note. All of the companies had experienced closure and radical downsizing in 1998 and therefore did not fulfil their obligations to the region in terms of return on investment from the initial high incentives that were provided to attract the organisations originally. On the basis of these case studies, it must be concluded that high-level incentive packages do not
equate automatically to good site selection or indeed a robust opportunity (Wighton et al 1999 and Eadon 1998).

A theory may also be offered that proposes that a company looking to move into a new country may wish to align itself with a region that has a history of the proposed sector of engineering associated with the inward investor. For example companies associated with chemical or heavy marine engineering may choose to locate in Teesside whereas those associated with ceramics may choose to locate in Staffordshire. The proposed model strategy would provide the inward investor with an indigenous workforce that has a cultural acceptance and level of experience of the proposed sector.

3.4.1 The Key Consideration of the Site Selection Process

One of the most important considerations on the site selection (and indeed whole growth opportunity) is that of the entrepreneurial ability of the management team (Leibenstein 1957). The key attributes of the entrepreneurial team are:

- The ability or discover investment opportunities and/or the ability to seek information and make an analysis of the same that can lead to the discovery of an opportunity.
- Possess access to resources and the capability to gather the necessary resources for the venture to succeed.
- Have the ability to promote the venture (sell) to others that may be interested in investing.
- Have the ability to organise the enterprise (i.e. recruit people, purchase materials and equipment etc.) and transfer power to other competent
individuals with the ultimate responsibility for continued management and success of the enterprise.

Biele (1999) states that theorists typically do not consider that these are certain key elements that are critical to the practical process of a successful inward investment project, these are:

- Timing of the project is critical. For example a large company may enter an area sooner than the SME’s and attract key staff by offering “stable” employment sooner. This scenario will drive labour costs up and could make the project untenable. Therefore speed of commissioning is important.

- SME’s will typically take longer to negotiate and secure the project funding. Confidential inward investment projects do not typically remain confidential for long. This could open the way for competitors to open in the same region in the same (or sooner) time scale, thereby developing a competitive environment where there was none.

- A risk assessment must be conducted to determine what is the likely scenario if the project is twelve months late.

- Any site location must be able to attract key management staff. For example professional people will be attracted by cosmopolitan cities but not necessary rural idylls. Therefore a location of just a few miles from the originally chosen site could mean the difference between success and failure to attract the right people.

Fellner (1954) states that project factors such as technological and organisational progress must be considered as first-level site selection criteria (i.e. is the project big enough, is the necessary infrastructure available and is it technologically robust with good management).
3.5 The Proposed Ideal Model of Inward Investment

Parker-Smith (1998) considers that there is a "political driver" in the UK to place all of the "investment eggs" in one basket, even though there is a high-risk of major job losses should a high-profile company exit a region. Hall (1998) and Jowit (1999) uphold Telford as an example of a local area that survives and prospers without any "major employers" by adopting a policy of "small company development" in order to spread the risk.

From the start of regional growth, there is little evidence to suggest that attracting a small number of technically diverse SME's into a region would have much effect on the overall economic growth of the area (Young, Hood and Peters 1993). It may however be argued that for regions looking to attract further (quality) inward investors, a strategy of targeting many smaller companies (after the lead risk seeking OEMs) may offer a safer prospect than trying to attract fewer larger companies. This is because many smaller companies may spread the overall risk of regional growth.

The proposed ideal model of inward investment is therefore to divide the overall investment budget over many smaller investment projects, the majority of which are more likely to survive and prosper. Should a small selection of investment projects fail, the remaining successes should be more able to absorb the fallout and reduce regional devastation.
CHAPTER FOUR – THE OPPORTUNITY COST OF INWARD INVESTMENT AND GREENFIELD SITE SELECTION PROJECTS
4.0 Introduction

Many companies that have highlighted a market or opportunity may be motivated by factors outside of the more logical financial boundaries. For example the desire to be first, or the promise of large returns form a single client relationship (Vernon 1966). This type of motivation may place undue influence on certain parts of inward investment project that in turn leads to failure (Hoch 1982). Hollins and Hollins (1999) state that it is possible to eliminate failure and opportunity costs by understanding what causes project failure. In the context of this work, opportunity cost includes all of the activities of the inward investment project prior to the actual decision to invest (i.e. run the project).

Byrd and Moore (1978) state that most decision-makers do not understand the concept of opportunity cost. Opportunity cost is seldom discussed or considered as a part of an inward investment project. Opportunity cost can however be one of the most significant factors that affect the procedure and outcome. As such consideration must be given to this subject and how it relates to the existing business and future growth. This chapter discusses the following issues:

1. The opportunity cost for the SME’S
2. The financial burden on the company
3. The risk of resourcing the project executives
4. The intangible loss
5. The combined effect of the opportunity cost
4.1 The Opportunity Cost for the SME's

Any agency associated with inward investment projects will, in principle, encourage any SME to settle in their region. The "attraction process" will include the provision of data on the positive aspects of the region and in most cases the incentives available (grants, training benefits, tax breaks etc.) for the chosen site. The whole financial package is released once the deal has been signed and it is drawn down on the successful delivery of the agreed milestones for the project. There is however, little evidence to suggest that development agencies discuss the opportunity cost of the process with the potential SME.

4.2 The Financial Burden on the Company

Any company, large or small, will incur both tangible and intangible costs during the inward investment process. These costs are likely to be proportionally higher for the SME because there is typically less available resource (both fiscal and labour) for non-operational activities (Anon [t] 1996). The process does not typically qualify for any grant or other types of assistance. The SME must fund and resource this activity.

Project resource is not often considered as an element of inward investment, however, the associated cost could have a direct and indeed damaging effect on the business. For example Styles deployed two senior executives to deliver the opportunity into the Company whilst existing operations executives continued to manage the core UK business. In the case of Styles, this strategy had the effect of increasing operating overhead.
The relevant management accounts and memoranda of Styles indicate that the Company invested in the region of £250k in the initial year before securing an offer of a financial deal. This investment sum had the effect of soaking up all of the profit in the year that expansion was being manifest and thus opened the Organisation to attack from aggressive shareholders that questioned the viability of the opportunity and indeed the competence of the executive team.

**4.3 The Risk of Resourcing the Project Executives**

An SME will be typically faced with diverting the attentions of operations executives and thereby risk the core business activities, or it will have to recruit specialist assistance/executives to manage the inward investment process. The former will place a burden on the organisation in terms of loss of focus of the management team and the latter will place a burden in terms of fees/salaries and associated costs.

There is also a great risk in terms of finding suitable qualified specialists or executives that are capable of understanding the core business of the SME whilst being able to drive the project through.

**4.4 The Intangible Loss**

Another area of risk relates to the possible intangible loss associated with the reallocation of resource. For example if we assume that an SME was able to commission a special project team for the inward investment opportunity, then
we must also assume that the same SME could do the same for other areas of the business. Other areas of business focus could include the growth of the current customer base by improving the conversion rate of quotes, quality/process improvements and/or development of new profitable product lines.

It may be argued that any of the alternative activities could grow the business more effectively and with less risk. Therefore, the prospect of intangible loss becomes apparent insofar as the high risk, "big opportunity" eclipses local yet vital core principles of the business.

4.5 The Combined Effect of the Opportunity Costs

There is little doubt that an SME embarking on an inward investment process will incur significant costs prior to the completion of the deal stage. The cost of the opportunity will have a tangible impact on the business. The net effect will include a diversion of profits and allocation of resource to potential non-core activities.

Before embarking on an inward investment project, the decision-makers of an SME must run a detailed risk analysis of the project in relation to the current core and future business opportunities. All likely outcomes derived from the analysis should be evaluated in terms of the likely costs to the company and possible returns available from a given course of action. This requirement is discussed in Chapter Eight that is concerned with a holistic site selection project.
CHAPTER FIVE – A STRUCTURED DECISION-MAKING PROCESS
5.0 Introduction

The selection of a new site involves a complex decision-making process that can include many conflicting requirements. The process will typically have a major affect on the economic outcome of the organisation concerned. As such, a structured decision-making process is necessary to reach a successful solution and remove the uncertainty of the inward investment project (Hodder and Dincer 1986).

Hurst (1991) states that decisions are based on perceptions. Any perception can be influenced at any stage in the overall decision-making process. Back and Back (1991) concur with Hurst and further maintain a key factor in successful decision-making is to stand firm on the outcome of the final decision (i.e. develop a strategy and adhere to it rigidly).

This chapter deals with the following issues:

1. The decision-making process
2. A structured approach to decision-making
3. Common actions undertaken during the decision-making process
4. A decision-making model
5. The typical pattern of decision-making in site selection projects
5.1 The Decision-Making Process

Decision-making is the method by which a process of "choice" is brought to a successful close. Most people typically process information in a conservative manner and fail to input data concerning the decision process correctly. The overall effect is that most complex decision outcomes are conservative in nature (Cohen, J 1964, Kleinmuntz 1968).

Effective decision-making processes (such as decision-making models) help decision-makers move rapidly and effectively to a successful conclusion (Egan 1994, Arntzen et al 1995). Radford (1984), Slack (1991), Longford (2000) and Vause (1999) state that all decision processes should be kept as simple as possible. This is achieved by reducing the problem to its core components (i.e. multilevel or cell based decision-making). Once the problem has been reduced to its core components, an analysis concerning the viability of each component should be conducted and must include:

- The time that the process will take
- The final effect on the decision-makers environment
- The final effect on the subject
- The ethical implications of the outcome
- The overall process (i.e. is it routine in nature or specialist)

Decision-making processes are usually defined in one of four functions, these are:

1. Risk neutral (the optimum function for any logical decision process)
2. Risk averse
3. Risk seeking
4. Mixed risk

As such the expected return on risk or the expected outcome from the investment or decision process will vary depending on the predominance of the function and the quality of the decision-making process. Possible outcomes from a predominance of the function are shown in the table 5.1.

<table>
<thead>
<tr>
<th>Table 5.1 – Possible Outcomes from a Predominance of the Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A risk neutral decision-maker will expect $U = RV$</td>
</tr>
<tr>
<td>A risk averse decision-maker will expect $U &lt; RV$</td>
</tr>
<tr>
<td>A risk seeking decision-maker will expect $U &gt; RV$</td>
</tr>
<tr>
<td>A mixed risk seeking decision-maker will expect $U \pm RV$</td>
</tr>
</tbody>
</table>

Where

$U =$ the investment
$RV =$ the return or expected value

Slovic and Lichtenstein (1971), Beach (1997) and Salvendy (1997) propose that a single decision (assuming that there is no neutral or undecided factor) is based on two possible outcomes, this is illustrated in figure 5.1.
Figure 5.1 - Schematic of a Single Decision Process

<table>
<thead>
<tr>
<th>E1</th>
<th>D1</th>
<th>C11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D2</td>
<td>C21</td>
</tr>
</tbody>
</table>

Where:

- E = state or decision focus
- D = decision options (yes/no)
- C = the decision outcome

Note: model assumes no neutral or undecided factor

For example the decision focus (E) may be represented as the question “do you want a ball”? The decision options are either yes (D1) or no (D2). The decision outcome (C) will be either to decide in favor of a ball (C11) or to decide against a ball (C21).

A decision model in its most simple format is based on positive/negative outcome from a duel proposition; this is shown in figure 5.2.
Where:

\[ E_1 \quad E_2 \]

\[ D_1 \quad C_{11} \quad C_{12} \]

\[ D_2 \quad C_{21} \quad C_{22} \]

Where:

- \( E \) = state or decision focus
- \( D \) = decision options (yes/no)
- \( C \) = the decision outcome

Note: model assumes no neutral or undecided factor

For example, the duel proposition may be "do you want a red ball (E1) or do you want a blue ball (E2). The Decision outcome (C) will be either to decide in favour of a red ball (C11), not in favour of a red ball (C21), in favour of a blue ball (C12) or not in favour of a blue ball (C22)

A complex decision model could therefore be developed and described as a series of single decision processes; this is illustrated in figure 5.3.
The decision process involved during a site selection project is complex. Tversky and Kahneman (1974) state that the successful completion of a complex decision process typically has a conjunctive character. For example, for the project to succeed, all of a series of minor events must occur. However, even when each of the minor events is, individually, likely to occur, the overall probability of success is typically low if the number of minor events is high.

The more meaningful decision model may therefore be developed from a series of "single decisions" that are linked to key decision criteria. Multiple decision criteria (M) have a direct link/influence between M1- M2 – M3 – M4 etc. with S1 – S2 – S3 – S4 etc. having a direct influence solely on the controlling criteria (M).

For example the key criteria (M1) may be "to play a game", with the single decision (S1) "ball game or card game". Assuming the answer is ball game, the second criteria (M2) may then evolve "what game" with a secondary decision (S2) "baseball or football". Assuming the answer is baseball, the third criteria (M3) may become "what type of ball" with secondary a decision (S3) "hardball or softball". Assuming the answer is softball, the forth criteria (M4) may become "colour of ball" with secondary a decision (S4) being "red ball or blue ball". Finally the fifth criteria (M5) may then become "where to play" with a secondary decision (S5) being park or street.

This is illustrated in figure 5.4.
5.2 A Structured Approach to Decision-making

Russo and Schoemaker (1989) maintain that adhering to a structured methodology can arrive at the right decisions. They state that there are four main criteria in making the “right decision”, these are:

1. “Framing” – The process of structuring the issue and defining the fundamental objectives
2. “Gathering intelligence” – The process of seeking robust data and “reasonable estimations”
3. “Coming to conclusions” – A methodology that follows rules and a systematic and reasoned approach.
4. “Learning from feedback” – A structured methodology that keeps an audited record of expectations and outcomes against the primary issue.
5.2.1 Framing

The decision frame is the terminology given to the perception of the outcome provided by the decision-maker prior to the “choice” being made. Normal patterns of behavior, habits and the specific characteristics of the decision-maker control the decision frame (Tversky and Kahneman 1981). Hawksworth (1999), places the framing strategy into four action-points, these are:

- The objective
- The desire
- The preferred outcome
- Contingency plan against failure of the preferred outcome

5.2.2 Gathering Intelligence

Slovic & Lichtenstein (1971) state that left to their own devices, decision-makers will use whatever decision aids they can to assist in the complex process of deriving an outcome. The decision aids will include:

- Rumors
- Cultural biases
- Self-evident truths
- Common sense
- Appeals to authority (management)
- Appeals to experts
All of the above are fallible sources of information and highlight greatly the need for a robust decision-making model.

5.2.3 Coming to Conclusions

The processes of framing and intelligence gathering are necessary but do not generate an outcome or indeed necessarily engineer a robust decision. Good decisions will only be found by following a logical and systematic procedure.

5.2.4 Learning from Feedback

Godfrey and Garner (1991) state that it is desirable to conduct the overall decision-making process using a group that comprises individuals assigned to control the task while others within the organisation support the process. Russo and Schoemaker (1989) further suggest that the “wrong” decision can be brought about by insufficient attention to any of the following criteria:

- Information and decision strategy
- “Frame” blindness (i.e. lack of focus on the issue)
- Lack of frame control (i.e. management of the issue and division of focus)
- Overconfidence in judgment and failure to gather robust data
- Taking high-risk shortcuts (i.e. an over-reliance on readily available data and “convenient” facts)
- Shooting from the hip (i.e. lack of formal control and management and a belief in being able to control complex decision processes from memory)
- Group failure (i.e. assuming that many “intelligent” people can make the collective right decision)
- Interpretational analysis and the failure to convert data correctly
• Lack of project control (i.e. insufficient recording of the process and data)
• Failure to audit the final decision

5.3 Common Actions Undertaken During the Decision-Making Process

Messick & Sentis (1984) and Bazerman (1998) provide some of the more common actions that are undertaken during the decision making process. These actions include:

• Decision-makers often lack important information regarding the definition of the problem
• Decision-makers only retain a relatively small amount of information in their usable memory
• Decision-makers will forego the best solution in favour of one that is acceptable or reasonable (try to find balance and/or equilibrium)
• Decision-makers pay more attention to confirming than disconfirming information
• Decision-makers often protect their initial decision by actively seeking out information that supports these decisions
• Decision-makers feel greater regret for acts of commission (i.e. what they did) rater than acts of omission (i.e. what they did not do)
• Decision-makers will never be totally neutral or de-biased
5.3.1 Pre-determined Belief Set

Typically most decision-makers have a pre-expectation of a decision outcome. An example of such an event may be “it will fail because I cannot comprehend the problem or the opportunity”. Tverski and Kahneman (1973) and Messick and Sentis (1985) claim that, even when the same information is available to all, individual perceptions of a situation differ dramatically depending on the role of the individual in the decision-making process. This is due in part to the simplified decision-making strategies employed by most people (Tverski and Kahneman 1974). Bazerman (1998) suggests that this process is beneficial in some cases because the saving in the time taken to reach a conclusion outweighs the loss of quality in the decision-making process.

Bazerman (1998) provides a “hypothetical value curve” for the decision making process, whereby the “neutral” decision is made from a combination of positive and negative influences without bias. However, depending on the decision-makers bias, the outcome will be either more positive or negative. The same problem will therefore be viewed differently by different decision-makers. This phenomenon is illustrated in figure 5.5 with positive and negative heuristic values provided for comparison.
Figure 5.5 - Schematic of the Decision-Making Value Curves

Note: If neutral (i.e. no bias present to cause influence), the complex decision should follow a path where the positive issues are viewed in a positive light (positive zone) and the negative issues are viewed in a negative light (negative zone). If there is a positive bias present then the positive issues will be viewed in a more positive light and the negative issues will be viewed more positively. If there is a negative bias present then the negative issues will be viewed in a more negative light and the positive issues will be viewed more negatively.

The work of Bazerman (1998), Salvendy (1997), Tversky and Kahneman (1974) and Walster et al. (1978) suggest that the basic heuristic (i.e. the predefined condition of decision-making) will have a great effect on the outcome. Indeed there is evidence to confirm that in many cases decision-makers develop an initial theory of outcome and modify the weight of the data to produce the desired result. For example, of particular note to this research
was the case of German Neulander (old DDR) that was perceived by many to be a third world country, perpetuating the communist manifesto and populated by lazy uneducated people. However, evidence from top industrialists such as E v. Keunheim (Chairman of the Supervisory Board of BMW) and D Herman (at the time CEO of Opel) does not match the basic heuristic. Both parties stated that the Neulander was in fact a good place to develop industrial operations because of the great flexibility and skills inherent in the workforce (see appendices 2 and 3). The evidence was exemplified by some of the most productive manufacturing plants in the EU being located in the region (i.e. Eisenach).

5.4 A Decision-Making Model

There are many different types of decision-making models (Zahedi 1986). All of which are designed to determine the outcome of a complex decision based on logical and rational data input. Wild (1989) and Bazerman (1998) provide two classifications of decision-making model, these are:

1. Descriptive – that describes relationships amongst variables, for example an interest in the bounded (framing and heuristic) way that decisions are made
2. Prescriptive – that describes the best course of action, for example linear models for making optimum decisions

This work is concerned with prescriptive decision-making and the development of a linear model that will generate the same solution to the problem based on the same inputs.
5.4.1 The Decision or Ranking Model

Bazerman (1998) and Salvendy (1997) state that a rational decision-making model ("classical decision") is based on a set of assumptions that prescribe how a decision should be made rather than describing why a decision is made. A decision or ranking matrix represents a good method for complex problem solving and overcoming the problem of how a decision "should" be made, rather than "is" made (Kmetovicz 1992, Arntzen et al., 1995, Finch and Luebbe 1995, Hollins and Hollins 1991, 1999, Richards and Moger 1999 and Cooper 1999).

Salvendy (1997) suggests that this type of process also provides a provenance for third party interest by providing an audit trail that is not available through other means. The model therefore overcomes the suspicion typically associated with complex decision-making.

Chapanis (1996), Kleinmuntz (1968), Owen (1999) and (Jayaraman 1999) however, provide a word of caution insofar that most models fail to encompass "real world" issues and influences such as the amount of time available to make the decision or user preference (heuristic). Importantly, the ability to secure robust and relevant data is often overlooked, as is the ability to direct the correct questions concerning the problem. Alter (1980) and Bailey (1996) offers a possible positive outcome to this scenario by claiming that the selection criteria of a decision-making model should be layered to allow the right level of input to be maintained by the most competent people. Straw (1980), Beach (1997), Longford (2000) and Barrans (2000) are clear in their statements that once an outcome is derived, then "a level of intellect is required to determine the true meaning of the data".
5.5 The Typical Pattern of Decision-making in Site Selection Projects

Companies typically concentrate on "more of the same" when they plan their expansion into a new geographical location. Most corporate decisions relating to site selection have typically been influenced on the size of the country, potential stability and "me-too opportunism" (Bartlett and Ghoshal 1989).

5.5.1 Contextual Considerations of Site Selection

In the context of complex decision-making processes (Schmitt and Chan 1998) maintain that more than one selection procedure is typically employed. For example there may be a primary selection process that eliminates inappropriate options, a secondary selection process that performs a short-listing mechanism and final selection via a ranking process for ranking multi-level complex processes that require a logical decision.
CHAPTER SIX – DEVELOPMENT OF THE STYLES SITE SELECTION PROCESS AND MODEL - AN ANALYSIS OF THE OVERALL PROJECT
6.0 Introduction

Styles had a number of false starts when planning new geographical expansion. The various projects may be summarised into two distinct groups these are:

1. Expansion Project One - UK focused site selection procedure
2. Expansion Project Two - EU focused site selection procedure

This chapter deals with the following issues:

1. An evaluation of the Styles UK focused site selection procedure
2. An evaluation of the Styles limited EU focused site selection procedure
3. The effect of regional investment strategies on the case study
4. The development of the Styles site selection criteria model
5. The original Styles site selection matrix
6. Historical analysis of the Styles decision outcome from the original site selection criteria model

6.1 Expansion Project One - UK Focused Site Selection Procedure

Just after completing the venture capital deal in 1994, Styles Executives proposed two possible geographical expansion scenarios these were:

1. Andover
2. Heathrow Airport
Both propositions have some historic significance and are included below for completeness.

6.1.1 The Andover Proposal

Styles originally conducted their sales and marketing activities from a separate office in Andover. The expansion project and therefore the site proposal was based on the then current Sales and Marketing Director taking over the responsibility for operations of the new site.

The outline of the proposal made no attempt to clarify the proximity of market or indeed workforce. The proposal does however act as an exemplar for Chistodoulou (1996) by showing that the only consideration, at that time, was the proximity to current location.

6.1.2 The Heathrow Proposal

As the UK market for certain Rapid Product Development services became more saturated and the value of orders began to reduce, it was reasoned that Styles could attract new, overseas customers by offering a "showroom" location near to a major international hub such as Heathrow Airport. It was reasoned that the customers would "just fly in and discuss the contract".

Once again little thought was given to market proximity or the overhead cost of such a venture.
6.1.3 Analysis of the UK Focused Site Selection Procedure

Neither of the original Styles proposals was based on any market or labour data, but rather convenience (Andover) and instinct (Heathrow Airport). Records show that both proposals were delivered to the shareholders in a raw and emotional manner. Both proposals were rejected and Company records suggest that the Board of Styles developed a negative bias to any geographical expansion from this point onwards.

When related to Russo and Schoemaker’s (1989) work on the decision-making process it is apparent that the executives of Styles did not generate an adequate framework and therefore the wrong outcome was delivered.

6.2 Expansion Project Two - EU Focused Site Selection Procedure

The original UK proposals failed before any structured site selection work or decision-making could be conducted. However, approximately two years later (1996) the Company tried once again to expand its geographic coverage. This time the project was to be broadened to cover other European states. A limited ranking matrix was developed in order to evaluate the EU focused selection procedure.

Originally Styles had two driving issues for the site selection procedure, these were (in order of importance):

1. The incentives package
2. A skilled workforce
The importance of the main criteria was later reversed when it was recognised that the whole opportunity would fail if the right workforce could not be recruited rapidly and in sufficient numbers.

With the driving criteria in mind, the Styles limited EU focused site selection procedure was conducted in two distinct sections these were:

1. Wider UK site search
2. Pan-European site search

### 6.2.1 Wider UK Site Search

Styles limited UK focused site selection procedure commenced in the UK, with specific target locations being the Midlands, Wales, North-West, North-East and South-East.

#### 6.2.1.1 The Midlands

The Midlands was originally the preferred location due to market proximity and a seemingly large supply of skilled labour. Specific sites were investigated from the target site locations. Bermuda Park, Nuneaton, scored the highest mark for the UK sites. However, the West Midlands Development Agency (WMDA), was not particularly supportive of the project (see Chapter 3.4 factors affecting successful inward investment projects).
6.2.1.2 Wales

Wales initially appeared to offer a good package of incentives. However, on further investigation it became apparent that the incentives were restricted to remote regions. Moreover, the Welsh Development Agency described the local population as “geographically loyal”. Typically the local population would not readily work outside of their own parish. As such there were major doubts regarding the possibility of recruiting enough skilled labour.

6.2.1.3 The North-West

At the time of the proposal, the North-West of the UK was awarded objective one status by the European Commission. The region was therefore able to offer some comparatively good incentive packages. The local market was not particularly good and the specific regions were closer (in time) to Styles home base than the nearest market. With this in mind, organic growth in the North-East was considered more risk averse.

6.2.1.4 The North-East

Organic growth in the North-East was the natural choice, however there were few incentives of any note, because the regional authority considered that the Company would naturally wish to expand locally and therefore it did not need to encourage it to do so. Importantly, the region suffered from a lack of suitably qualified people and it was considered that the Company would not be able to expand to a critical level.
6.2.1.5 The South-East

The South-East was eliminated from the initial search, because no financial incentives were available to offset the additional costs of this high-cost region.

6.2.2 Pan-European Site Search

The search was widened to include many other European countries where it was considered that the package of incentives and available workforce were favourable. Initial inquiries were made via the Commercial Attaches of the Embassies of Portugal, Spain, Italy, Greece and Germany. The Germans were the first to respond followed by the Italians.

6.2.2.1 Germany (Neulander)

At the time of the opportunity, Germany was in a unique position due to the process of reunification of the Eastern States (old German Democratic Republic). Specifically the regions were offering the maximum permitted package of incentives allowed by the EU and had 22% unemployment. The country was trying to encourage high-technology engineering companies (RPD) into the region. Importantly Styles matched the profile and strategy of the region in terms of target investment projects for the region.

6.2.2.2 Italy

There were some attractive packages of incentives being offered by the Italian Government, however the qualifying regions were located in the far
south of the Country (away from possible markets) and as such, the Country was disqualified from the search.

6.2.2.3 Portugal

Portugal has been the hub of the European mould tool-making sector for many years. The authorities did not wish to see "another" toolmaker enter the market place and cause disruption to the indigenous players. The Development Agency declined to enter into discussions with the Company.

6.2.2.4 Greece

A comparatively reasonable package of incentives was available from Greece, however, workforce and proximity to an existing market were issues that could not be resolved to the satisfaction of the project executive. The Country was eliminated from the search as a result of this.

6.2.2.5 Spain

Spain had a novel manner of conducting inward investment projects. The development Agencies required a full business plan (with financial projections) before they would discuss possible locations or incentives packages. This presented a "catch 22 situation" because the Styles Executives reasoned that they could not develop a full plan until they had focused on a region and specific site.
6.3 The Effect of Regional Investment Strategy on the Case Study

Hanson (1999) stated that there was little co-operation between the national, regional and local UK development agencies. The West Midlands Development Agency had developed a strategy of attracting Foreign Direct Investment directly into the region that was also in competition with the local support groups.

During the Styles site selection project, the West Midlands Development Agency had a strategy to attract low-value-added work into the region. The strategy also included the preference for low capital intensive projects (i.e. sandwich factories). Therefore the Styles project was unattractive on both counts.

The IIC (the national support group for the whole of the Neulander) worked directly with the regional support groups. The Saxony Development Agency had an alternative strategy for high-value-added jobs and capital intensive projects. The German strategy aligned well with the Styles business strategy. As such, a more comfortable relationship was built, more rapidly, between both parties. The business relationship acted as a catalyst for the development plan.

6.4 The Development of Styles Site Selection Criteria Model

The whole decision matrix for the site selection criteria for the proposed new Styles site was further developed from four additional criteria. The full site
selection model was based on a first past the post, weighted criteria system described by Beach (1997). The mechanism of this type of model is discussed in section 9.3.2. The Styles site selection model contained a total of six selection criteria, these were:

1. Government incentive support
2. Availability of labour
3. Strategic location
4. Support Group
5. Infrastructure
6. General Impression

All of the site evaluation was undertaken by one of the executives of Styles. This action is in common with the recommendations of Beach (1997) and Wassermann (1999), who consider that it is of great importance to maintain a constant marking or ranking procedure throughout the selection process.

### 6.4.1 Government Incentive Support

The executive team of Styles recognised that the venture had to be viable in its own right. However the Company had no cash reserves, due partly to the dynamics of the UK market and partly due to the initial rapid growth of the Company. The only perceivable way in which to grow in a rapid manner and to the scale necessary was thought to be with significant cash aid.

There was also an element of "us too", insofar as certain executives of Styles thought that if other companies had received packages of incentives then they should be offered them also.
An early decision was made to secure the maximum financial support possible from government offices, it was reasoned that this would reduce the level of equity funding required and preserve shareholder percentage within the executive.

This decision weighted the entire proposed project and much "confirming data" (as described by Tversky & Kaneman 1974, Godfrey & Garner 1991, Bazerman 1991 and Salvendy 1997) was sought and introduced into the decision-making procedure. For example alternative strategies of growth by acquisition and/or joint venture were ruled out because it was argued that these types of ventures could not be sustained within the dynamics of the Rapid Product Development market.

6.4.2 Availability of Labour

The executive team of Styles rated a skilled workforce highly. The core business of Styles lay in a workforce able to respond rapidly to customer requirements. The executives initially thought that a workforce would be relatively easy to recruit. However early analysis during the site selection procedure of many UK and pan-European sites showed that it would be difficult to recruit a significant number of people without starting a wage war with the local competition (assuming that the right number of suitably qualified people existed in the region). This would raise the operating cost of the business and the end products may not have been viable on the open market. The general strategy of the case study confirms much of the literature regarding the key placement of labour in the selection process (Millward 1995 and Tighe 1998).
As the project progressed, the executive team changed their weighting of criteria to favour the workforce criteria instead of government incentives. The new key criteria was thought necessary because it was reasoned that the ultimate viability of the project hinged on the workforce.

6.4.3 Strategic Location

The Styles operation was considered to be a European exemplar for the Rapid Product Development sector. However, the core products of Styles (plastic prototype components) were typically sourced locally by the customer base. Contemporary research indicated that the customers had a tradition of expecting to buy a prototyping service that was within reach of their factories (i.e. local supply). The executive team was committed to finding a site that was more central to high-value-added manufacturing. The new location had to secure the existing Styles operation and also had to offer a secondary market, that could be exploited along side the existing UK market.

The speed of commissioning of the new facility was also considered critical because the UK market for certain technical Rapid Product Development services had become low-value commodity items (Styger 1996). Styles had a limited product portfolio at this time and was suffering from its inability to earn revenue from more profitable services.

6.4.4 Support Group

The responsibility for any process of inward investment and therefore site selection must be placed firmly within the company undertaking the work.
However, the process may be eased and assisted by support agencies, but the quality of support agencies varies greatly (Anon [u] 1996). Support agencies typically fall into three main categories, these are:

1. National Support Agencies
2. Regional Support Agencies
3. Local Support Agencies

6.4.4.1 National Support Agencies

National Support Agencies are typically focused on the economic development of the whole country. They are supposed to act as the first point of contact between the prospective investor (company) and the regional development agency. Typically all National Support Agencies claim to be impartial when considering possible sites for new business development but they will invariably direct a prospect to the "best" region (i.e. the one with the highest level of unemployment, incentives or workforce)

6.4.4.2 Regional Support Agencies

Regional Support Agencies tend to take an umbrella approach to any potential investment project insofar as they will look after the best interests of their region but not favor any single location in that region. The Regional Support Agencies tend to be the most active support body because they are able to work “on the ground” with the potential investor as well as operating at a political level. Regional Investment Agencies will however only focus on their region. There is little if any co-operation between regions and their areas of demarcation may exclude the best-fit options for a project.
6.4.3 Local Support Agencies

Local Support Agencies focus on the local economic development strategy (for example the town or county such as Coventry and Warwickshire). There is typically much internal competition between the Local Support Agencies. This is exemplified by the myriad of overseas offices operated by the Local Support Agencies. Local Support Agencies typically have a limited choice of available sites and they can only offer the sites that they have in their area.

6.4.5 Infrastructure

The local infrastructure was of less importance to the Styles site selection criteria. The Company had a limited need to be near to motorways, and an airport, but the position was not as critical as it would have been for example a distribution or logistics group, because the movement of bulk materials or consignment stock was not a part of Styles business process.

6.4.6 General Impression

The issue of general impression boiled down to the combination of all of the above criteria plus more intangible and subjective issues such as quality of local hotels, proximity of areas of client entertainment, other organisations in the area, training schools, the local community etc. These criteria were evaluated subjectively within a limited time-frame and were therefore a snapshot in time.
In order to ascertain the most favorable location for Styles new manufacturing site, a process of evaluation was undertaken. The first stage of the process was to set the selection criteria and weighting that should be apportioned to each criteria. An evaluation procedure was commenced that included:

- Site visits to all proposed locations
- In-depth interviews with political leaders
- In-depth interviews with local industrialists

A profile of each proposed location was built up and specific rankings for each of the possible locations recorded against a predetermined table. The original rankings are shown in the table 6.1.
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<td>Newton Aycliffe</td>
<td>2</td>
<td>3</td>
<td>2.5</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Certain sites were not included into the original Styles selection process due to their low scores. This action is in line with the recommendations of Longford (2000) concerning statistical analysis of complex decision models (see section 9.4).
6.6 Historical Analysis of the Styles Decision Outcome from the Original Site Selection Criteria Model

The Styles executive team considered that Germany offered the best single strategic location for the whole of Europe. Indeed Randlesome (1996) describes Germany as being "the powerhouse" of Europe with an educational, financial and social structure in-line to encourage and sustain a strong engineering base. He also claims that during the first eighteen months of the process of reunification, 25% of the East-German workforce became unemployed or were placed on short-time. This occurred during the process of rationalisation of the traditional communist managed, labour intensive, industries that were designed as much for full employment as they were for productivity. The combination of both factors offered a unique opportunity for any high-technology based engineering (RPD) companies looking to invest into the EU.

There was no doubt that a labour pool was available within the region and that it would satisfy the requirements of Styles. Indeed there was no other location in the EU that had such a mass of unemployed, yet qualified, engineers.

Investigation at the time suggested that the type of overall support package being offered, by the German government, for the Neulander had a limited period. This was because of the unique situation in this region (compared to the rest of the EU) at this time. The Styles executive team considered that it was inappropriate to undertake further investigation into other targeted EU countries. This was because under EU rules, the incentive packages being
offered, in the Neulander, could not be beaten by any other country within the European Union.

Chapman (1999) states that German industry spends over three times more (as a percentage) on research and development compared to the UK. This does not take into account the market size that is two and half times larger than the UK. It is therefore possible to conclude that the opportunity for RPD products and services in terms of market penetration and growth would be greater in Germany than in the UK.

6.6.1 The Final Outcome

Styles chose Döbeln (located between Dresden and Leipzig) in the German state of Saxony as the first target site for expansion. This site scored the highest marks (99 out of a possible 115) within the original Styles site selection criteria model.
CHAPTER SEVEN – ANALYSIS OF THE ORIGINAL SITE SELECTION MODEL OF THE CASE STUDY
7.0 Introduction

A committee comprising of Styles company executives, regional development agency personnel and external advisors determined the original Styles selection criteria. The same committee assigned the weighting values from which the original site selection model was developed. In an effort to maintain a consistent level of marking throughout the entire site selection process, only one executive of Styles undertook the ranking (scoring) of all of the target sites. This procedure follows the recommendations of Swoter (2000)

Records indicate that the overall physical aspects of the site selection process appear to have worked well. However, questions remain regarding the accuracy and quality of the site selection model.

This chapter discusses main questions raised from the original site selection process, specifically:

1. Were the original site selection criteria of Styles robust?
2. What happens if the ranking values change?
3. What is the true ranking of the selection procedures?
4. What is a more robust model of the site selection criteria?

7.1 Were the Original Site Selection Criteria of Styles Robust?

It is fair to say that, although basic and limited in coverage, the original site selection criteria were robust. Indeed although much extended, five out of the
original six criteria have been carried forward into the final site selection model of this work. The sixth (General Impression) has not been carried forward. The reason for not carrying the General Impression criteria forward is discussed in section 7.2.2.

### 7.2 What Happens if the Ranking Values Change?

We may assume that common sense was applied to the ranking of the target sites (Lip 1996). However, we do not know if the original weighting of the model had an overall effect on the decision outcome, or if the “best overall” site was indeed selected.

Table 7.1 shows the total ranking for each of the original target sites. Site #1 represents the theoretical maximum or desired outcome and it is used as a benchmark throughout this section. Site #8 was the original chosen site (Döbeln).
Table 7.1 – The Total Ranking For Each of the Original Target Sites

<table>
<thead>
<tr>
<th>Site #</th>
<th>Ranking (overall total score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site #1</td>
<td>115</td>
</tr>
<tr>
<td>Site #2</td>
<td>67</td>
</tr>
<tr>
<td>Site #3</td>
<td>48</td>
</tr>
<tr>
<td>Site #4</td>
<td>89</td>
</tr>
<tr>
<td>Site #5</td>
<td>79.5</td>
</tr>
<tr>
<td>Site #6</td>
<td>77</td>
</tr>
<tr>
<td>Site #7</td>
<td>84</td>
</tr>
<tr>
<td>Site #8</td>
<td>99</td>
</tr>
<tr>
<td>Site #9</td>
<td>82</td>
</tr>
<tr>
<td>Site #10</td>
<td>65</td>
</tr>
<tr>
<td>Site #11</td>
<td>51</td>
</tr>
<tr>
<td>Site #12</td>
<td>76</td>
</tr>
<tr>
<td>Site #13</td>
<td>68</td>
</tr>
<tr>
<td>Site #14</td>
<td>60</td>
</tr>
<tr>
<td>Site #15</td>
<td>67</td>
</tr>
<tr>
<td>Site #16</td>
<td>38</td>
</tr>
<tr>
<td>Site #17</td>
<td>61</td>
</tr>
<tr>
<td>Site #18</td>
<td>45</td>
</tr>
<tr>
<td>Site #19</td>
<td>55</td>
</tr>
<tr>
<td>Site #20</td>
<td>45</td>
</tr>
<tr>
<td>Site #21</td>
<td>64</td>
</tr>
<tr>
<td>Site #22</td>
<td>67</td>
</tr>
<tr>
<td>Site #23</td>
<td>53</td>
</tr>
<tr>
<td>Site #24</td>
<td>57</td>
</tr>
</tbody>
</table>

Site #8 attained the highest ranked score (99 marks) and was chosen as the new location. This basic decision-making process ("highest score wins" or "first past the post") is consistent with the proposals made by Finch and Luebbe (1995) Müller and Schimmel (1999).
It is also interesting to note that the original selection matrix had only 6 criteria as a basis for the outcome. Therefore the recommended maximum number of criteria (20) for the optimum selection outcome was also complied with (Müller and Schimmel 1999).

The figure 7.1 shows the outcome from the original site selection model as a graph. This representation clearly indicates the status of each of the target sites in relation to the others. This format is used for discussion purposes throughout this section.

**Figure 7.1 - Total Ranking (Original Values)**

Note: Site One is the theoretical maximum score or optimum desired outcome
7.2.1 Experiment One – To Determine the Outcome of the Original Site Selection Process with Modified Weightings

Although we may assume that the original selection criteria were robust, we need to understand if the original weightings had a great effect on the outcome. Understanding the effect of weighting on the site selection model is important because it may be possible to set the weightings of the model to secure a desired outcome instead of achieving the best outcome from a neutral bias.

Table 7.2 provides a list of new experimental weightings for the original site selection model.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Experimental Weighting (original weighting shown in brackets)</th>
<th>Rational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>5 (3)</td>
<td>It may be reasoned that it is important to be close to a single client (see table 2.4 companies C &amp; D)</td>
</tr>
<tr>
<td>Labour</td>
<td>5 (5)</td>
<td>Skilled workforce is important in the RPD sector</td>
</tr>
<tr>
<td>Incentives</td>
<td>3 (4)</td>
<td>This may be a nice bonus but not necessary for the project to proceed</td>
</tr>
<tr>
<td>Support Group</td>
<td>2 (4)</td>
<td>There may be little need for the assistance of a support group</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>4 (3)</td>
<td>A client may require the company to deliver components on a JIT principle</td>
</tr>
<tr>
<td>General Impression</td>
<td>4 (4)</td>
<td>The site may still have to “feel right”</td>
</tr>
</tbody>
</table>

Figure 7.2 shows the outcome of the experimental weightings when applied to the original ranking values.
The results show that Site #8 achieved the overall highest score and would therefore be the chosen site under the rules provided by Finch and Luebbe (1995) Müller and Schimmel (1999). Indeed when a comparison is made between the two sets of figures (experimental and original values) we note that although there is some modest realignment of the individual scores of some of the sites, none are significant enough to alter the original outcome. Table 7.3 provides a comparison between the experimental and original rankings.
Table 7.3 – Comparison Between the Experimental and Original Values

<table>
<thead>
<tr>
<th>Site #</th>
<th>Experimental Ranking (overall total score)</th>
<th>Actual Ranking (overall total score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site #1</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Site #2</td>
<td>67.5</td>
<td>67</td>
</tr>
<tr>
<td>Site #3</td>
<td>46</td>
<td>48</td>
</tr>
<tr>
<td>Site #4</td>
<td>92</td>
<td>89</td>
</tr>
<tr>
<td>Site #5</td>
<td>74.5</td>
<td>79.5</td>
</tr>
<tr>
<td>Site #6</td>
<td>73</td>
<td>77</td>
</tr>
<tr>
<td>Site #7</td>
<td>82</td>
<td>84</td>
</tr>
<tr>
<td>Site #8</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>Site #9</td>
<td>78</td>
<td>82</td>
</tr>
<tr>
<td>Site #10</td>
<td>63.5</td>
<td>65</td>
</tr>
<tr>
<td>Site #11</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td>Site #12</td>
<td>81</td>
<td>76</td>
</tr>
<tr>
<td>Site #13</td>
<td>72</td>
<td>68</td>
</tr>
<tr>
<td>Site #14</td>
<td>58.5</td>
<td>60</td>
</tr>
<tr>
<td>Site #15</td>
<td>67.5</td>
<td>67</td>
</tr>
<tr>
<td>Site #16</td>
<td>31.5</td>
<td>38</td>
</tr>
<tr>
<td>Site #17</td>
<td>64.5</td>
<td>61</td>
</tr>
<tr>
<td>Site #18</td>
<td>40.5</td>
<td>45</td>
</tr>
<tr>
<td>Site #19</td>
<td>54.5</td>
<td>55</td>
</tr>
<tr>
<td>Site #20</td>
<td>40.5</td>
<td>45</td>
</tr>
<tr>
<td>Site #21</td>
<td>62.5</td>
<td>64</td>
</tr>
<tr>
<td>Site #22</td>
<td>67.5</td>
<td>67</td>
</tr>
<tr>
<td>Site #23</td>
<td>49.5</td>
<td>53</td>
</tr>
<tr>
<td>Site #24</td>
<td>54.5</td>
<td>57</td>
</tr>
</tbody>
</table>

Figure 7.3 shows a comparison of actual and experimental results in a graphical format. It is interesting to note that the profile of the two sets of results remain close at all times. So whereas the original criteria would appear to have some affect on the outcome, the “natural winner” emerges again apparently confirming the quality of the original decision-making process.
The results from the initial experiment raise a secondary question insofar as they could indicate that either: if enough criteria were included into the matrix then the natural winner will result each time, or that there is a possibility that these results were just coincidental.

7.2.2 Experiment Two – To Determine if the Outcome of the Original Site Selection Process With Modified Weightings was Coincidental

In an attempt to determine if the outcome was coincidental, a second experiment was undertaken to discover what would happen if a whole
criterion such as the General Impression was removed from the decision matrix. In effect would the removal of a criterion alter the overall value enough to introduce an alternative “winner” to Site #8?

Figure 7.4 shows the outcome of the experimental weightings (minus General Impression) when applied to the original ranking values.

**Figure 7.4 - Experimental Change of Weighting - Minus General Impression**

<table>
<thead>
<tr>
<th>Site #</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
<th>#9</th>
<th>#10</th>
<th>#11</th>
<th>#12</th>
<th>#13</th>
<th>#14</th>
<th>#15</th>
<th>#16</th>
<th>#17</th>
<th>#18</th>
<th>#19</th>
<th>#20</th>
<th>#21</th>
<th>#22</th>
<th>#23</th>
<th>#24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- Site One is the theoretical maximum score or optimum desired outcome
- This table based on modified weightings

Site #8 achieved the highest score even when the General Impression criteria was removed. Figure 7.5 provides a graphical comparison of the three profiles (actual, modified weighting and modified weighting minus general...
impression). The profiles of the results remain close with only minor adjustments occurring along the curves.

**Figure 7.5 - Comparison of Actual, Experimental Results & Experimental Results Minus General Impression**

Note: Site One is the theoretical maximum score or optimum desired outcome

It is possible that the result obtained by removing the General Impression criterion may be something of a misnomer because the General Impression criterion should be a true reflection of the overall outcome of the decision matrix. As such we could reasonably assume that the essence of "general impression" was present in each of the other criteria and is therefore reflected in the outcome. Hence the overall outcome by removing General Impression is to reduce the numeric value of the winner not the actual winner.
This is the reason why General Impression was not carried forward into the final site selection model.

7.2.3 Experiment Three – To Introduce a More Severe Reaction on the Original Outcome of the Original Site Selection Process

A third experimental process was undertaken in an attempt to introduce a more severe reaction. To achieve this result the values for General Impression were reintroduced into the matrix, but the Incentives criterion were given a value of zero. Styles had placed a great deal of emphasis on incentives and it is possible that Site #8 was winning in each scenario because of a higher contribution being achieved from the criterion compared to the other criteria.

Figure 7.6 shows the outcome of the experimental weightings (zero value for Incentives) when applied to the original ranking values.
Note: Site One is the theoretical maximum score or optimum desired outcome

Once again the original outcome remains the same. Site #8 still achieved the highest score although its original numeric value is somewhat reduced. Figure 7.7 provides a graphical comparison of the four profiles (actual, modified weighting, modified weighting minus general impression and modified weighting minus incentives). The graph illustrates that the overall profiles of each of the results remain close with only minor adjustments occurring in certain places along the curves.
Figure 7.7 - Comparison of Actual, Experimental Results, Experimental Results Minus General Impression & Experimental Results Minus Incentives

Note: Site One is the theoretical maximum score or optimum desired outcome.

The incentives curve does tend to be more severe than the others, but this is because there was a great deal of emphasis placed on this particular criterion within the original site selection process. However, the winning sites tend to remain winners and the losers tend to remain losers.
7.2.4 Experiment Four – To Determine the Effect of Zero Weighting on Each Criterion of the Original Site Selection Model

If such an important criterion such as Incentives has little effect on the overall outcome, it is important to discover if any of the other criterion's have a key effect on the result. Figure 7.8 provides a graphical comparison of each set of experimental data with one of the criterion valued at zero each time.

Figure 7.8 - Comparison of Actual Value Mapped Against Actual Value Minus One Criteria (Incentives, General Impression, Location, Labour, Support Group & Infrastructure)

Note: Site One is the theoretical maximum score or desired outcome
Figure 7.8 illustrates that in each case the overall outcome is the same with Site #8 having the highest score. There is also a broadly similar pattern of profiling between each set of results.

### 7.2.5 Conclusion to the Experimental Work Investigating the Effect of the Weightings on the Criteria Model

The overall results of the experimentation suggest that there is little effect on outcome if the criteria weightings change once the score has been given to a site. As such it may be said that once the weightings have been set on the selection model, then the model should typically operate in an unbiased form. Influence will only be exerted by the individual rankings achieved against each criteria listing.

It is however important to decide if the original Styles site selection model covered enough detail or if it allowed subjective decision-making to take place.

From the analysis of the Styles site selection model and the associated decision process, it would appear that the original model actually allowed a great deal of subjective decision-making to be conducted. Company records show that there were many sub-criteria decisions made during the process that were hidden in the criteria of the final model. There must however be a high level of decision-making transparency for any site selection model to work effectively. A high-level of transparency will allow an audit trail to be established from a logical decision-making process.
7.3 What is the True Ranking of the Selection Procedure?

The ranking and decision-making process associated with the Styles project delivered an outcome that remained intact (Site #8 winning) despite removing criteria and/or changing the original weightings. It is therefore fair to say that in terms of the Styles project, the values were pretty much on-line (minus general impression). The overall list of criteria was however not as comprehensive as the final site selection model developed in this work.

7.4 What is a More Robust Model of the Site Selection Criteria?

The results achieved by changing the weightings of the criteria suggest that it must be possible to develop a more comprehensive model than that which advocates the first past the post decision-making solution based on a limited number of generalised criteria.

The design of most decision models typically places the majority of focus on the weighting multiplier. However, the actual site decision is usually made during the point at which a site is ranked. The ranking section of the model and/or decision process is typically hidden and not well documented. Typically most of the current research into decision models gives little insight into methods of providing a transparent ranking procedure.

A more comprehensive and transparent model encompassing more detail and allowing less room for error is therefore required. The model must also provide a level of transparency and an audit trail that removes wherever
possible any element of subjective decision-making.
CHAPTER EIGHT – THE SITE SELECTION MODEL WITHIN THE CONTEXT OF A HOLISTIC SITE SELECTION AND SITE DEVELOPMENT PROJECT
8.0 Introduction

Site selection is a complex and multi facetted problem and most commentators do not consider the site selection criteria in enough detail. This is particularly true in-terms of the ranking value or sector, for example; engineering compared to commerce or specific needs such as labour compared to capital incentives (Lee, Green and Kim 1981, Dunning 1988, Carter, Person and Peng 1997, Farber 1998, Badri 1999, Remmelg 2000).

There is however little point in developing a robust site selection model if the model does not relate to the total (holistic) site selection process or project. This chapter discusses:

1. The pestlied principle in relation to the site selection process
2. The argument for a holistic site selection process
3. The holistic site selection process defined as a stage gate process

8.1 Consideration of the Pestlied Principle in Relation to the Site Selection Process

Harding and Long (1996) introduce the Pestlied principle, that is an assumption that states that various factors connected with the organisation can have a significant impact on the performance of that organisation when operating within their sphere of influence. The Pestlied principle aligns well with the overall concept of site selection insofar as all potential influences (hazardous or not) must be taken into consideration during the selection process.
A schematic of the Pestlied principle is shown in figure 8.1.

**Figure 8.1 - Schematic of the Pestlied Principle**

---

### 8.2 The Argument for a Holistic Site Selection Process

The most successful site selection processes are those that consider and rank all of the key factors of the project and their potential impact on the business goals (Tinbergen 1954, Hodder and Dincer 1986, Cohen and Lee 1989, Cunic 1998 and Parker 1999). Pongpanich (2000) brings the principle together by providing a site selection model that is holistic and comprehensive. Pongpanich's selection model may not however suite the overall needs of SME's in the EU RPD sector because it lacks the specific input necessary for this sector.
8.3 The Holistic Site Selection Process Defined as a Stage Gate Process

It should be possible to define the overall holistic site selection model for SME's in the EU RPD sector as a series of linear stages (Hoch 1982, Hoffman and Schniederjans 1994 and Finch and Luebbe 1995). The linear definition will include the actual site selection process that in effect becomes one action within the whole procedure that is in its self-controlled by many levels of influencing factors (for example provision of third party funding).

A full selection or project model should begin to take the form of a stage gate model (Cooper 1999 and Sage 2000) and can be described in the graphical format shown in figure 8.2.
Figure 8.2 – Schematic of the Stage Gate Model of the Holistic Site Selection Process

Stage 1

- Initial screen
- Preliminary investigation
- Go/kill project

Stage 2

- Detailed investigation
- Go/kill project

Stage 3

- Development & site selection
- Run site selection model

Stage 4

- Go/kill project
- Test & validate

Stage 5

- Go/kill project
- Due diligence
- Independent check on data

Stage 6

- Go/kill project
- Commission site

Project Review (Learn from Feedback)
A more detailed description of each of the stage gates of the holistic site selection process is discussed below.

### 8.3.1 The Trigger

Most companies will have developed a corporate strategy that is not dependent on a single tactical manoeuvre (Vause 1999). A single tactical manoeuvre may be expressed as the corporate desire to expand into country X, rather than a series of possible tactical options such as possible new site expansion, generic growth, trade sale etc.

The Trigger pre-empts the formal investigation stages of the holistic site selection model by investigating all possible tactical options in relation to the overall corporate strategy.

A schematic of the Trigger function of the holistic site selection process is shown in figure 8.3.

---

**Figure 8.3 – Trigger: Analysis of the Current Business and Future Requirements**

- **Answer the following key questions**
  1. What is the current corporate strategy
  2. Does the process of inward investment and new site selection fit in with the strategy
  3. What are the other possible tactical moves that may enable a similar return (perform SWOT analysis)
  4. Can the inward investment project be funded
  5. Can the inward investment project be resourced (opportunity cost)
  6. Can the inward investment project be managed

- **Run a logical check list of the decision-making process**

<table>
<thead>
<tr>
<th>Gate 1: If positive in all aspects move to stage 1</th>
<th>If negative kill the project</th>
</tr>
</thead>
</table>

---

122
8.3.2 Stage 1: Preliminary Investigation

The preliminary investigation will include the generation and analysis of all of the current market data and financial projections of the sector. Various scenarios will be modeled and mapped against current core corporate strengths and weaknesses. Management and support roles will be defined and project tasks assigned.

The project becomes "live" at this stage and cost is incurred (typically defined as opportunity costs). A prudent risk assessment must be conducted to evaluate the opportunity. Likewise, a firm decision to proceed must be made at this stage. All key and senior people must be committed to the decision.

A schematic of the preliminary investigation stage of the holistic site selection process is shown in figure 8.4.
Figure 8.4 - Stage 1: Preliminary Investigation

<table>
<thead>
<tr>
<th>Consider and analyse the current market and sector dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the current state of the market</td>
</tr>
<tr>
<td>2. Who are the main players in the market</td>
</tr>
<tr>
<td>3. What are the current trends</td>
</tr>
<tr>
<td>4. What are the current opportunities</td>
</tr>
<tr>
<td>5. What are the current threats</td>
</tr>
<tr>
<td>6. What are the genuine customer requirements</td>
</tr>
</tbody>
</table>

Provide scenarios and solutions to compete in the market under current conditions.

What is the current Corporate performance
What is the current core skill-base
What is the logical extension to the current core skill-base

Who will:
- Project manager the process
- Who will be in the support team
- Who will be in the team to conduct due diligence
- Who will be in the team to sign off the project at key stages (stage gates)

Run a risk assessment based on an analysis of the data.

Gate 2: If positive in all aspects move to stage 2
If negative kill the project

8.3.3 Stage 2: Detailed Investigation

If a firm, positive decision is made as a result of the preliminary investigation, then national and regional target locations are sourced. Utilising the assistance of local support groups such as embassy staff, RDA's, trade and professional associations and academic institutions may extend positively the internal project team. It should be noted that the data generated by some of the locally based support team may have a bias because (assuming a robust project proposal exists) local support teams will naturally want the company to locate in their region.
Certain key questions must be answered at this stage, including:

- Does the target(s) match the key requirements outlined in the trigger and stage 1 analysis?
- Do officials in the target area want the project in their region?
- Does the culture of the region match that of the company?

If the answers to the key questions are positive, then the project should be moved onto the next stage. If one or more of the key questions are answered negatively, then the project should be killed to avoid incurring further opportunity costs.

A schematic of the detailed investigation stage of the holistic site selection process is shown in figure 8.5.
8.3.4 Stage 3: Development and Site Selection

Stage 3 involves running the site selection model on specific sites in target regional locations. The data generated will indicate if there is a suitable location that is worthy of developing. It should be noted that the overall "winner" may be little more that the best of a series of poor performers. Therefore "real world" analysis is necessary to determine the validity of the results. The selection model must therefore be able to offer a transparent audit trail to enable the right level of analysis to be performed.

If the analysis of the development and site selection stages is positive, then the project may move onto the next stage. A schematic of the development and site selection stage of the holistic site selection process is shown in figure 8.6.

<table>
<thead>
<tr>
<th>Figure 8.6 - Stage 3: Development and Site Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>The site selection model is used at this point in the holistic site selection process, therefore, run the site selection model in full</td>
</tr>
<tr>
<td>Note: there is a paradox concerning the benefits of performing detailed financial analysis on the opportunity without specific consideration to the site or performing the site selection first and then conducting financial modelling. Experience suggests that it is better to select a site and then perform the financial modelling because the figures will be more specific and therefore more reliable.</td>
</tr>
<tr>
<td>Gate 4: If positive in all aspects move to stage 4</td>
</tr>
<tr>
<td>If negative kill the project (or re-run stage 2 again with other sites)</td>
</tr>
</tbody>
</table>

8.3.5 Stage 4: Test and Validation

Once a site has been selected, it should be possible to perform more detailed analysis in terms of Return on Investment (ROI), Nett Present Value (NPV) and best and worst case scenario planning. Internal and external sales projections should also be possible (i.e. how much work will be generated
from the mother company and how much work will be generated from the new site).

A further and more detailed risk assessment must be conducted regarding all of the key areas such as management and workforce, sector dynamics, possible competitor reaction and technological advancement. The internal risk assessment will form the core questions raised by any provider of third party financing.

If the answers to the questions are positive, then the project can move onto the next stage. A schematic of the test and validation stage of the holistic site selection process is shown in figure 8.7.

<table>
<thead>
<tr>
<th>Figure 8.7 - Stage 4: Test and Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run all financial models</td>
</tr>
<tr>
<td>Consider:</td>
</tr>
<tr>
<td>• Return on investment</td>
</tr>
<tr>
<td>• Net present value</td>
</tr>
<tr>
<td>• Best and worst case scenarios</td>
</tr>
<tr>
<td>Perform risk assessment on key areas such as:</td>
</tr>
<tr>
<td>• Sales projections (internal)</td>
</tr>
<tr>
<td>• Sales projections (external)</td>
</tr>
<tr>
<td>• Sales projections (third party)</td>
</tr>
<tr>
<td>• Key people</td>
</tr>
<tr>
<td>• Skilled workforce</td>
</tr>
<tr>
<td>• Sector dynamics</td>
</tr>
<tr>
<td>• Competitor reaction</td>
</tr>
<tr>
<td>• Technological advancement</td>
</tr>
</tbody>
</table>

Note: It may be necessary to raise third party finance (i.e. bank loans, venture capital, possible share issue etc.)

Gate 5: If positive in all aspects move to stage 5
If negative kill the project
8.3.6 Stage 5: Due Diligence

There will be a considerable level of "buy in" by the time the project reaches the due diligence stage. This is both positive in terms of project commitment and potentially negative in terms of possible judgmental biases being set by members of the project team and management. It is possible that the team will now be looking for data to confirm their decision making and desires (Tversky and Kehneman 1973). It is therefore vital that independent third-party due diligence is performed in order to verify all data (Rankine 1999).

If the due diligence is positive, then the project can move onto the next stage. A schematic of the due diligence stage of the holistic site selection process is shown in figure 8.8.

<table>
<thead>
<tr>
<th>Figure 8.8 - Stage 5: Due Diligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run internal and external due diligence</td>
</tr>
<tr>
<td>Verify all previous data</td>
</tr>
<tr>
<td>Note: This section may be performed by an external third party if finance is required and/or by independent consultants to verify if the decision was made with a neutral bias and if a prudent evaluation of the data was performed</td>
</tr>
<tr>
<td>Gate 6: If positive in all aspects move to stage 6</td>
</tr>
<tr>
<td>If negative kill the project</td>
</tr>
</tbody>
</table>

8.3.7 Stage 6: Commission the Site

If all of the stage gates have been passed successfully, then there is a good chance that the project is robust and worthy of realisation. Commissioning of the chosen location will include all of the typical aspects associated with site development including:
- Funding (i.e. the provision of third part capital)
- Erection of the building and provision of services
- Selection of capital equipment
- Recruitment of workforce
- Training
- Marketing and sales generation

A schematic of the commissioning stage of the holistic site selection process is shown in figure 8.9.

<table>
<thead>
<tr>
<th>Figure 8.9 – Stage 6: Commission the Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run the project</td>
</tr>
<tr>
<td>This section will include areas such as:</td>
</tr>
<tr>
<td>- Funding (i.e. the provision of third part capital)</td>
</tr>
<tr>
<td>- Erection of the building and provision of services</td>
</tr>
<tr>
<td>- Selection of capital equipment</td>
</tr>
<tr>
<td>- Recruitment of workforce</td>
</tr>
<tr>
<td>- Training</td>
</tr>
<tr>
<td>- Marketing and sales generation</td>
</tr>
</tbody>
</table>

Note: This is a project management task that may be outside of the site selection brief but is a part of the holistic process

Prepare for project review

8.3.8 Project Review

The project review is a vital part of the holistic site selection process but often forgotten or postponed during the start-up phase of the project. However if the first site selection project is successful, then it is reasonable to assume that further sites will be developed. It is therefore important to ensure that the
same mistakes are not repeated in order to improve the model and overall process.

A schematic of the project review stage of the holistic site selection process is shown in figure 8.10.

<table>
<thead>
<tr>
<th>Figure 8.10 - Project Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>At a set time not less than twelve months and not more than twenty four months after the beginning of stage 6, perform a full de-brief and analysis of the holistic site selection process. Document the findings and use to improve the process for future projects</td>
</tr>
</tbody>
</table>
CHAPTER NINE – THE THEORETICAL SITE SELECTION MODEL
9.0 Introduction

It is clear that the site selection model cannot be take out of context from the whole site selection process. However, most decision-making models (site selection models) are typically limited in coverage, depth (criteria) and do not provide a transparent and auditable function. Importantly most decision-making models suggest that a first past the post outcome is robust and absolute, however, the outcome may have no real value in a real world decision-making situation. Additionally some decision-making models are overly complex and tend to deter full interaction by the users.

This chapter covers aspects of the new site selection model that was developed as a part of this research work. The new model has expanded significantly in depth and coverage from the model covered in the previous sections.

This chapter provides:

1. A list of the standard criteria for site selection
2. A rational of how the selection model criteria weightings and sub-level rankings were derived
3. A description of the structure and mechanism of the site selection model
4. A guide to analyse the data produced from the site selection model in order to deliver a robust decision outcome
9.1 The List of the Standard Criteria for Site Selection

From the literature discussed earlier in the thesis, the following criteria for site selection have been selected and are shown below in table 9.1.

<table>
<thead>
<tr>
<th>Number</th>
<th>Criteria (Top-level criteria)</th>
<th>Additional Considerations (Sub-level criteria)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic factors</td>
<td>1. market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. existing customer base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. size of market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. accessibility to other markets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. potential growth</td>
</tr>
<tr>
<td>2</td>
<td>Political stability &amp; country risk (reception to the project)</td>
<td>N/A (see note i)</td>
</tr>
<tr>
<td>3</td>
<td>Financing</td>
<td>1. sources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. types of finance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. availability of equity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. availability of capital funds</td>
</tr>
<tr>
<td>4</td>
<td>Incentives</td>
<td>1. national</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. regional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. land</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. capital grants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. low/free interest loans</td>
</tr>
<tr>
<td>5</td>
<td>Physical Infrastructure</td>
<td>1. roads</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. rail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. airports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. seaports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. telecommunications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. site availability (land)</td>
</tr>
<tr>
<td></td>
<td>Language</td>
<td>N/A (see note ii)</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>6</td>
<td>Availability and quality of workforce</td>
<td>1. skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. flexibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. culture</td>
</tr>
<tr>
<td>7</td>
<td>Industrial relations and labour laws</td>
<td>N/A (see note iii)</td>
</tr>
<tr>
<td>8</td>
<td>Supply base</td>
<td>1. quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. number</td>
</tr>
<tr>
<td>9</td>
<td>Distribution base</td>
<td>1. quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. number</td>
</tr>
<tr>
<td>10</td>
<td>Competitors</td>
<td>1. quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. number</td>
</tr>
<tr>
<td>11</td>
<td>Technological status</td>
<td>1. information technology status</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. logistics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. production developments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. research capability</td>
</tr>
<tr>
<td>12</td>
<td>Embedded technological skills</td>
<td>1. history of the sector within the region</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. local sector know-how</td>
</tr>
<tr>
<td>13</td>
<td>Quality of life factors</td>
<td>1. education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. cultural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. leisure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. cost of living</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. any previous connection with the area</td>
</tr>
<tr>
<td>14</td>
<td>Presence of pre-existing plant</td>
<td>N/A (see note iv)</td>
</tr>
<tr>
<td>15</td>
<td>Speed of commissioning</td>
<td>1. time taken to set up a plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. time taken to construct a building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. time taken to recruit workforce</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. time taken to establish sales line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. time taken to set up a legal company (i.e. limited company)</td>
</tr>
</tbody>
</table>
| 17 | Fiscal | 1. economic policy  
|    |       | 2. exchange rates/single monetary union  
|    |       | 3. import control  
|    |       | 4. taxation  
| 18 | Support Group | 1. national political  
|    |       | 2. regional political  
|    |       | 3. local political  
|    |       | 4. national development agency  
|    |       | 5. regional development agency  
|    |       | 6. local development agency  
|    |       | 7. commitment to project  
| 19 | Entrepreneurial ability of management team | 1. "Searcher" potential (ability to discover opportunities)  
|    |       | 2. Resources access capability  
|    |       | 3. Ability to promote venture  
|    |       | 4. Ability to organise venture (top level)  
| 20 | Quality of local management | 1. Organisational ability  
|    |       | 2. Financial ability  
|    |       | 3. Technical ability  
|    |       | 4. Operational ability  
|    |       | 5. Sales & marketing ability  
|    |       | 6. Strategic & tactical ability  

Site selection is a complex multi-level process that incorporates many aspects of business that are typically outside of a simple geographical choice. Certain criteria of the selection model could cause the model to become too complex or potentially encourage the user to focus excessively in a single area to the detriment of the overall picture. The notes below discuss certain examples of this scenario in relation to the new model. It is therefore proposed that separate due diligence is conducted in these cases and the overall judgement carried into the model as a value.

Note i: Complex judgements concerning political stability and the risk of the proposed country are best conducted as a separate programme of due diligence and the overall judgement incorporated into the model.
Note ii: Analysis and data concerning the level of competence of the native language of the company selecting the new site needs to be established separately and an overall judgement made as a part of the due diligence process. The overall assessment can then be incorporated into the model.

Note iii: Issues relating to industrial relations and labour laws could either cause the model to become overly complex and/or cause the user to focus too specifically in one area of the decision-making process. An audit of industrial relations and labour laws should be conducted separately and a judgmental value (outcome) incorporated into the model.

Note iv: The issue of a pre-existing plant is set at the beginning of the project. At this point it is either decided if this is desirable or not. In the case of this study it was not and was therefore awarded one mark.

9.1.2 A Two-stage Weighting and Ranking Process

By including a list of secondary considerations, or more correctly sub-criteria, the commentators and contributors to the list of the standard criteria for site selection have (without necessarily recognising the fact) offered a two-stage list.

Whereas there is much time given over to the key criteria to be weighted, there is little mention (over the inclusion for consideration) of the sub-criteria to be ranked. Overlooking the sub-criteria issues of the problem is a common error in many decision-making models. Ignorance or lack of understanding of the sub-criteria allows for a level of subliminal decision-making to occur within the decision-making model. It is this “grey” area of the decision model that introduces error into the decision-making process.

9.2 A Rationale of how the Selection Model Criteria Weightings and Sub-level Rankings Were Derived

The new selection model helps the user to find values that in turn assist in focusing logically on key criteria essential to successful site selection. The values will assist in overall profiling and real world analysis (see section 9.4).
The key criteria may be formulated generally into five groups, these are (in no order of importance):

1. Business support issues (physical infrastructure, supply base, distribution base, competitors, presence of pre-existing plant)
2. Technical issues (language, technological status, embedded technological skills)
3. Economic issues (economic factors, financing, fiscal)
4. People issues (availability and quality of workforce, industrial relations/labour laws, quality of life factors, entrepreneurial ability of the management team, quality of local management)
5. Political issues (political stability and country risk, incentives, speed of commissioning, support group)

Interestingly, the RPD practitioners typically state that the people issues are most important, whereas the economists will typically favour economic issues. The RDAs typically focus on the support and incentives available followed by the economic. Potential clients would prefer to see a supplier locate close to the manufacturing and/or research centres and will always favor proximity and supply chain issues (Vitols 2000, Eyles 2001, Cottingham 2001, Frohmader 2001, Park 2001, Mellburg 2001). The basic bias to ones own area of interest or specialist profession is not surprising, but it does confirm the overall complexity and multi-level process of the problem.

For the purpose of this work, the weightings for the model have been based upon the requirements during the original project. It is fair to reason that a different company may have a different set of priorities based on the same basic criteria. The new model is flexible enough to allow fast modification of the weightings and/or the addition and removal of criteria should this be
necessary. Overall, the new model provides a data set that is acceptable to the requirements of real world decision-making and analysis.

Real world decision-making is interested in the outcome and the process of arriving at the outcome. There is typically little interest in any numeric value given to the outcome. For example the final numeric value of the outcome could be 1000 or 0.001, however, the outcome remains the same regardless of the value.

9.2.1 The New Decision Model Rule Book

The "rule book" for assigning values to the new model is discussed below.

9.2.1.1 Rule Book – Stage One: Setting Top-level Criteria

The top-level criteria of the new model provide the list of key issues to the problem. These will typically be "management focused". In an actual live study, the issues and values would be determined by consultation with the management team.

The new model allows the number of top-level criteria to be expanded or contracted as necessary, the key is however to force a decision from the participants of the process in terms of a proportional value (i.e. 1 – 20). For example the issue of pre-existing plant was of no value in the original project and has therefore been allotted 1 mark in the top-level criteria structure. Whereas the entrepreneurial ability of the management team was considered of great value and has therefore been allotted 20 marks in the top-level criteria.
There are two basic strategies for assigning the top-level criteria values (Longford 2000), these are:

1. Group negotiation – where a team assigned to the project debate the issues and negotiate the level of importance (value) that the particular criteria should be awarded.
2. Pairing off – where the structure of criteria is determined by pairing off the "most important" and "least important" until no further criteria remain.

Either strategy is acceptable but should be chosen in relation to the project dynamic (i.e. the culture of the company, its decision making procedures and the people involved). The pairing off strategy was adopted for this work.

By forcing a decision, the new model demands the ranking of each of the criteria (there is no option to adopt a neutral or equal status to the criteria as there was in the original model). The user is as such required to think about key attributes more closely than they would typically do in a normal situation.

The table below provides a modified SWOT analysis of the pairing off of the top-level criteria.

<table>
<thead>
<tr>
<th>Pairing Number</th>
<th>Most Important Criteria (of pair)</th>
<th>Least Important Criteria (of pair)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entrepreneurial Ability of the Management Team</td>
<td>Presence of Pre-existing Plant</td>
</tr>
<tr>
<td></td>
<td>Lewis (1999) states that the description and title of the entrepreneur is over used and has thus become debased. He maintains that the breed of person to drive a new project through should in fact be labeled &quot;searchers&quot;. These are the individuals that seek consistently opportunity and then link technical expertise to first class business</td>
<td>The weightings for the new site selection model were developed for the original Styles project that was specifically for greenfield development (i.e. new site in a new location). Typically existing sites designed for RPD companies do not become available unless a company goes into receivership or is offered for sale. These types of project require different weightings but it is not unreasonable to</td>
</tr>
</tbody>
</table>

139
processes. If the entrepreneurial ability (capacity to "search") of the management team is weak then the whole opportunity is potentially at risk because the company will not be able act in a decisive and rapid manner necessary to take advantage of any situation.

The entrepreneurial ability of the management team is the most important criteria of any site selection project because there is no opportunity without the entrepreneur(s). This criteria has therefore been allocated 20 in the criteria listing to reflect the overall importance of people issues along with recognising a hierarchical structure in this section.

<table>
<thead>
<tr>
<th>2</th>
<th>Quality of Local Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>The local indigenous management team will be drawn from the region and will from the line management of the new site. This team is essential to any new site development project because future operational efficiency will be dependent on this teams performance. They must therefore be capable of the task or the commercial viability of the opportunity will be lost.</td>
<td>Supply Base</td>
</tr>
<tr>
<td>Quality of the local management team is the next most important issue after the entrepreneurial ability of the management team and has therefore been allocated 19 in the criteria listing in recognition of the hierarchical nature of people issues.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Availability and Quality of Workforce</th>
</tr>
</thead>
<tbody>
<tr>
<td>The availability and quality of the local workforce is of the prime importance in any site selection decision-making process (Anon [r] 1987, Spaeth 1988 and Culem 1988, Anon [v] 2000). In consideration to the RPD sector, the workforce must be capable of the task (sufficiency trained and experienced) and be in ready supply. There is no opportunity without the workforce, but this must be taken into context with both the entrepreneurial ability of the management team and the quality of the local management. This issue has therefore been allocated 18 in the criteria listing.</td>
<td></td>
</tr>
<tr>
<td>Distribution Base</td>
<td></td>
</tr>
<tr>
<td>In common with the supply base, distribution of the end product from a RPD manufacturing site is typically in low-volume, by a carrier/courier service provider. Unless there is a special relationship to a single client company (i.e. automotive manufacturer) proximity to clients for distribution purposes is not a high priority (Kuzin 2000).</td>
<td></td>
</tr>
<tr>
<td>Distribution base has therefore been allocated 3 in the criteria listing to reflect its overall low-level importance.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is essential that the management team of the mother company is able to communicate complex themes and abstract ideas to the indigenous management and workforce in the chosen region. If there is a language barrier then it will have to be overcome. Overcoming the language barrier will suggest that the model could be modified for this type of situation.</td>
<td></td>
</tr>
</tbody>
</table>

In the context of this work, the presence of a pre-existing plant has therefore been allocated 1 in the criteria listing because there was no requirement for an existing plant within the original brief.

Most regional rules on incentives state that the business plan must stand up on its own merits, the incentives are there to cause (incentivise) the prospective company to locate to the region and not elsewhere.
add time, cost and risk to any new project.

Language can represent a major challenge to the project and has therefore been allocated 17 in the criteria listing lower only to the "people issues".

Hoch (1982) states that incentives are always overplayed and do not necessarily lead to successful project outcomes in the long-term. In reference to the RPD sector for example the workforce is more important than incentives as indeed are issues concerning competitors. Incentives have therefore been allocated 4 in the criteria listing to reflect their importance compared to both the distribution base and competitor issues.

<table>
<thead>
<tr>
<th>5</th>
<th>Technological Status</th>
<th>Competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies in the RPD sector use high-technology leading-edge equipment. Any company operating in this sector must be able to access technology and technological support. For example whereas incentives may not be an imperative to the overall success of the project, access to ISDN lines are because the majority of client data is supplied by the client base to RPD service suppliers electronically. The technological status of a region has therefore been allocated 16 in the criteria listing thus reflecting its level of importance directly behind the people and language issues and in front of embedded technological skills.</td>
<td>The EU RPD sector is expanding rapidly and clustering of companies should not in principle cause serious problems to the viability of the new site. For example there were eight companies operating in close proximity in the UK Midlands during the period of study. There may however be an issue if over concentration of companies could restrict possible recruitment or cause a wage-war. Competitor issues are considered to be of more importance than incentives, because they could have an affect on the success of the plan. They were not however considered having as much as an impact on successful completion as for example speed of commissioning of the site or indeed the overall technological status of the region. Competitor issues have therefore been allocated 5 in the criteria listing.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6</th>
<th>Embedded Technological Skills</th>
<th>Speed of Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The RPD sector employs a high number of specialist technical professionals. The blend and range of necessary skills cannot be learned overnight. Although this criterion may be considered similar to technological status of the prospective region, the technological status of the region must be considered first then followed by the embedded technological skills. The embedded technological skills have therefore been allocated 15 in the criteria listing to reflect the importance and sequencing of this particular aspect of the project.</td>
<td>Compared to larger organisations, SMEs will typically have a tighter time scale to begin to return revenue from the development project. This is especially true if third party financing is involved. Speed of commissioning must be considered of more importance than competitor issues because rapid site development will deliver revenue directly to the company. However, it may be possible to develop a site quickly but the region may not be able to support the site technically or with the correct blend of skilled people. Speed of commissioning of the site has therefore been allocated 6 in the criteria listing because the sequence of the whole project and the people and technical capabilities of the region influence it.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7</th>
<th>Economic Factors</th>
<th>Quality of Life Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most companies are typically driven to replicate</td>
<td>The global RPD workforce is inherently mobile</td>
<td></td>
</tr>
</tbody>
</table>
indigenous commercial success abroad, hence the process of inward investment and new site selection. The local market place will have a direct influence on the new site location for most companies regardless of sector. However, the RPD sector includes certain service industries such as toolmaking that are in such short supply globally that the customer base is willing to travel extensively to source the product. Because of its high-level of skills. EU laws allow citizens to move and work in any state with equal ease. Good quality of life factors for the workforce are a “people issue” and are as such reasonably important because cost will be incurred if the company has to keep employing new people to replace migrant employees.

The RPD sector has dual influencing factors (people and technical issues). However economic factors will then follow quickly because whereas a strong local economy is desirable for site selection and development projects, the sector does benefit from being able to export product almost as easily as it can deliver to a local market place.

The sequencing of economic factors after the people and technical issues is reflected in the allocation of 14 in the criteria listing and the fact that general economic factors should be focused upon in the preliminary investigation activities of the project.

The overall fiscal policy of the region must be considered. For example what is the economic policy of the region (not to be confused with general economic factors)? Is the region targeted on agriculture or call centres in favor of manufacturing that represents the client base of the RPD sector? Also does the tax policy or the exchange rates of a region make the project non-competitive.

The fiscal policy of a region is aligned with but follows in importance from general economic factors and has therefore been allocated 13 in the criteria listing because it can have a dramatic affect on the project if the company gets the analysis wrong.

Experience suggests that because RPD companies are “job focused” they benefit from good industrial relations. RPD companies typically work to the same high standards regardless of geographical location. This is typically because of the utilisation of leading edge technology and cultural similarity of the practicing engineers and support staff (this scenario may not be the same in general manufacturing sectors).

Industrial relations and labour laws are another important people issues that has more importance to the company than quality of life factors but are less risky than fiscal issues. It has therefore been allocated 8 in the criteria.

This EU RPD sector is focused on fast time-to-market, as such it is reasonable to assume that good market access is essential in securing business. However, since the companies concerned in the sector are typically involved in producing batches of one product for many different clients, proximity to a courier service would be more essential than proximity to any single client.

It is likely that most SMEs in the RPD sector will need to secure external financial support to expand into a new location. The finance will typically be sourced from venture capital, private and/or bank funds. The availability of external funding will depend on the region, for example comparatively easy in Germany or hard in the UK.

Financing is typically an economics issue and should have been investigated at the preliminary
Overall physical infrastructure becomes a reasonably important logistical consideration albeit in a different manner to more traditional high-volume service providers.

Physical infrastructure has less importance than fiscal issues during the startup phase of the project and has therefore been allocated 12 in the criteria listing. However, all appropriate communications tools must be embedded into the prospective site to enable the company to perform its core services.

Financing has a higher initial importance to the company project than industrial relations and labour laws and has therefore been allocated 9 in the criteria listing because it could have a short-term affect on the project.

<table>
<thead>
<tr>
<th>10</th>
<th>Support Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The support group should provide the &quot;lubrication&quot; that enables the overall project to run smoothly. The function of the support group includes assistance in finding the site, providing data on employment and commercial law and cultural expectations of the region. The support group has less overall importance to the project than physical infrastructure because it has a limited &quot;shelf life&quot;. It does however have more importance than the political nature of the region because of the ability of a good support group to influence the political policy of a region if a good project exists. Support group and has therefore been allocated 11 in the criteria listing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th>Political Stability and Country Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Officials within the proposed target region must want to attract the project to their area. A poorly received project may face all manner of obstacles such as delays in permits and licenses and/or restriction in trade. This may raise the overall risk of the project and/or the risk of the country. Also the country or region may be politically unstable, for example, a new political party just elected may change the strategy of inward investment within the region. Good local economies will typically have stable governments that will want to attract RPD type projects. Changes in the political environment may affect the short/medium-term viability of the project but not necessarily the delivery. In relation to the start-up phase of the project, political stability and country risk ranks behind the support group issues but in front of financing and has therefore been allocated 10 in the criteria listing.</td>
</tr>
</tbody>
</table>

### 9.2.1.2 Rule Book – Stage Two: Setting Sub-level Criteria

Most top-level criteria will typically be accompanied by a series of sub-level criteria. A single top-level criteria and associated sub-level criteria make up a decision cell.

The collective sub-level criteria of a decision cell are allotted a total of 25 marks. The marks are apportioned to each sub-level criterion that best reflects the level of importance of the sub-level criterion in relation to the
others in the decision cell. In practice, it does not matter what the total allotted marks for the sub-level criteria are. However, 25 marks is a reasonable number that can be distributed to the sub-level criteria in order to establish the given importance of each of the sub-level criteria in relation to its fellows. This process is the method of showing the total value of the each sub-level criteria (i.e. importance \[a/25\] x value \[b/5\]). The table below provides an example of the allocation of the sub-level criteria marks.

<table>
<thead>
<tr>
<th>Number</th>
<th>Criterion</th>
<th>Weighting</th>
<th>Sub-level criteria</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic factors</td>
<td>14</td>
<td>1. market</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. existing customer base</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. size of market</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. accessibility to other markets</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. potential growth</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: the full listing of all top-level and sub-level criteria is provided in Table 9.5 – Table of Weighting and Ranking for the Standard Criteria for Site Selection Model.

In common with the top-level criteria, the management team may set the values of the sub-level criteria by a process of group negotiation or trading off. There is a provision to allow the sub-level criteria to share a common mark, because in certain cases the sub-level issues may share a common level of importance (as in the case of quality of local management where an equally balanced team is essential).

By limiting the sub-level values to 25 marks per-decision cell, the new model reduces the overall risk of the final “numbers” influencing unduly the overall outcome. In the case of a decision cell only having one sub-level criterion, it was considered that the best rule for this model was to apportion all of the cell
mark to a single issue if there were no sub-level criteria. By following this rule, the profile (see section 9.4) will not show any unusual variations that could lead the user to be influenced adversely.

The overall ranking procedure forces an early set of decisions to be made whilst providing transparence and audit capability within the model.

The table below provides the rationale for the marks apportioned to the sub-level criteria of the economic factors decision cell.
Table 9.4 - The Rationale for the Marks Apportioned to the Sub-level Criteria of the Economic Factors

<table>
<thead>
<tr>
<th>Sub-level Criteria Number</th>
<th>Sub-level Criteria</th>
<th>Rationale</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Market (trends)</td>
<td>Whereas a certain amount of work will be expected initially from the mother site, it is important to consider that the new site will need to generate its own business eventually, therefore factors such as the actual current size and possible market expansion should be considered. In this case the sub-level criteria was apportioned five marks to reflect its greater importance over existing customer base and size of market but it was not considered to be as important as the other sub-level criteria.</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Existing customer base</td>
<td>Inward investment is focused on new market development and/or the migration of the production unit to satisfy the requirements of a specific client (i.e. tier one supplier to and automotive manufacturer). The RPD sector is not generally as customer specific as some of the volume manufacturers. It is possible to assume that the company will attract a client base if the market place is existent. In the case of this study, existing client base was considered of least importance.</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Size of market</td>
<td>This is linked to market trends insofar as a region must be able to generate enough local business to support the new site. However ease of accessibility to the market (i.e. how much percentage of the available market can the company take) is more critical than the actual size of the overall market opportunity.</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Accessibility to other markets</td>
<td>RPD work is typically generated from a large catchment area, it may therefore be advantageous to consider a &quot;central&quot; area if possible in order to optimise the potential business opportunity. From a start-up point of view, a central location should enable the company to spread the risk of new business acquisition by capturing some of the local and outlining business from the same location. This issue was considered to be the highest importance in this decision cell.</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Potential growth (&quot;of local market&quot;)</td>
<td>New site development is concerned with growth opportunities. It is doubtful that a project will be viable if there is no opportunity to grow within the chosen region. Local market growth must therefore be considered carefully. This was considered to be of second highest importance after accessibility to other markets.</td>
<td>6</td>
</tr>
</tbody>
</table>

9.2.1.3 Rule Book — Stage Three: Marking the Site

A combination of fieldwork and due diligence analysis enables the user to rank each of the sub-level criteria and thus mark the prospective site. The
ranking is conducted on a value of 1–5 (1 represents the area of low-performance and 5 represents the area of high-performance). The user will employ the existing home site of the company as the benchmark for assessing the performance and value of the site under investigation.

The new model generates a value for the optimum desired outcome (i.e. the maximum possible rating of performance and that used to measure the performance of prospective sites against). The optimum desired outcome is established by awarding 5 marks (i.e. maximum permissible marks) to each of the sub-level criteria.

Figure 9.1 provides the marking of the overall decision cell for economic factors.

<table>
<thead>
<tr>
<th>Figure 9.1 – Illustration of the Maximum Marking (Optimum Desired Outcome) of the Overall Decision Cell for Economic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>Weighting</td>
</tr>
<tr>
<td>Total Score</td>
</tr>
<tr>
<td>Total sub-level score</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-level criteria</th>
<th>Sub-level ranking</th>
<th>Sub-level scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>market</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>existing customer base</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>size of market</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>accessibility to other markets</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>potential growth</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: The sub-level scoring is based on the maximum allowable mark the will vary on actual fieldwork. A description of the mechanism of the decision cell is provided in section 9.3.2. The "total score" of 1750 is a value used to provide a point along a profile curve in order to assess the performance of other prospective sites.
Once a site has been ranked, its marks must remain unaltered, unless a full assessment is undertaken again. However, top and sub-level criteria ranking may be changed over the duration of the project. The new model will automatically modify the profile curves of the sites in accordance with the new rankings and in relation to each other (see section 9.3). The new model allows for the reassigning of values because the research findings from this work indicate that improved information will typically come to light during the project that will have an impact on the decision (i.e. quality of workforce).

9.2.2 Description of the Actual Values Used

Descriptions of the actual values used in assessing the performance of the new model are discussed below in the order presented in table 9.1 – Standard Criteria for Site Selection. In this case, the author acted as the “management team” and set the values based in part on the original Styles project and requirements. The Styles requirements were used in order to provide a datum for comparative analysis of the old and new models.

It is reasonable to suggest that any management team would assign different values based on their own requirements and experiences. The new site selection model is however flexible enough to allow the weighting and ranking values to be modified for any given scenario.

Table 9.5 provides a list of the main criteria and allocated values.
<table>
<thead>
<tr>
<th>Number</th>
<th>Criteria</th>
<th>Weighting</th>
<th>Sub-level criteria</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic factors</td>
<td>14</td>
<td>6. market</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7. existing customer base</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8. size of market</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9. accessibility to other markets</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10. potential growth</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Political stability &amp; country risk (reception to the project)</td>
<td>10</td>
<td>N/A</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Financing</td>
<td>9</td>
<td>1. sources</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. cost</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. types of finance</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. availability of equity</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. availability of capital funds</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Incentives</td>
<td>4</td>
<td>1. national</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. regional</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. training</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. land</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. capital grants</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6. low/free interest loans</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Physical Infrastructure</td>
<td>12</td>
<td>1. roads</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. rail</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. airports</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. seaports</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. telecommunications</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6. site availability</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Language</td>
<td>17</td>
<td>N/A</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Availability and quality of workforce</td>
<td>18</td>
<td>1. skills</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. availability</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. cost</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. flexibility</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. culture</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Industrial relations/labour laws</td>
<td>8</td>
<td>N/A</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Category</td>
<td>Score</td>
<td>Items</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------</td>
<td>-------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| 9 | Supply base                       | 2     | 1. quality  
2. cost  
3. number |
| 10| Distribution base                 | 3     | 1. quality  
2. cost  
3. number |
| 11| Competitors                       | 5     | 1. quality  
2. cost  
3. number |
| 12| Technological status              | 16    | 1. information technology status  
2. logistics  
3. production developments  
4. research capability |
| 13| Embedded technological skills     | 15    | 1. history of the sector within the region  
2. local sector know-how |
| 14| Quality of life factors           | 7     | 1. education  
2. cultural  
3. leisure  
4. cost of living  
5. any previous connection with the area |
| 15| Presence of pre-existing plant    | 1     | N/A |
| 16| Speed of commissioning            | 6     | 1. time taken to set up a greenfield plant  
2. time taken to construct a building  
3. time taken to recruit workforce  
4. time taken to establish sales line  
5. time taken to set up a legal company (i.e. limited company) |
| 17| Fiscal                            | 13    | 1. economic policy  
2. exchange rates/single monetary union  
3. import control  
4. taxation |
| 18 | Support group | 11 | 1. national political | 4 |
|    |              |    | 2. regional political  | 3 |
|    |              |    | 3. local political     | 2 |
|    |              |    | 4. national development agency | 4 |
|    |              |    | 5. regional development agency | 3 |
|    |              |    | 6. local development agency | 2 |
|    |              |    | 7. commitment to project | 7 |
| 19 | Entrepreneurial ability of management team | 20 | 1. "Searcher" potential | 8 |
|    |              |    | 2. Resources access capability | 6 |
|    |              |    | 3. Ability to promote venture | 6 |
|    |              |    | 4. Ability to organise venture (top level) | 5 |
| 20 | Quality of local management | 19 | 1. Organisational ability | 6 |
|    |              |    | 2. Financial ability   | 4 |
|    |              |    | 3. Technical ability   | 4 |
|    |              |    | 4. Operational ability | 4 |
|    |              |    | 5. Sales & marketing ability | 4 |
|    |              |    | 6. Strategic & tactical ability | 4 |

9.3 A Description of the Structure and Mechanism of the New Site Selection Model

It is important to consider the principle of standard decision-making models if a full understanding of the structure and mechanism of the new selection model is to be gained.
9.3.1 How Typical Selection Models Work – The Principle of First Past the Post

Beach (1997) provides an equation to describe the process of first past the post decision-making model, this is shown below:

\[ Ye = a + B_1C_1 + B_2C_2 + B_3C_3 + \ldots + B_nC_n \]

Where:
Ye = rating of performance (outcome)
C = coded answer to a question (subliminal)
B = standardised weighting
a = sealing constant (i.e. the person undertaking the ranking or scoring)

This type of equation (and therefore decision-making model) provides a rigid and inflexible outcome. In relation to site selection, the equation treats every possible new site location (target site) in the same manner. The model typically assumes that all data is additive and provides little opportunity to recognise that criteria may be interrelated or mutually dependent. By providing a mechanism that forces a “balancing” or trade off of top and sub-level criteria (issues), the new model recognises the fundamental issue that new site selection specific criteria for local and overall opportunity are interrelated and mutually dependent. Balancing or trade off of top level criteria is incorporated in stage-one of the rulebook. A project record is kept for auditing use.

First past the post decision-making models do not permit a sufficient level of transparency. These types of model also allow subjective and/or subliminal
decision-making to be hidden within the decision matrix. This is because first past the post decision-making models hide much of the actual decision-making process in the blind sub-criteria levels (i.e. availability of roads and rail facilities within infrastructure) that are intrinsic in the decision-making process but not recorded in the model or project records.

9.3.2 A Description of How the New Selection Model Works

A more accurate model may be possible by developing a cellular system of top level criteria that incorporates sub-group (sub-level) criteria into the model in order to account for the two-stage process highlighted in section 9.1.2. The model will also provide the critically important audit trail for decision-making and remove much of the subliminal decision-making process inherent in most site selection models.

The following key points describe the function of each decision cell of the new site selection model:

1. Weighting - The weighting is set at the beginning of the project. The value (X) represents the order of importance given to any of the standard criteria for site selection
2. Outcome (total score) - The outcome is represented as the value given to the group of sub-level criteria (Y) multiplied by the weighting (X)
3. Sub-level criteria value - The total sub-level criteria value (Y) is derived by providing a distributed weighting value (N) for all of the sub-level criteria (a, b, c, d, e...), that is multiplied by a variable ranking (R) derived during the site ranking or scoring process.
A more developed equation to describe the site selection decision-making model is shown below assuming the principle of first past the post when applied to a cell based model:

\[ Y_e = Z_1 (Y_1 (a(NxR), b(NxR), c(NxR), d(NxR), e(NxR)...x X_1) + Z_2 (Y_2 (a(NxR), b(NxR), c(NxR), d(NxR), e(NxR)...x X_2) + .... \]

Where:

\( Y_e \) = rating of performance (outcome)

\( Z_1 \) = Total score for the decision cell

\( X_1 \) = weighting for decision cell (top level criteria)

\( Y_1 \) = total sub-level criteria value for decision cell

\( N \) = distributed weighting value for all of the sub-level criteria

\( R \) = a variable ranking derived during the site ranking or scoring process

\( a, b, c, d, e... \) = sub-level criteria

An example of the function of the new site selection model is shown in figure 9.2 based on two decision cells (top-level criteria) from the original site selection model discussed in section 6.4.

The top-level of the model provides the measure of importance (weighting) given to any criterion. The sub-level provides a measure of performance of the individual site and also provides a benchmark of the performance of one site against another in any given criterion.
Figure 9.2 An Example of the New Site Selection Criteria Model

<table>
<thead>
<tr>
<th>Criteria</th>
<th>INCENTIVES</th>
<th>SUPPORT GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total score</strong>&lt;br&gt;(Sub-level total X weighting)</td>
<td><strong>476</strong></td>
<td><strong>1122</strong></td>
</tr>
<tr>
<td><strong>Sub-level total score</strong></td>
<td>119</td>
<td>102</td>
</tr>
<tr>
<td><strong>Sub-level criteria &amp; sub-level ranking</strong></td>
<td>Total must not go above 25</td>
<td>Score 1-5</td>
</tr>
<tr>
<td>National</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Regional</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Training</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Land</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Capital Grants</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Low/interest free loans</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Commitment to project</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: example score based on two decision cells of site #3 of the original Styles case study but with new weightings and rankings substituted

The final site selection model was developed within Excel™. A printed copy of the full site selection model is provided in Appendix Five.

9.3.3 The Argument for This Selection Model

Most decision-making models do not provide or encourage “real world” decision-making processes or outcomes. For example, Canel and Khumawala (1996) provide a ranking of site selection criteria based on low-cost high-production output. Unfortunately this type of ranking has little
influence on the development of the model for RPD companies where the focus is on high-value-added low-volume production (batches of one).

Every site selection project is different and (even if the company remains the same) the weightings of the criteria can change over time. There is therefore a need to develop a model that lists all of the major criteria but that is flexible enough to allow the weightings to change. This site selection model satisfies these requirements because the weightings (top and sub-level) can be assigned or reassigned at any time depending on new information becoming apparent during the cause of the project (see section 9.2.1 The New Decision Model Rule Book).

9.3.3.1 The Benefit of this Decision-Making Model

There have been many attempts to develop complex computer programmes for decision-making, however, these models are only as good as the data that is programmed into them. Computer models use complex mathematical calculations to deliver an absolute outcome that has little regard to the human or real world aspects necessary to deliver a “usable” solution for the subject or situation (Nahmias 1993, Lewis 1999). Also the recipient of the data (decision outcome) has no insight into the decision process and does not typically understand the outcome. In this situation, the recipient of the decision data does not necessarily buy into the outcome (Willman 2000).

Above all the decision outcome must be compatible with a very simple solution procedure (decision-making process). It is a mistake to overcomplicate any decision-making model (Hodder and Jucker 1985).
The new model is based on tangible choices and trade offs as advocated by Lewis (1999). The objective is to establish a level of control and rules to enable a logical and measured approach to achieving an outcome.

9.4 The Process of Real World Data Analysis – Or Coming to a Decision Outcome

A process of “real world” analysis is required to find the best overall site from the data generated by the selection model (Finch and Luebbe 1995). Longford (2000) states that this is best achieved by analysing the individual values of each decision (cell) and matching the profiles achieved against a benchmark of the optimum desired outcome. For example, there may be several sites that match consistently the profile of the optimum desired outcome sample but their scores are lower than other non-conforming outcomes. In this case, the lower scores should be eliminated from the analysis. Effort and judgment should be targeted at those sites that match closely the overall desired outcome. Any discrepancies should be evaluated and an assessment and decision made on the overall effect that this will or is likely to have on the outcome. This is why there is a need for an audit trail and why first past the post is not the best solution for complex decision-making. This is discussed below in more detail.

9.4.1 Data Curve Analysis

The new site selection model produces a series of cell values that are the outcome of each weighted top-level criteria multiplied by the ranking of the total value of the sub-level criteria that relates to the cell. The values
generated from each of the cells of the site selection model can be used to produce a data curve. It is therefore possible to exploit this feature and undertake an analysis procedure that looks for the best fit of curves based on the optimum desired outcome (theoretical maximum) (Vause 1999, Longford 2000 and Barrans 2000).

For example a curve depicting the optimum desired outcome would have a total value of X. A curve (a) generated from the values derived during the ranking process may have a total value of X-10 but follow a lesser path to the optimum desired outcome. The overall score may be generated by a single higher value (spike) than comparable sites in one of the criteria listings (i.e. infrastructure). A second curve (b) may follow a much closer overall path to the optimum desired outcome and still score an overall value of X-10. At this point the assessor will have to use judgment to determine which of the curves (possible sites) is the best "fit" to the optimum desired outcome. This scenario is shown below schematically in figure 9.3.
Figure 9.3 – Schematic to Illustrate the Need for Real World Judgment in the Analysis of Selection Data

The use of data curve analysis (i.e. the actual outcome data plotted against the optimum desired outcome data) provides a simple (transparent) decision-making process that exploits all of the decision data used to achieve the outcome. All of the decision data can be audited. The ability to audit the data fits well with real world decision-making theory insofar as ambiguous data and complexity are removed from the process.

The new site selection decision-making matrix may be described as the equation is shown below.
Ye = Z₁ (Y₁ (a(NxR), b(NxR), c(NxR), d(NxR), e(NxR)...x X₁) plotted against Z optimum desired outcome

Z₂ (Y₂ (a(NxR), b(NxR), c(NxR), d(NxR), e(NxR)...x X₂) plotted against Z optimum desired outcome......

Where:
Ye = rating of performance (outcome)
Z = Optimum desired outcome from the decision cell
Z₁ = Total score for the decision cell
X₁ = weighting for decision cell (top level criteria)
Y₁ = total sub-level criteria value for decision cell
N = distributed weighting value for all of the sub-level criteria
R = a variable ranking derived during the site ranking or scoring process
a, b, c, d, e... = sub-level criteria
CHAPTER TEN - A FUNCTIONAL TRIAL OF THE NEW SITE SELECTION CRITERIA MODEL
10.0 Introduction

This work has been undertaken to research and determine a robust site selection model for small to medium sized enterprises based in the European Rapid Product Development sector. As such a functional trial of the new site selection model must be conducted to test the validity of the model.

This chapter provides:

1. The theoretical best profile of the optimum desired outcome for SME’s based in the European RPD sector
2. A selected series of trials and analysis of original case study sites
3. A series of new sites for trial and analysis
4. A comparison of the two best profiles plotted against the optimum desired outcome

10.1 The Model Profile of the Optimum Desired Outcome for SME’s Based in the European Rapid Product Development Sector

The new site selection model was developed as a programme in Microsoft Excel™. Automatic calculation routines were included within each decision cell in order to simplify the operation of the model. The design of the site selection model followed the structure and mechanism described in section 9.3. The values were attributed to the top-level weightings and sub-level rankings as discussed in section 9.2. Full scores of five marks per sub-level
ranking were then awarded to each issue in order to determine the theoretical maximum or optimum desired outcome of each decision cell.

An example of the optimum desired outcome ranking of two decision cells of the new decision model is illustrated in figure 10.0.

<table>
<thead>
<tr>
<th>Figure 10.0 An Example of the Optimum Desired Outcome Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>Weighting</td>
</tr>
<tr>
<td>Total score (Sub-level total X weighting)</td>
</tr>
<tr>
<td>Sub-level total score</td>
</tr>
<tr>
<td>Sub-level criteria &amp; sub-level ranking</td>
</tr>
<tr>
<td>Total must not go above 25</td>
</tr>
<tr>
<td>National</td>
</tr>
<tr>
<td>Regional</td>
</tr>
<tr>
<td>Training</td>
</tr>
<tr>
<td>Land</td>
</tr>
<tr>
<td>Capital Grants</td>
</tr>
<tr>
<td>Low/interest free loans</td>
</tr>
<tr>
<td>Commitment to project</td>
</tr>
</tbody>
</table>

Note: example score based on two decision cells of the new decision model. The full ranking for the whole model is illustrated in table 9.2.

The optimum desired outcome (decision profile), delivered by the new site selection model, for SME’s based in the European Rapid Product Development sector is illustrated in figure 10.1.
Figure 10.1 – Profile of the Optimum Desired Outcome for SME's Based in the European Rapid Product Development Sector

Note: This profile represents the maximum score possible for all decision cells, it is used as the benchmark for all of the results generated by the case studies. The values (1–20) shown in the X axis correspond to the top level criteria are illustrated in table 9.2 and in the decision model in Appendix Five (see also section 9.1).

10.2 A Selected Series of Trials and Analysis of Original Case Study Sites

For experimental purposes the only the sites selected for trial and analysis were those that scored greater than seventy (70) marks in the original site selection model (i.e. those sites that should have followed more closely the profile of the original optimum desired outcome).
10.2.1 Analysis of Site #8 Within the bounds of the New Site Selection Model

Figure 10.2 illustrates the profile of site #8 (the winner) of the original site selection case study plotted against the profile of the optimum desired outcome.

![Figure 10.2 – Profile of Site #8 Plotted Against the Profile of the Optimum Desired Outcome](image)

At first sight, it would appear that the profile of site #8 follows a reasonably close path to that of the optimum desired outcome. Issues 1 – 3 (Economic, Political stability & country risk and Financing) show a modest deviation. On closer examination of the sub-level criteria of the decision model we find that the deviations are geographical considerations that would not really change much between any site in the same local. Issue 4 (Incentives) matches the...
optimum desired outcome. Whereas there is a slight deviation with issue 5 (Physical infrastructure).

Attention is drawn to issue 6 (Language). There is clearly a major deviation from the optimum desired outcome, compared to the other points on the profile. It should be noted that the “Language” decision cell has no sub-level multiplier. As such, the ranking is based on the single question “is the local usage level of the native language of the company looking to open an new site high”? For site #8, the level of language of the company was low, indeed the original project records indicate that the region was slow to embrace English as a second language. This fact may have been critical in the original selection but may have been overlooked because it was hidden in the original site selection model.

The model also highlights some deviation in issue 7 (Availability of workforce). This is a critical consideration in the Rapid Product Development sector. Investigation of the model indicated that the deviation is due to three of the sub-level issues (cost, flexibility and culture) only achieving 60% of the possible sub-level marks. Further due diligence would therefore appear to be advisable to ascertain the true impact of this on the overall project.

The other criteria are typically a close match to the optimum desired outcome. There is a slightly larger deviation in issues 19 (Entrepreneurial ability of the management team) and issue 20 (Quality of the local management team). Investigation of the model indicates that the site actually maintained a level of between 80% and 100% in the sub-level criteria of issue 19 and was in fact quite high. The model further shows that the local management team was weak in the sales and marketing and strategic areas. The model would have thus provided an early warning of weakness. It may be argued that the early
warning provided by the model could have offered an opportunity to address the issue before it became a serious barrier to the successful completion of the project.

10.2.2 Analysis of Site #4 Within the bounds of the New Site Selection Model

Figure 10.3 illustrates the profile of site #4 of the original site selection case study plotted against the profile of the optimum desired outcome.

Figure 10.3 – Profile of Site #4 Plotted Against the Profile of the Optimum Desired Outcome

The profile of site #4 would appear at first sight to follow a reasonably close path to that of the optimum desired outcome. There is typically a large
deviation in issues 6 (Language) and 7 (Availability of workforce). Also issue 18 (Support group) is apparently lower than desirable.

10.2.2.1 An Overall Comparison of Site #4 and Site #8 Plotted Against the Optimum Desired Outcome

The benefit of the new model becomes manifest when a comparison is made between the optimum desired outcome, site #4 and site #8. It is noted instantly that site #4 does not achieve a higher profile than site #8 in any of the criteria. It should therefore be possible to eliminate site #4 rapidly from consideration because the profile of site #8 is equal or better in each of the major criteria (i.e. there is no possibility of encountering the scenario discussed in section 9.4.1).

Figure 10.4 illustrates the profile of site #4 of the original site selection case study plotted against the profile of the optimum desired outcome and site #8.
10.2.3 Analysis of Sites #5, #6, #7 and #9 Within the bounds of the New Site Selection Model

Similar profiles and analysis can be made of site numbers 5, 6, 7 and 9 when plotted against the profile of the optimum desired outcome. The profiles of each of the sites are shown in figures 10.5, 10.6, 10.7 and 10.8 respectively.
Figure 10.5 - Profile of Site #5 Plotted Against the Profile of the Optimum Desired Outcome

Figure 10.6 - Profile of Site #6 Plotted Against the Profile of the Optimum Desired Outcome
Figure 10.7 - Profile of Site #7 Plotted Against the Profile of the Optimum

Desired Outcome

Figure 10.8 - Profile of Site #9 Plotted Against the Profile of the Optimum

Desired Outcome
Site #7 out-performed site #6 in original site selection model. This was due to the site achieving higher marks in the general impression (feel good) and location criteria. However, when the sites are analysed in more detail within the new model it becomes clear that there is little to differentiate either site. The new model has provided more clarity than was possible with the original model.

It is interesting to note that site #8 achieved a higher score than site #9 in original model, but both of the sites were in the same local. There is no indication (apart from the criteria score) relating to possible reason for this outcome within the original model. Figure 10.9 provides a comparison of the profiles of site #8 and #9 plotted against the profile of the optimum desired outcome.
The profiles of the two sites indicate that they are both matched except for issue 13 (Embedded Technological Skills) where there is a deviation. Analysis of the sub-level criteria indicate that site #8 achieved 100% for both sub-level issues whereas site #9 only achieved 80% by comparison. The reason for the difference may be attributed to the facts that site #8 had several robust product development companies within the local. The history and know-how was considered to be greater than that of site #9 that only had modest representation of the sector within the region.

The profile of the two sites also indicates a modest deviation in issue 16 (Speed of commissioning). Analysis of the sub-level criteria indicates that the two sites were in fact matched in all aspects except for the time to construct
the building. Site #8 achieved an 80% rating against 60% for site #9. This was due to the local authorities being positive and providing written assurances that there would be no issues or objections relating to planning permission.

Time to construct the building could lead to lower return on investment over a fixed period and cause potential financial difficulty. The new model has thus provided clarity to focus in on an area where a risk assessment may be made and an informed decision concluded.

**10.2.4 Analysis of Site #12 Within the bounds of the New Site Selection Model**

Most of the higher-ranking sites from the case study were located in Germany. Site #12 was the only non-German (UK) location and the only target within outside of Germany to achieve a score higher than seventy marks in the original case study. Figure 10.10 shows the profile of site #12 plotted against the optimum desired outcome.
Site #12 provides a significantly different profile to the other case studies and is worthy of closer analysis.

There appears to be a significant deviation in issue 1 (Economic). This is in line with the state of the UK market during the time of study. The profile shows that the site achieved a match with the optimum desired outcome in issue 2 (Political stability and country risk). There is modest deviation for issues 3, 4 and 5 (Financing, Incentives and Physical infrastructure). The site matches issue 6 (language) as expected. There is a major difference between the optimum desired outcome and issue 7 (Availability of workforce). This was a key issue behind the motivation for the original project. Issues 8 – 16 either match or deviate in a modest manner from the optimum desired
outcome. There are however larger deviations in issues 17 (Fiscal) and 18 (Support group). Issues 19 (Entrepreneurial ability of the management team) and 20 (Quality of local management) are the same as the other locations.

10.2.4.1 Comparison of Site #8 and Site #12 Plotted Against the Optimum Desired Outcome

It is logical to expect similar types of outcomes from similar sites in the same country, however, a more valid test must be a comparison of site #8 and site #12 plotted against the optimum desired outcome. Figure 10.11 illustrates the profile of site #8 and site #12 plotted against the optimum desired outcome.

Figure 10.11 – Profile of Site #8 and Site #12 Plotted Against the Optimum Desired Outcome
The comparison provided by the profiles of the two sites (#8 and #12) plotted against optimum desired outcome indicate that the sites did not share common attributes but rather differed in their overall performance in many of the key criteria. It is reasonable to suggest that if the basic scoring derived from the original site election project was conducted in a different manner then site #12 could have scored higher and been chosen over site #8 even though its profile does not resemble that of the optimum desired outcome. The lack of conformance may not have been realised by the project team due to the lack of transparency in the original decision-making process.

10.2.5 Overall Analysis of the Original Site Selection Process When Transposed into the New Site Selection Model

The new model indicates that site #8 followed a closer path than any of the other target sites from the original project and as such remains the overall “winner”. However, the new model has contributed to the overall knowledge of the process because more transparency is included into the decision-making process and the strengths and weaknesses of the site are more easily understood. As such the model allows the user to make real world judgment on the site and map it against other sites to determine if there is a logical trade off of attributes or if there is a major area of omission that could kill the project. This may be exemplified by the comparison of site #8 and site #12.
10.3 A Series of New Sites for Trial and Analysis

The new model has been used in the selection process for a new series of sites. For the purposed of this work the sites have been numbered consecutively (25 – 29) from the original target locations.

All of the new target sites were located in different European countries and as would be expected, have profiles that differ in many respects. Figure 10.12 illustrates the profiles of sites #25, #26, #27, #28 and #29 plotted against the optimum desired outcome.

Note: The project funding for the new projects came from guaranteed private sources therefore gained maximum score in this series of case studies.
By adopting the analysis techniques advocated by Vause (1999), Longford (2000) and Barrans (2000) it is possible to eliminate rapidly all of the target locations that do not match closely that of the optimum desired outcome. Therefore, sites #25, #26, #28 and #29 were eliminated from the search. The profiles of each of the sites are shown in figures 10.13, 10.14, 10.15 and 10.16 respectively.

**Figure 10.13 – Profile of Site #25 Plotted Against the Optimum Desired Outcome**

![Graph showing profile of Site #25 plotted against optimum desired outcome.](image-url)
Figure 10.14 – Profile of Site #26 Plotted Against the Optimum Desired Outcome

Figure 10.15 – Profile of Site #28 Plotted Against the Optimum Desired Outcome
10.3.1 Analysis of Site #27 Within the Bounds of the New Site Selection Model

Site #27 had the closest profile match to the optimum desired outcome and was chosen as the best possible location for this particular project. Figure 10.17 illustrates the profile of site #27 plotted against the optimum desired outcome.
There appears to be close match between the profile of site #27 and the optimum desired outcome. Many of the key criteria have achieved a perfect match and others are close. There are potentially five areas that show some deviation and are worthy of closer analysis.

There is a deviation occurring in issue 2 (Political stability and country risk). Site #27 achieved a level of 80% and is therefore reasonably high. The reason for loosing some of the marks was because the region had gone through some change in recent times and was not viewed as stable as for example West Germany. There is also a deviation in issue 6 (Language). The site once again achieved 80% because English was not the first language of the region. However project records indicated that the
investigator did not encounter any one who could not speak English. The profile also shows a modest deviation in issue 12 (Quality of life factors). The sub-level criteria rankings indicated that this was due to there being no previous connection with the region. It was therefore considered of minor importance to the successful conclusion of the project. Issue 19 (Entrepreneurial ability of the management team) showed some deviation, however this was the same for all of the sites in this study and was therefore considered to be of little concern especially since the criteria achieved 80% or above in each sub-level. The final issue 20 (Quality of local management) achieved 100% in three of the sub-level criteria (organisational, financial and technical ability) and 80% in the remaining sub-level criteria (operational, sales & marketing and strategic & tactical ability). These rankings were considered to be high and the project low-risk in the management criteria.

The new model provided a clear indication of the performance of site #27 against that of the optimum desired outcome.

10.4 A Comparison of the Two Best Profiles Plotted Against the Optimum Desired Outcome

Although not possible in the actual timing and sequential nature of the two live projects, the overall "winners" from each project make an interesting case study when compared together. Figure 10.18 illustrates the profiles of site #8 and site #27 plotted against the optimum desired outcome.
Sites #8 and #27 showed the closest matches within their own projects, however, the model illustrates clearly that site #27 follows a closer path to the optimum desired outcome than site #8. The most notable variances between the target sites occur in issues 1 (Economic), 3 (Financing), 6 (Language and Quality of local management team). The new model allows the user to match the profiles of the sub-level criteria if necessary. Figure 10.19 illustrates this facility for the issues 1, 3, 6 and 20 for sites #8 and #27 plotted against the optimum desired outcome.
Figure 10.19 illustrates how the decision model is able to reproduce comparative decision profiles from the sub-level criteria. This facility is particularly useful because it enables a clear and issue specific audit trail if required. The new decision model therefore allows the data to be investigated fully at the point of top-level deviation from the optimum desired outcome.

There is a temptation to incorporate a sub-routine into the decision model that will enable calculations to be conducted in order to deliver a statistical value based on, for example, standard deviation methodologies (Montgomery and Runger 1999). A mathematically derived outcome will deliver an "absolute value". Typically most decision models rely on an absolute value to provide the optimum desired outcome that may in certain cases be manifest as the
highest score or "first past the post". When used by an inexperienced operator, this type of model can deliver the wrong outcome that has little or no transparency. The user is however typically inclined to take the outcome on face value without performing any true analysis on the subject and/or necessarily understanding the mechanism and dynamics of the problem (Leonard and Straus 1998, Vause 1999, Longford 2000 and Barrans 2000). The new model therefore excludes statistical calculations to ensure that a more rigorous analysis of the data is conducted and a more informed and transparent outcome concluded.
CHAPTER ELEVEN – CONCLUSIONS
11.0 Introduction

This work has been undertaken to research and determine a robust site selection model for small to medium sized enterprises based in the European Rapid Product Development sector. The contribution of this work to “the body of knowledge” has been to introduce a new, flexible and transparent decision-making model that can be used to profile the prospective target sites and understand which target is the best overall match to that of the pre-set optimum desired outcome. In so doing, this work has brought together decision-making theory, the process of inward investment, the needs and dynamics of the European Rapid Product Development sector and provides a solution that satisfies the unique challenges of the problem.

To-date, most site selection models have been too rigid and have not provided a link to current “real world” decision-making processes and outcomes. Also most of the decision-making models have tended to be developed for service and logistics based operations. Less research has been undertaken into developing models specifically for Rapid Product Development operations where the dynamics of the business place different requirements on the model compared to other sectors of commerce.

As such the research was successful and delivered a positive result against the original specification.

This chapter provides the conclusions that:

1. Site selection is best undertaken with a multi-level decision-making model that reflects the complex nature of the problem
2. Site selection is not an exact science but rather a complex process that is affected by many conflicting factors.

3. Site selection is a physical and tangible problem that requires real world analysis to determine a robust outcome.

4. Decision priorities (criteria) will change over time, a robust decision model must as such be sufficiently flexible to accommodate this requirement.

5. Styles chose the right site at the time but did not fully understand the selection process of the controlling factors involved in the project.

11.1 A Multi-level Decision-making Model

Site selection is best undertaken with a multi-level decision-making model that reflects the complex nature of the problem. All contributors to the site selection criteria provide a top-level criteria list that includes sub-level criteria. However, little consideration is given to the sub-level criteria even though this is where the actual decision process takes place. By providing a descending value for each of the top-level criteria and a limited total value for each of the sub-level criteria it is possible to force a decision instead of allowing an ambiguous and subliminal decision processes.

11.2 The Principle of Decision-making Under Uncertainty

Site selection is not an exact science but rather a complex process that is affected by many conflicting factors. As such the principle of decision-making under uncertainty (such as site selection) should in fact be considered as decision-making within tolerance. The level of data (in terms of detail and quality) sets the tolerance band. The decision-making model captures the data and allows a transparent audit of the data.
11.3 Real World Analysis

Site selection is a physical and tangible problem that requires real world analysis to determine a robust outcome. The model provides a series of data curves that can be matched against the optimum desired outcome. The data curves allow a process of real world analysis without the need for overly complex and rigid computational models.

11.4 Is the Model Robust?

Decision priorities (criteria) will change over time, a robust decision model must therefore be sufficiently flexible to accommodate this requirement. The decision-making framework (top-level and sub-level criteria) can be set with ease. The design of the model is such that the cells can be expanded or reduced without having to re-programme or re-design the model. Decision data can be easily inputted into the pre-set framework and a series of data curved are generated that map the physical location against that of the theoretical optimum desired outcome. As such the model can be easily updated, as further knowledge is generated or specific requirements become known.

11.5 Was Styles Correct in the Original Site Selection Project?

Styles chose the right site at the time but did not fully understand the selection process of the controlling factors involved in the project. The Company did not understand fully the mechanism of choice or the strengths and weaknesses apparent in their selection. The Styles model lacked
transparency and it was difficult to communicate the decision-making process, it was as such difficult to achieve a sufficient level of buy-in from all of the stakeholders in the project. This effect could have been overcome with a more transparent selection model such as the one derived from this research work.

11.6 Final Conclusions

It may be suggested that the new site selection model is an extension of the top-level criteria decision model originally produced within the case study. However, by looking at the whole profile not just the final outcome (first past the post), it is possible to investigate the whole decision-making process at the ranking (sub-criteria) stage. The models and decision-making process becomes transparent. It is therefore possible to apply real world decision-making analysis to the complex process and achieve a more logical and robust outcome.

Site selection is a multi-level process, the cellular structure of the model fits well with real world decision theory and it is flexible and provides a transparent audit trial. Including mathematical deviation routines into the model would deliver an overall value to the outcome of the decision and/or individual decision cells. However, the presence of a numeric value would lead to greater reliance on the absolute nature of the mathematics to the detriment of a full understanding of problem and the analysis necessary to solve it.

Site selection decision-making models should not be reliant around the first past the post principle, but rather a profile solution based on the "best fit" and
real world analysis of the data produced from the decision cells of the individual case.
CHAPTER TWELVE – RECOMMENDATIONS FOR FURTHER WORK
12.0 Introduction

Areas of further work arising from this research may include:

12.1 Further Experimentation with the Weighting and Ranking Values and Expansion of the Cell Structure of the Decision Model

This research work has provided a good first stage analysis of the key criteria for site selection for small to medium sized enterprises based in the European Rapid Product Development sector. However, site selection is a complex issue and each case will have individual aspects. The new model provides some level of flexibility within the cellular structure to accommodate the individualistic nature of site selection projects. It should however be possible to undertake further research to further optimise the weighting and ranking values of the model.

Furthermore, it should be possible to expand the sub-level criteria or add further top-level and sub-level criteria to the model. For example, language has a critical role to play in inward investment projects but it was only initially considered as a holistic (single) sub-level criterion. It may be possible to expand the sub-level to include issues such as embedded knowledge base, level of learning in schools, level of adult education, synergy of language to that of the investing company and exposure of the investing company’s language in the media.
The expansion of top-level criteria may for example include more focus on opportunity cost and the risk involved in project start-up. Indeed the model may be expanded to include a "super top-level" that opportunity cost would form a critical feature alongside financial and commercial due diligence.

Certain sub-level criteria may also be expanded via an ultra sub-level criteria section. For example sales and marketing ability may have an ultra sub-level that includes ability to market and sell in a business to business (B2B) environment, ability to market and sell in a business to consumer (B2C) environment, ability to conduct direct sales and marketing and ability to operate in a customer focused environment.

12.2 Research into Linking and Expanding the Site Selection Model to Include Aspects of Financial and Commercial Due Diligence

Site selection represents one stage in the overall inward investment process. The inward investment project is in turn a complex decision process. Further research may be undertaken into linking the new site selection model to other key areas of the inward investment process such as financial and commercial due diligence.
12.3 Research Methods to Incorporate an Automatic Rulebook and Blind Weighting into the Decision-Making Model

The site selection model was developed as a programme within Excel™. Excel™ has a facility that enables the programmer to incorporate automatic text and "rules" into the programme. This facility may prove to be a useful addition to the new model because it will enable inexperienced users to more easily rank target sites in accordance with standard protocol.

A further feature of the model could be to "hide" the visible weighting cells from the top-level and sub-level criteria. The user may then rank a target site "blind" and should not be influenced by the perceived importance placed on any of the criteria.

12.4 Research the Impact and Level of Risk Involved During The Opportunity Cost Phase of the Inward Investment Project

Many inward investment projects fail. There are numerous reasons for failure but a significant number of projects fail at the opportunity cost stage (see section 8.3.2 Stage 1: Preliminary Investigation). Research may be undertaken to determine the impact of the project start-up and failure and the level of risk involved during the opportunity cost phase of the inward investment project. A greater level of understanding of the impact of opportunity cost will almost certainly lead to a higher level of successful projects.
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APPENDIX ONE – RECORD OF CASE STUDY INTERVIEWS DATES AND LOCATIONS
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<td>CEO</td>
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<tr>
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<td>C Wilkening</td>
<td>CTO</td>
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<tr>
<td>7.3.00</td>
<td>Sedgfield (meeting)</td>
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<td>15.3.00</td>
<td>Birmingham (ARPD meeting)</td>
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<td>ii. R Haley</td>
<td>ii. Director</td>
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<td>iii. 21.1.00</td>
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APPENDIX TWO – TABLE OF KEY INTERVIEW QUESTIONS
**Table of Key Interview Questions – Appendix Two**

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**Interview Questions**

1. Brief company history
2. What is the strategy for growth?
3. Has the Company moved location in the EU?
4. Why did the Company move?
5. What type of location model was used (i.e. gut reaction or criteria selection)?
6. What criteria were involved in the decision-making process?
7. What were the criteria used?
8. What was the key factor or criteria?

**Notes**

a. 

---

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APPENDIX THREE – MEETING NOTES WITH EBERHARD v. KUENHEIM (CHAIRMAN OF THE SUPERVISORY BOARD OF BMW)
Meeting Notes

Participants

Erich v. Kuenheim Chairman of the Supervisory Council, BMW
Gordon Styles Styles Precision Components Ltd.
Lee Styger Styles Precision Components Ltd.
Dr. Röthig Economic Development Agency Saxony
Dr. Graetz County Council CEO
Manuel Hertweck IIC

Location
Mockritz, Saxony

Date

Re
Styles' planned investment in Germany

• Meeting was set up through the IIC to ascertain whether and how Mr. von Kuenheim may assist in Styles' activities in Germany.

• Meeting started with an introduction by Gordon Styles to the company and its planned German operation.

• Mr. von Kuenheim gave the following advice:
  - recruitment is the key. The first person on board should be the Head of Personnel. This should ideally be someone who
    a) comes from the region.
    b) has spent some time in the US/UK.
    c) can think like an entrepreneur.
  - excellent people can be found in the New German Länder. BMW/Rolls Royce found very good staff in Brandenburg with a level of ingrained skills that allows them to perform better than their counterparts in western Germany or the UK.
  - in terms of financing, 25 – 33 % should be equity financing.
  - BMW already purchases 30 – 40 % of its inputs abroad, carmakers are used to this.

Mr. von Kuenheim also offered to put Styles in touch with BMW's toolmaking department once the company is operational in Döbeln.
APPENDIX FOUR – LETTER FROM DAVID HERMAN
(CEO OF OPAL MOTORS)
January 23, 1998

Dear Mr. Styles,

I was recently informed by the IIC that you are considering an investment in a rapid prototyping and precision tooling facility in the New German Länder (NGL).

As a member of the supervisory board of the IIC and Vice President of General Motors Corporation, I would encourage you to proceed with this investment. As you know, General Motors is one of the largest foreign investors in the New German Länder. Our plant in Eisenach (Thuringia) is the most productive General Motors site in Europe. A key driver in this is the availability of an extremely qualified and dedicated work force. Other factors which you should consider in your decision to locate in the NGL are the labour cost differential with the western states, the higher degree of regulatory flexibility and the availability of considerable investment incentives.

The New German Länder now offer an additional competitive advantage: the services of the IIC. I trust that the IIC has been providing you with high quality and comprehensive advice on your planned investment.

We would be delighted if you were to decide to come to the New German Länder and following your investment, I would be pleased to introduce you to relevant managers at Opel/General Motors to discuss opportunities for your products and services.

If you have any further questions, please do not hesitate to contact my office.

Yours sincerely,
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**Sub-level Criteria**

must not exceed 25 score 1-5

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**Sub-level Criteria**

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<td>Strategic &amp; tactical ability</td>
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APPENDIX SIX- ARTIST IMPRESSIONS OF POSSIBLE NEW FACTORY BUILDINGS RELATING TO THE CASE STUDY
ELEVATIONS
PROPOSED 40,000sq.ft. UNIT
APPENDIX SEVEN – COPIES OF PUBLISHED PAPERS WITH RELEVANCE TO THIS WORK
Appendix 7.0 Published Work

In relation to this research work, the author has published the following papers:


2. Adding Value through Product Development, Engineering Designer, November/December 1999, The Institution of Engineering Designers. (This paper was awarded the Institutions prize for the best paper of 1999)


4. Education and Training in RP&M, Time-Compression Technologies, Volume 8 Number 5. (Joint Paper)
The Institution of Engineering Designers is a professional body for designers who operate in widely diverse fields of Engineering practice, in industry, consultative practice and education.

Its members are concerned with applying their skills to the solution of the design and draughting problems of industry, commerce, education and government, and also with the administration and management of design and draughting activities.

The Institution promotes high standards of competence, professional conduct and integrity. It also has a "crusade" function in trying to persuade everyone - from government, through management and educationists, to parents - of the primary importance of good engineering and product design for the nation's economic well-being and to improve mankind's quality of life.

The IED believes that there is no substitute for excellence, that good design pays, that good design demands good design staff, and that management should give as much thought to design policies, re-education of design staff and modern design aids as it does to acquiring more productive manufacturing equipment.

The Institution is an Engineering Council nominated body. It is also a supporting member of the British Standards Institution and The Foundation for Science and Technology.

Support for the Feasibility Study
The feasibility study was conducted with support from the DTI.

Front Cover Picture
The front cover picture illustrates a rapid injection moulding tool that was manufactured and tested as a part of the EU supported IMS RPD collaborative project under Framework IV. The tool was designed and tested by De Montfort University and manufactured by STYLES.
Final Report

Feasibility Study into a Collaborative Network for the UK Rapid Product Development Sector

May 1999

Prepared by

Lee E J Styger
Executive Manager: Technology & International Special Projects
STYLES Precision Components Limited

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1.0 Executive Summary

The UK Rapid Product Development (RPD) sector is defined as those organisations that provide services involving the rapid design and development of products for a third party manufacturing organisation. The sector includes organisations practising in any or all of the following activities:

- Conceptual design
- Engineering design
- Test and analysis
- Modelmaking
- Prototyping
- Rapid Toolmaking
- Short-run or bridge production
- Value-added/niche manufacture

The distinguishing features of an RPD company are:

- Rapid and responsive
- Customer focused
- Fast and efficient electronic communication

The UK RPD sector is dominated by SMEs (companies of up to 250 employees). These organisations deliver high-value services to first/second tier suppliers and OEMs. Importantly, the sector also offers high-value/skilled employment opportunities.

The sector contributes to making UK manufactured products more competitive. Because of its comparatively "young" and fragmented nature, the RPD sector is undervalued. This has caused a limited amount of take-up and exploitation by the manufacturing organisations that would be best able to benefit from the sector's services.

A Feasibility Study into a Collaborative Network for the UK Rapid Product Development sector was initiated to determine the best ways of developing the sector and its take-up within UK manufacturing industry.

The feasibility study was divided into four sections, these were:

- Sector interviews - The Supplier Companies
- Customer interviews - The User Companies
- Action Group Meetings
- Four regional meetings of representative sector practitioners and users
- Report and Recommendations

Interviews were conducted with supplier organisations and as a result 26 common issues were identified as being of importance. In depth interviews were then conducted with user organisations. There was general agreement between the customers and the RPD suppliers about the issues involved.

Following these interviews, a series of regional action group meetings were held in order to develop a workable strategy based upon the original 26 common issues.

Five main "drivers" were developed from the action group meetings. It was considered that these drivers would form the core activities to develop the strength and viability of the sector. The drivers formed the final recommendations of the feasibility study. The final recommendations are listed below:

- A sector trade association to be formed
- High-level industrial signposting and awareness programmes to be developed
- A major benchmarking exercise to determine the current core competencies of the RPD sector and future needs of the customer base
- Formal educational and training programmes to be developed
- RPD service locator to be developed (electronic and hard-copy)

This feasibility study recommends the establishment of a collaborative support network for the UK Rapid Product Development sector and highlights the possible impact of such a network in the short, medium and long-term. The report outlines the proposed areas of work necessary to grow and sustain the sector to the advantage of the UK's manufacturing industry.
2.0 The Big Picture

The UK Rapid Product Development sector is able to:

"advance the competitive nature of UK products"

It is sometimes said that UK designers and product developers are the best in the world. But overseas companies often take their ideas and get products to market quicker and more competitively than UK companies. The UK Rapid Product Development sector offers a means to rectify this situation.

Not only will UK manufacturing benefit from improved "time to market", but the Rapid Product Development sector has the means to "try and test" before market entry - thereby contributing to product quality. Making UK manufacturing more effective in delivering products quickly to the market will help to increase employment opportunities and contribute to the UK's 'balance of payments'.

To ensure maximum benefit from the opportunity, it is essential that a new sector trade association be formed, perhaps entitled 'The UK Rapid Product Development Association' (RPDA). For the RPD sector to join existing associations will do little to resolve the issues raised by the majority of the participants in this feasibility study. There is a danger that this young sector would be dominated by the agendas of existing organisations. Also, the nature of the sector is not reflected in the names and images of existing associations, which are too "narrow" in terms of interests and members - whereas a new association would provide a wide church of, for example, designers, rapid prototypers, rapid toolmakers, moulders etc. - who would be more focused.

A new "purpose-built trade association" would aim to educate manufacturers in the benefits to be gained from using the services of the Rapid Product Development sector. This would introduce new business into the sector to the benefit of all association members. This aim would provide the main common goal to unite the sector.

Once the UK manufacturing industry begins to hear and see the benefits that the Rapid Product Development sector can bring, it is forecast that increased business will be generated at a higher level than the sector can currently accommodate. As a result, new recruits will be needed as business grows. New academic courses and various education and training provisions, including industry standard apprenticeships schemes, will need to be introduced.

What appears at present to be revolutionary changes will become a natural evolution - but it all begins with a new trade association.

It was interesting to note that the four action group meetings associated with the feasibility study provided models for the proposed trade association (that is, a networking opportunity and a debate about common issues that unite). In time, this can only lead to mutually beneficial and profitable collaborations.

The main benefits of a sector trade association include:

• a common voice
• development of standards
• nurturing opportunities
• joint venture opportunities
• technological support
• awareness generation
• signposting
• benchmarking
3.0 The Opportunity

The European Rapid Product Development sector is valued in excess of £30bn (Footnote 1). A variety of specialist UK companies, many of which are world-class players, populate the sector. It is these companies who help to stimulate innovation and provide value-added services that benefit manufacturing industry.

However, UK manufacturing industry must be able to match and keep pace with the "best in the world". It is the aim of the UK Government to close the performance gap of UK industry with its competitors (Footnote 2) and also increase greatly the UK manufacturing base. This means improving UK manufacturers' ability to produce innovative new products and create high-value services. This can be achieved, in part, by a robust and coherent Rapid Product Development sector.

80 per cent of product costs are determined at the design stage (Footnote 3). In consequence, the efficiency and effectiveness of the product development process within manufacturing industry is becoming more and more critical for business success.

Few of the companies serving the UK Rapid Product Development sector are able to offer a full portfolio of technical services. The sector is fragmented and under-valued. In part, the under-valued nature of the sector is a result of "impact dilution" - as a result of companies delivering "small-scale" and partial services to the client - instead of a complete service. This could be overcome by incorporating a more formal "virtual supply" or collaborative network consisting of like-minded companies that are committed to and focused on the needs of the customer.

There is a need for a collaborative framework for the UK Rapid Product Development sector to enable the sustained growth of the sector and the wide variety of organisations it serves. This document outlines the proposed areas of work (referred to here as 'SCOPE', see below) necessary to grow and sustain the UK Rapid Product Development sector.

4.0 Background to the Rapid Product Development Sector

There are indications that the European RPD market will double in size over the next five years. However, despite the current value and future predictions of market size, there is no 'Standard Industry Classification' (SIC) code for the sector.

The UK Rapid Product Development sector is typically dominated by SMEs most of whom, by their very nature, are capable of moving quickly to exploit new opportunities. These organisations provide an essential foundation for UK manufacturing industry, supporting and supplying the first tier suppliers who in turn deliver to the original equipment manufacturers (OEMs).

Recent findings, such as the DTI initiated 'Technology Foresight Workshops' and EPSRC's 'Responsive Manufacturing Panel', suggest that the UK can only remain competitive and sustainable by moving higher up the value-added supply chain. A responsive manufacturing base, capable of moving rapidly into new niche or diverse markets, requires value-added strategies.

The design and development process and therefore the value-added content of the product is held by the SMEs that operate within the RPD sector. It is these organisations and their highly skilled and motivated personnel that deliver the high-value added products and services to the manufacturing base of the UK.

Footnotes

5.0 The Need for a Collaborative Support Network

If UK manufacturing industry is to be capable of increasing the added-value of its products and thereby compete in world markets, then there is an immediate need for a coherent and well-defined Rapid Product Development sector.

The UK Rapid Product Development sector is populated by many world-class players. However, most of these companies appear to either:

- **operate in a single segment of the market - that is contrary to future needs of the customer base who are seeking a more holistic RPD service**

or

- **offer similar services in close competition with other companies within a particular segment - thereby having no differentiation or unique selling point**

Neither scenario benefits the UK manufacturing industry as well as it might. Many opportunities are lost because the necessary combination of skills to exploit and promote the technology are not available. What is needed is a "holistic" and coherent process which reflects the best practices required for the needs of an efficient new product development (NPD) process. RPDA personnel with appropriate education and training are necessary to effectively contribute to the concurrent/simultaneous practices used by leading companies in their NPD process.

A collaborative support network, consisting of the right partners, will provide the solution to the current dilemma and thereby advance the competitive nature of UK products.

6.0 The Mission of a Collaborative Support Network

The mission of the proposed collaborative network is to define, promote, and support the UK Rapid Product Development sector and disseminate to industry the sector's vital role in the competitiveness of UK manufacturing industry.

The proposed network will incorporate a collaboration of industrial practitioners (typically SMEs), academic and professional institutions and specialist trade associations. Those already associated with the network recognise the need to develop the holistic core framework of Rapid Product Development in order to sustain and grow their own specialist interest areas.

The feasibility study was instigated by industrial practitioners, some of whom are associated with the CIRPS special interest group and other special interest groups and trade associations (e.g. RPMA, GTMA). The main aim of the study being to determine the key areas of action necessary to secure the long-term future of the sector.

A "holistic" and coherent process is required to reflect best practice
7.0 The Feasibility Study

The feasibility study was divided into four sections, these were:

- Sector interviews
  - The Supplier Companies
- Customer interviews
  - The User Companies
- Action Group Meetings
  - Four regional meetings of representative sector practitioners and users
- Report and Recommendations

7.1 Sector interviews
- The Supplier Companies

A representative sample of organisations involved in the supply of RPD services were interviewed. The interviews were conducted to determine the key issues for growth and sustainability within the sector. 26 common issues were identified from the interviews. These issues formed the basis for the other sections of the feasibility study.

7.2 Customer interviews
- The User Companies

In-depth user company interviews provided an opportunity to gauge the response of "sector customers" to the key issues raised by the suppliers of RPD services. The 26 key issues were presented to the user companies to determine the common areas requiring action.

It was initially thought that only a limited number of common issues would be highlighted as a result of the interviews and that these would form the basis of the recommendations of the feasibility study. However, there was little difference between the suppliers and customers perception of the key issues. Likewise, larger and smaller organisations showed minimal difference (11%) in the ranking of the key issues.

7.3 Action Group Meetings

The combined interview procedure delivered a very narrow band-width between the key issues as viewed by the suppliers compared to the customers. In view of this, the action group meetings were targeted at delivering a workable strategy from the original 26 key issues.

Five main "drivers" were developed from the action group meetings. The drivers formed the principle recommendations of the feasibility study and are discussed below.

8.0 Analysis of the Action Group Meetings

The primary aim of the Rapid Product Development (RPD) sector should be to establish a programme of "education" - focused upon the benefits offered to the UK's Manufacturing Industry. With the support of Government officials and captains of industry, a concerted PR campaign should be undertaken - starting at boardroom level.

The Rapid Product Development sector is both dynamic and "glamorous". Any long lasting RPD sector collaboration can only come about through a recognised trade association. The majority of the action group participants thought that a new trade association should be created which specifically reflects the "rapid" nature of the services provided by the sector. Links should be forged between existing trade bodies that are serving the traditional areas of product development.

To encourage early collaboration by RPD sector companies and generate an awareness within manufacturing industry, it is recommended that the new trade association should produce its own electronic 'Guide to Rapid Product Development Services'.

The UK Rapid Product Development sector is young, but already offers new career/employment opportunities. However, these opportunities bring about new education and training needs that should be addressed and actioned.
There is a general call for the better ‘signposting’ of existing grant funding and other initiatives. When applying for such assistance, the action group participants would like to see a workable mechanism for practical support. This is especially necessary for the smaller or younger companies who are “too busy running the business to seek assistance”. It is considered that many funding and assistance initiatives are not suited to the "rapid" nature of the projects undertaken by RPD sector companies. Many participants in the study thought that the time taken in applying for assistance often means an "opportunity" for business is lost. A new scheme is recommended, aimed specifically at the RPD sector with “fast tracking” financial aid decisions which can be introduced in the medium-term.

Standard payment terms would assist the RPD sector greatly. The payment terms should free cash for re-investment and provide a level of security in terms of creditor risk and bank involvement. It was suggested that payment terms should be on a 'progressed payment' basis for services rendered.

All participants in the study want to see sustainable growth but with the minimum of "red tape" - the message is "be efficient and targeted" at the issues which need resolving in order to achieve this. The user companies largely understood and agreed with the issues and concerns discussed. Collaboration and networking is universally agreed to be good and beneficial to the development of RPD businesses.

### 9.0 Outline of Proposed Rapid Product Development Sector Charter

An outline of a proposed Rapid Product Development sector charter was discussed during the feasibility study. The intent is shown below:

**UK Rapid Product Development Companies**

"Focused on making our customers profitable"

via

A credible, capable and business approach

involving

Professional expertise and strategic innovation

thereby

**Adding value**

through

**Quality, Reliability and Service**
10.0 Recommendations - Programme of Further Work

The feasibility study into the collaborative network for the UK Rapid Product Development sector highlighted five tangible areas that would encourage growth and sustainability in the long-term, these were:

1. A sector trade association
2. High-level industrial signposting and awareness
3. A benchmarking exercise to determine the core competencies of the UK Rapid Product Development sector and the future needs of the user companies
4. Development of formal educational training programmes
5. Development of a sector service locator guide (both electronic and hard-copy)

10.1 A Sector Trade Association

A sector trade association should be established to unite the fragmented nature of the sector and co-ordinate many of the issues that were voiced during the feasibility study. Rather than an affiliation to an existing body (such as the GTMA or FEDC), the majority of the participants of the feasibility study considered that a new body would be beneficial and a more positive course of action - particularly in the short term. However, future affiliation or amalgamation should not be ruled out in the longer-term.

At present, there are a number of specialist interest groups (such as CIRPS, RPMA etc.) who have done much to promote and support the UK Rapid Product Development sector. The new trade association would not look to duplicate work already undertaken, or reinvent the wheel, but rather develop the major proposals formulated during the feasibility study. It would create a truly representative body that is appropriate to the maturing organisations which make up the RPD sector.

The following action plan is therefore proposed:

1. Establish a network of interested parties with a working panel directed to establish and deliver a set of goals necessary for further growth. These may include a charter, voting procedure, links with support organisations, a ‘membership’ list and a capability matrix, together with special interest groups for specific technological issues.
2. Develop a sector identity encompassing all of the needs of the ‘membership’.
3. Develop links with existing trade and professional bodies
4. Either incorporate into a formal trade association or affiliate with an existing trade association as befits the nature and wishes of the membership.

Requirements to Fulfil the Action Plan

The action plan represents a bold yet achievable set of recommendations. There are sufficient indications to suggest that the industrial practitioners will welcome and embrace this proposal. However, a dual process of pump priming along with a full-time secretariat for the trade association will be necessary to realise this goal.

The estimated impact of this work is shown in Section 11.0.

10.2 High-level Industrial Signposting and Awareness

There is little doubt that Rapid Product Development sector companies can advance the effectiveness and efficiency of product development and thereby help to deliver higher profits for UK manufacturing industry. However, many of the decision-makers within manufacturing industry are unaware of the potential financial benefits that exploiting the services of RPD companies can bring. A major, high profile, signposting and awareness programme is needed to target the boardrooms of UK industry. This programme must be initiated and sponsored at the highest ministerial level and supported by captains of UK industry. The programme can later be linked through the Inside UK Enterprise Initiative and similar initiatives as a sustainable follow up.


10.4 Development of Formal Educational Training Programmes

Quality education across the whole spectrum of the sector will ensure its world-class standard and ensure long term survival and growth. Three main areas of work are needed, these are:

1. Apprentice training
2. Academic training
3. Professional recognition

10.4.1 Apprentice training

New apprentice schemes need to be developed. There is a ready market for properly trained people. The schemes should be developed under a joint collaboration between a recognised training provider and nominated industrial practitioners.

A working party should be established to fulfil this role.

10.4.2 Academic education and training

In common with apprentice training, there is a need and ready market for good quality academically qualified people. However, standard undergraduate and postgraduate courses do not necessarily offer the breadth or base that the sector needs. Therefore, new courses should be developed in collaboration with nominated industrial practitioners to satisfy the demand.

A working party should therefore be established to fulfil this role.

10.4.3 Professional Recognition

Professional accreditation is needed for training courses that are already in existence. Based upon professional recognition, this should link to CPD programmes that in turn become a basic personal and corporate necessity. Therefore, a programme promoting CPD is necessary - combined with further development of accredited courses. This should be undertaken by professional institutions.
10.5 Development of a sector Service Locator Guide (both electronic and hard-copy)

Once the promotion and awareness activities are underway, a sector service locator guide is needed. This must be independent and carry no sponsorship or advertising. However, once this activity is established fully, it will probably need to be under the supervision of the trade association.

It is considered that the product locator guide will eventually become a fully interactive electronic tool. However, the utilisation of web-based services is not high at the moment and in the interim, a hard copy should be developed to run in parallel.

Requirements to fulfil the Recommendation

A collaborative body needs to be established to develop and deliver the sector 'service locator'. The service locator will probably become self-funding through the trade association in later years.

11.0 Impact and Return arising from the Programme of Work

It is considered that the recommended programme of work will adequately address the short, medium and long-term needs of the sector. The major impact will be witnessed within the first five years (from initiation), however further results will be achieved in the longer-term as the sector becomes more established and coherent.

The table below illustrates the possible impact of the programme of work.

| Possible Impact of the Programme of Work |
|-----------------|----------------|----------------|
| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **Impact** | **Short-term** | **Medium-term** | **Long-term** |
| A sector trade association to be formed | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| High-level industrial signposting and awareness programmes to be developed | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| A major benchmarking exercise to determine the current core competences of the RPD sector and future needs of the customer base | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Formal educational and training programmes to be developed | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| RPD service locator to be developed (electronic and hard-copy) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
Conclusions

In 1998 the European Rapid Product Development sector was valued in excess of £30bn, yet there is no SIC code. Because of this lack of general awareness, little wonder that the sector is fragmented and undervalued.

The RPD sector mirrors the short-term, quick return, thinking of much of the UK's financial sector (investors and banks). As such the sector has the potential to provide an edge to the UK manufacturing industry's ability to produce winning products. The UK Rapid Product Development sector can satisfy the punishing demands of modern industry, including matching the market time demands, placed upon it by the OEMs and first tier suppliers. The sector has the ability to keep work and contracts within the UK thus creating more high-value employment opportunities.

An evangelical programme and recruitment drive would bring much needed new talent into the sector. This will not only support the "rapid" product development area that the sector personifies but also UK industry as a whole. This will benefit industry and the country by overcoming the myth that the UK no longer has a manufacturing base.

There is much synergy between the key issues raised by the RPD supplier companies and the user companies. Whereas improvement and growth is considered paramount, there is a need to keep "red tape" to a minimum whilst delivering a professional and value-added service to customers.

There is great personal and corporate commitment within the sector. This is linked to the belief of both the RPD sector suppliers and customers that the UK is a nucleus of world-class value-added providers.

The consistent message from the sector is "education, education, education".

The UK Rapid Product Development sector has the ability to:

"advance the competitive nature of UK products"

Lee EJ Styger
Annex

A.0 Methodology

The feasibility study was divided into four sections, these were:

- Sector interviews
  - The Supplier Companies
- Customer interviews
  - The User Companies
- Action Group meetings
- Report and recommendations

A.1 Sector interviews
- The Supplier Companies

The supplier company interviews allowed organisations to voice any issues that they considered would improve the competitiveness of the sector and lead to increased growth. Interviews were conducted with a sample of 37 companies involved in supplying Rapid Product Development services. To ensure a representative response and theme, RPD service suppliers to manufacturing industry were drawn from across the whole of the sector.

The supplier companies were typically SMEs or divisions of larger organisations that operate as SMEs (i.e. self-directed/self-sufficient profit generating centres), outside of any corporate or government support. The supplier company list was not considered to be exhaustive but, never-the-less, representative of the sector as a whole. The list was augmented by five support/professional agencies and three universities.

A.2 Sector interviews
- The User Companies

The user company interviews provided an opportunity to gauge their responses to the issues raised by the supplier companies involved in the study.

A.2.1 Background to the User Companies

The user companies interviewed were selected from a variety of sources including industry directories, trade magazines intelligence databases. Every effort was made to ensure as wide a spread of sectors as possible, these included:

- Automotive
- Aerospace
- Consumer goods
- Security systems manufacturers
- Communications
- Engineering
- Electronics
- Plastics processors

All those who participated in the survey were senior executives within the organisation, typically owners / managing directors / chief executives or director level.

For maximum benefit, those interviewed were selected from those who possess some direct purchasing experience from the UK Rapid Product Development sector (i.e. from one or more of the following: conceptional design, engineering design, test and analysis, modelmaking, prototyping, short-run or bridge production, value added/niche manufacture).

88 per cent of the companies questioned were based in England/Wales, the remaining 12 per cent in Scotland.

A.2.2 Size of Companies Interviewed

It was decided not to probe for financial information as a means of ascertaining size, because some companies (especially SMEs) were reluctant to divulge such information; and, without a size definition, they would have been ineligible to take part in the survey. The number of staff employed was therefore used as the defining measure. The breakdown by company size of those who participated in the study was:

1 - 50 employees - 33 per cent
51 - 250 employees - 33 per cent
251 + employees - 34 per cent

The two-thirds split in favour of user company SMEs was considered a good balance, although a comparative breakdown of results from larger companies was also obtained (see graph for “larger organisation key variances”).

A total of 265 companies were contacted before the agreed size split and previous user criteria were met. 100 companies were then interviewed. All of those questioned were assured that individual responses would not be divulged, nor would those surveyed form the basis of a database for the use of other organisations.
A.2.3 Approach to the Survey

The survey was undertaken by telephone. Those questioned were first given a full explanation for the purpose of the feasibility study. The emphasis of this introduction was that, "The Rapid Product Development sector recognises that it is both young and fragmented, yet because of the potential advantages it affords UK manufacturers, it now wishes to consider how best to move forward. This has culminated in collaborative discussions between many of those in the sector and a number of key issues have been identified. It is these issues that the sector now wishes to discuss and gauge the reaction of those who would be recipients of the sector's services".

A.2.4 Number of Key Issues

In all 26 key issues were put to user companies. The average time per survey was 35 minutes which, by any standards, represents an in-depth study.

A.2.5 Response Ratings

It was decided not to rely upon a straight "yes", "no", "don't know" response as this would not have accurately reflected the levels of importance. A 1-10 score in terms of importance placed on each key issue was adopted, i.e. a rating of 1 would indicate minimum importance, 10 - maximum importance with degrees of strength of feeling between these. The cumulative scores per key issue were totalled and expressed as a value out of a possible maximum total score of 1,000. This total was then divided by 10 and rounded up or down to the nearest percentage point to give a percentage rating. This is shown in the table on Page 16.

A.3 The Action Group Meetings

Four action group meetings were conducted. The content of the meetings formed the core of the findings of this report. The issues were discussed openly and recommendations made by the participants. The common issues have been reported below along with the recommendations for further work.

B.0 The Key Issues, Ratings and Action Group Discussions

The Supplier Companies raised a total of twenty-six key issues as follows:

1. UK only - pre-competitive research programme
2. Overcoming the short-term mentality of UK Industry and Finance
3. Recognition of a holistic sector
4. Improving the dynamic nature of UK Industry
5. A demonstrator evaluation body
6. Provision of safe-havens
7. Long-term investment funds
8. Readily available grant funding for SMEs
9. Learning curve trial grants
10. Industry standard payment terms
11. Major Project clearing house
12. Operating standards
13. Audited benchmarking
14. Audited technology transfer activity
15. Audited 'New Technology' evaluation programme
17. 'World-class' Rapid Product Development practitioner profile
18. Industry standard apprentice schemes
19. Industry academic qualifications
20. Industry professional qualifications
21. Sector Trade Association
22. Licence to Practice
23. Supply Chain education
24. Boardroom education
25. Active 'signposting' mechanism
26. Web-site locator of services

The issue, description, customer response level and commentary from the action group meetings were recorded on the bar chart on Page 16.
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<th>Actual Score</th>
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Table of Results to Survey Questionnaire

Level of Importance
- Maximum 1,000
Annex

B.1 UK only - pre-competitive research programme

The Issue
There was a need for a UK based pre-competitive, collaborative research programme, such as CRAFT. This would overcome the costly and sometimes inappropriate process of finding European partners. The proposed scheme would also ensure advantage for UK based companies by keeping research results in the UK.

Customer Response
70 percent of the user companies interviewed thought that this proposal had some merit.

Action Group Discussion & Recommendations
It was pointed out that UK companies had benefited greatly from pan-European collaborative programmes and one of the real benefits was contact with other EU companies. It was also pointed out that other programmes exist that were specifically designed for UK-only participation and this key issue may not be associated with the programmes in general, but rather a lack of good and effective signposting. This sentiment was supported generally - along with a call to reduce the overall bureaucracy involved in the signposting activity and the application for funding in general.

Teaching Company Schemes were held up as good examples of delivering specific in-company development projects.

Framework V was also cited as a potential means of overcoming some of the perceived issues relating to existing programmes.

Note: Framework V is the next round of European Commission funding for pan-European collaborative programmes.

B.2 Overcoming the short-term mentality of UK Industry and Finance

The Issue
Manufacturing industry represents the economic foundation of the UK. The Rapid Product Development sector possesses a high-value-added skills and knowledge base. The sector has very large and sustainable growth potential. However, significant growth could not be achieved by manufacturing industry due to a short-term financing mentality - a mentality perhaps more suited to other sectors. The typical short-term nature of business needed to be challenged through a process of education and support mechanisms.

The typical view of the short term nature of business needs to be challenged.

Case Study: 'Automotive Lens' project
ARRK Europe

Collaborative project
An Automotive Lighting Project involving different CAD systems and engineers working in four countries with new customers and a need for exceptionally high visual quality prototypes also attaining near production quality engineering and optical properties, has recently been completed.

ARRK liaised directly with their customers, a tier one automotive lighting supplier in Germany and Spain and also with a car manufacturer based in both Japan and the UK.

As the production of 6 sets of 22 components, full sets of both headlights and rear lights was needed in 6 weeks from receipt of final data, timing was critical, with the information being provided in the form of surface Catia Data, solid Catia plus some IGES data output from native CADDS.

The prototypes were for full car builds and also to complete some photometric testing. The requirement was to provide assembled sets including wiring harness and testing for operation, water tightness and body fit and function.

Cross-company Team working
One of the key areas for the success of the project was the team working between all three companies. Progress on the project was far from smooth despite good pre-project planning by all the parties involved and serious possible delays were incurred for a number of reasons.

Two days before the initial data was due, the car body shape was changed as the automotive manufacturer's aesthetic design team needed to incorporate a tighter standard of body to lens fit, having seen similar fit attained by their main competitor, on a visit to the Geneva motor show in the week prior.

This information was immediately relayed to ARRK who were able to switch planned resources in order to work on the rear lighting masters, thereby shortening their production time and releasing more resources to work on the data for the front lenses.

Unique design
A larger amount of optics was incorporated into the reflectors of the headlights to enable easier and more economic production of polycarbonate components. New optic patterns were developed to give greater light intensity, so reducing the power needs to the bulbs and extending life of the lighting sets in production.

There is a lack of good and effective signposting
Annex

Customer Response
This issue scored 81 per cent from the user companies and was one of the highest levels of agreement obtained during the feasibility study.

Action Group Discussion & Recommendations
This issue was initially considered to be a case of "preaching to the converted". However, after consideration, the general consensus was that engineering companies run by engineers return a profit, whereas engineering-based companies run by accountants do not.

Current financial investment and funding practices within the UK inhibit companies taking a longer view. This presents a major obstacle to sustainable growth. However, if used effectively, tax relief incentives were cited as a useful tool for encouraging growth.

B.3 Recognition of a holistic sector

The Issue
Clusters of supplier company SMEs offering specialist high-value-added products and services typify the UK product development sector. Both supplier and user companies need to recognise the sector as being an holistic entity and realise that the sector has the capability to advance the competitiveness of UK products.

Customer Response
66 per cent of the user companies responded favourably to this issue.

Action Group Discussion & Recommendations
The action groups stated that the sector needed a "voice" and wider recognition would evolve from good collaborative association. Also, if the sector was to grow and satisfy the ever increasing demands being placed upon it, then the active co-operation of RPD companies and trade/professional associations was essential.

The action groups thought that the OEM's perception of the sector was currently defined by old terminology and values which need to be addressed. They concluded benchmarking studies and educational programmes were needed.

Benchmarking and educational programmes needed

Case Study: RPD Design
David C.F. Royle BA MA MCSD

The field of Rapid Product Development is vast: after all - what is design? For example, in recent times, we have been assisting design houses with problems related to membrane keypads for the colour blind and working out iconic designs using the principles of semantics. On other occasions, we have been looking at static air curtains and cyclone vacuum systems for the removal of pharmaceutical waste in the production of tablets. Some of the most recent work has been with regard to rapid product development, where we worked with SMEs in the plastics industry looking at a range of methods that they can use to produce prototypes more rapidly, considering a vast array of technical solutions, in conjunction with the equipment they have at present and their client base. Part of this study, was to incorporate the needs of the client base, which in a three week period of study and reports produced a bonus of over £100,000 worth of business enabling the directors to formulate their future plans for this company.

This type of corporate co-operation between consultants and directors, is now being found very helpful, and can often pay great dividends, especially when the outsider acts as a "non-executive" director and can work for long periods bringing in new ideas, and allowing the organisational management to discuss their concepts for the future. It may be that the company may need more than one consultant to bring in other aspects, such as, product merchandising. In conclusion, working in a close relationship with companies, who have foresight and embrace the challenges of modern product development and design is the way forward.
B.4 Improving the dynamic nature of UK Industry

The Issue
A programme to increase the dynamic nature of UK industry and encourage entrepreneurs with a technological/engineering background was needed across all sectors of manufacturing industry.

Customer Response
78 per cent of the interviewed user companies recommended this action.

Action Group Discussion & Recommendations
The action groups thought that this key issue linked closely with recognition of the 'holistic' nature of the sector. The issue of professional recognition and standards was discussed at length, encompassing professional qualifications and the need for 'world-class' accreditation. Possible links to the GTMA's world-class profile were drawn.

An interesting, "bigger picture" view was presented suggesting that Rapid Product Development aided risk management. By helping to lower the high risks associated with new product development, RPD supplier companies were contributing to an increase in the growth of UK manufacturing industry's competitiveness.

B.5 A demonstrator evaluation body

The Issue
A body should be established comprising industry practitioners and government officials to monitor and approve applications for funding for 'industry demonstrators'. This would overcome the unnecessary duplication of demonstrator sites and focus the demonstrators on pre-competitive work - where there was a need for benchmarking and evaluation programmes.

Customer Response
62 per cent of the user companies thought that this was a good proposal. This lower response level may be linked to the perception that "red tape" would be associated with government involvement.

Action Group Discussion & Recommendations
There was overall agreement that strong and continual links should be maintained between manufacturing industry and academia and that there should be no competition (perceived or actual) between the two.

The use of "incubator units" within the university system to develop technology prior to full commercial exploitation via established industrial companies was proposed and accepted.

Case Study:
'Travel Dental Kit' for major retailer
Albyn of Stonehaven Ltd

The Company
Core business activity: Design and manufacture of health and beauty products
Year established: 1972
Customers: Famous retail chains including Boots, the Chemists, Body Shop, Superdrug Stores, Lloyds Pharmacy and the John Lewis Partnership
Number of employees: 60
Location: North East Scotland

The Task
• Replace a commodity product (incorporating a single use tube of toothpaste) being imported from the Far East
• Create an exclusive design capable of accommodating a multi-use tube of branded toothpaste
• Meet a target retail selling price
• Ensure that environmental concerns were addressed
• The kit to be compact, tactile and capable of incorporating four-colour printing.

The Method
Design options were explored using concept sketches and block models (produced by Norman McNally Design and CA Models respectively). Vacuum castings were produced from silicone moulds to enable:
- the preferred component design to be finalised
- printing jigs and fixtures to be validated
- packaging specifications to be finalised

The castings enabled the customer to carry out pre-launch market testing and ensured that only minor modifications were required on the fully automatic multi-impression moulds.

The Benefits
• A significant reduction in the number of product design iterations and time to market
• The customer has enjoyed a significant increase in unit sales since the product was launched in 1995
• A new market was developed when a major international airline decided to include the toothbrush in their comfort pack. This has resulted in annual sales of 3 million units.
Annex

It was considered important to have a link between academic research and the needs of industry, this was considered best supported through the trade/professional associations.

B.6 Provision of "safe-havens"

The Issue
Many entrepreneurs and technical practitioners in companies operating in the product development sector do not have the critical mass or business acumen to initially run a company large enough to maintain all of the necessary business support activities. A "safe-haven" was proposed to perform this task. A network of locations that provide facilities and support for start-up and "fringe" companies associated with the sector was needed. The safe-haven need not be specially created (i.e. new buildings and infrastructure etc.), but could be housed within existing OEMs and SMEs.

Customer Response
67 per cent of user companies thought that the provision of safe-havens was a good proposal.

Action Group Discussion & Recommendations
The consensus was that such units already existed and that this was essentially an issue of 'signposting'. It was pointed out that, compared to existing support providers, the new Regional Development Authorities might move towards a more efficient and responsive signposting and support mechanism.

B.7 Long-term investment funds

The Issue
The culture of short-term investment loans and high interest financing does not match well with the needs of capital intensive, but high-value-added, companies operating in the product development sector. A mechanism for providing long-term, low interest investment funds was necessary. This process could be provided via private or public capital, but it must be adequate (i.e. major investment over a seven year period) to enable safe and sustainable growth of the RPD companies concerned.

Case Study: 'Automotive Castings'

Warwick Manufacturing Group

The case study describes work undertaken by Oliver Johnson and Tim Cant of NPL Technologies*[1] in collaboration with Warwick Manufacturing Group (WMG). The study centres on the prototyping of a cast iron exhaust manifold with integrated turbocharger and wastegate. In this practical investigation, 12 alternative routes were assessed, including CNC and Rapid Prototype (RP) patterns to produce sand moulds and sand cores produced by laser sand sintering, a recently introduced RP process.

As part of this study, WMG produced sand cores using an EOS-S700 laser sand sintering machine. The laser sand sintering process enables complex cores and moulds to be produced directly from CAD data. The CAD data is sliced into horizontal layers and which are "drawn" on the surface of a layer of resin coated sand using a CO₂ laser. The laser cures the resin, bonding the sand together to produce a fused layer and this process is repeated layer-by-layer until the full core or mould is completed.

The final results of the study showed that, where low numbers of castings are required, the best overall route is a combination of sand sintered cores with sand moulds produced from CNC machined patterns. This route not only reduced the time required to produce castings from over 55 to just 20 days but also gave the lowest relative cost. Moreover, this combination of the latest RP technique with tried and trusted CNC patternmaking gave almost 100 per cent confidence of meeting the desired quality.

NPL are continuing to develop and exploit commercially the results of this work, offering a service with marries traditional highly skilled patternmaking with the latest CNC and rapid prototyping techniques.

* Oliver Johnson - Joint Managing Director
Tim Cant - Technical Director, NPL Technologies (formally Nuneaton Patterns Limited)
[1] Oliver Johnson, Tim Cant, Practical Applications of Time Compression Techniques to Fast Prototyping of Automotive Metal Components, TCT '98.

Cast Iron Manifold with Integrated Turbocharger and Wastegate
Customer Response
78 per cent of the user companies thought that the provision of long-term investment funds in RPD companies would make a significant difference to manufacturing industry.

Action Group Discussion & Recommendations
There was general agreement on this issue. It was pointed out that Rapid Product Development has the potential to return significant profits. Although most of the supplier companies are small, their collective returns could be significant to a potential investor. It was considered that this was another area where a sector specific trade association could become invaluable and help negotiate a sector deal with one of the commercial banks (not necessarily located within the UK).

However, concern was voiced that, if not overseen and assisted properly younger companies could over-stretch their facility. It was suggested that all companies should appoint a non-executive director to act as a financial advisor.

It was also considered that tax relief against particular levels of investment would offer a feasible solution that could be introduced quickly and have a positive effect on sector growth.

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B.8 Readily available grant funding for SMEs

The Issue
A method and provider was needed to enable SMEs to access grant funding quickly and without incurring major "opportunity costs". Opportunity costs can be higher in some cases than the final grant funding, thus making the principle pointless. The final grant sum was typically low and, when a cost analysis was undertaken on the work involved to obtain the funding, the monetary value of the grant was often less than the value of the effort needed to obtain the funding. Also, much of the current funding mechanism was perceived to be a gamble i.e. considerable work with high odds against success.

Customer Response
77 per cent of the user companies thought that a simple grant funding mechanism was necessary.

Action Group Discussion & Recommendations
The speed of decision making and the sheer amount of red tape were cited as the main reasons for confusion and "mistrust" of current systems of grant funding. A call was made for better signposting, typically the Business Links are viewed as a mixed bag, some good, some not. Some group

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Case Study: 'Portable Toothcare'

Douglas Plastics Ltd

Douglas Plastics were asked to look at the project to make a toothbrush that incorporated a solid dentifrice giving total toothcare in one unit. There were no drawings or sizes to work on, but it had to be small enough to fit into an inside pocket or a ladies handbag.

Firstly, together with the customer, we talked to a prototyping company and, after a day and a half, we had something that could be produced by the SLM method. Everyone was happy, a further 10 vacuum castings were made and brushed.

The product's market research potential was forecast at between 200k to 300k per annum. It was decided to proceed with the manufacture of the tools using CAD data from SLA prototypes.

After funding was arranged, the tools were made in 14 weeks - without having the solid dentifrice. The development of the dentifrice will take further work e.g. debugging trials and formulations, this cost has still to be finalised. The capital to fund the project to completion has yet to be allocated. The project timing to completion is estimated as 20 weeks.

The portable tooth care was launched with a company that wanted to be in toothcare i.e. Ther-Med and Zinger.

Costings for SLA, Vacuum castings and CAD
£3,500 - 14 days

Tooling - 4 off 4 individual moulds
£50,000 - 14 weeks

Solid Dentifrice R & D
£18,000
- still to be funded and completed

Up to date 150,000 have been produced.

The provision of long-term investment funds in RPD companies would make a significant difference to manufacturing industry.

RPD companies have the potential to return significant profits.
members were concerned that certain Business Links do not provide what was required.

-There was a suggestion that provisions should be made for "quick technological feasibility studies". Because they have the resources to locate and study the available grants, a view was expressed that larger companies appear to be more able to secure grants - whereas smaller companies need help to locate and secure the funds.

**B.9 Learning curve trial grants**

**The Issue**

Grant funding should be made directly available to the user companies or potential user companies for technological trials. The funding should be on a "one-off" basis and targeted directly at the Rapid Product Development 'supplier companies' to ensure the highest level of quality and service.

**Customer Response**

This proposal achieved a high level of agreement by the user companies who rated it with an 80 per cent level of support.

**Action Group Discussion & Recommendations**

The most significant issue to come from the action group meetings was that some of the participants considered that grants for technological trials were counter productive. It was considered that this type of activity results in an unrealistic position which was wasteful (i.e. If a full justification was required, then any resultant work would not be commercially viable). There was a call that all user companies should stand on their own feet when it came to testing proven technologies. This statement should not be confused with the funding of pre-competitive development.

The funding of learning curve trials was considered to devalue the products and services of the RPD sector because, once the user companies had paid for the service at the initially low level of cost, this perception of costs remained for any further commercial work.

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**Case Study: New switch design**

*RP Solutions*

As Rapid Prototyping has become accepted, so manufacturing industry has increased the demand for functional Rapid Prototypes that simulate the performance of the final production component without having to resort to an alternative process such as soft tooling. *RP Solutions* in conjunction with *MTE Ltd.* have recently proved that this is now possible.

Using the Fused Deposition Modelling (FDM) technology developed by Stratasys Inc., *RP Solutions* produce robust accurate prototypes in ABS plastic suitable for fit and function testing. *MTE Ltd.* manufacture industrial electrical switching equipment. They have recently made a conscious decision to take advantage of any available new technologies where appropriate. To this end the company invested in 3D CAD and investigated the possible benefits of Rapid Prototyping.

This project was a completely new switch design. It was hoped that the normal screwed assembly might be replaced by a less labour intensive snap fit arrangement. The Rapid Prototyping process selected had to allow for a number of iterations of the component's design and allow a degree of fit and function testing. It was decided that the FDM process offered by *RP Solutions* would suit their requirements best.

Initially the designers had fairly modest expectations of what testing their prototypes could be used for. By the end of the project they had been used as tactile models to confirm the size and shape, as a fit and function model to prove the basic functioning of the assembly and finally as a dynamic test model in a live electrical circuit. Four general iterations were made to the assembly although many more minor individual component iterations were made. FDM components were made at each stage.

*MTE*'s decision to use FDM Rapid Prototypes was justified when the production tooling was delivered and proved to be right first time. In the global marketplace there are obvious advantages derived from reduced time to market, being able to prove the design using Rapid Prototyping also saves on costly changes to the production tooling. The Senior Design Engineer was and still is effusive in his praise of the Rapid Prototyping process and FDM in particular. His reasons for choosing FDM are very clear, "Unlike the typical Rapid Prototype example of a mobile phone where a concept model is acceptable, our part had to function so our prototype had to as well".  
(Reproduced from Design News April 1998)
B.10 Industry standard payment terms

The Issue
The products and services that are provided by the Rapid Product Development sector are high-value. Projects can take some time to complete. Also, payment at the end of a project can take a considerable time to realise (160 days is not unknown). This often means user companies become long-term debtors to their RPD suppliers, thereby making planning for reinvestment in new capital items of equipment and services very difficult. Of greater importance, a robust business becomes more highly geared than was desirable and could be perceived to be "in financial difficulty". In order to release cash into the RPD sector for further sustainable growth, there was a need for industry standard payment terms.

Customer Response
Although this issue related to the faster payment of invoices, 70 per cent of the user companies agreed that this was a good proposal.

Action Group Discussion & Recommendations
Much discussion was held regarding this issue. There was general agreement that industry standard payment terms were necessary. But concern was expressed over a need for acceptable terms and for all companies to comply with these terms. It was considered that a sector trade association should address this issue. Also, if it was going to work, then supply chain education and commitment was vital. Insofar that in Sweden rapid payment was the norm, the Swedish approach was suggested as being a role model. It was agreed generally that UK manufacturing companies have been allowed to get away with late payment, and that this is one of the reasons that there has been little real growth in value-added services.

The group also considered that the government should become involved in this issue and help drive the message home to the OEMs and first tier suppliers that their value-added providers were being crippled or made bankrupt by poor payment.

The actual terms were discussed, these included the adoption of the toolmakers 1/3, 1/3, 1/3 payments. This was however considered inappropriate to prototypers who, for example, produce the product so quickly that 50 per cent payment on order and 50 per cent on delivery was more suitable. The design section proposed that all

Annex

Industry standard payment terms must be introduced

Value added providers are being crippled or made bankrupt by late payment

Case Study: Hozelock

STYLES

What?
- 5 off Hozelock Backplates in PP similar material in the correct colour and texture

Why?
- Market Testing
- Integrity of Design
- Prove CAD data
- Exhibitions

How?
Layer removal on SLA Model
Extensive painting and texturing
Large silicone rubber tool
5 off PP similar vacuum castings

Where?
All under one roof at STYLES

How Long?
2 Working weeks

Background Information
Operating worldwide, Hozelock is one of Europe's leading manufacturers of gardening equipment with its own vacuum casting department. However, since most of its components are quite small it did not have the size of machine necessary to produce a newly designed carry handle back plate for one of its hose reels.

Producing high quality prototypes of this new product was essential for Hozelock as it is a company policy to test market to ensure total market satisfaction prior to tooling.

Hozelock also places major emphasis on standards of corporate identity. The carry handle back plate prototype therefore needed to be produced in Hozelock Grey.

Prototypes of equal quality were also produced in green.

Senior Designer Nick Laciofano said: "STYLES approached the job professionally and we were all well pleased with the turn-around and the finished products".

Models produced by STYLES were shipped and exhibited to agents throughout Europe and sufficient was the quality that the whole exercise achieved its objective. Hozelock's pre-marketing appraisal exercise was successful and has now contributed to the promotion of the end product.
Trust and communication is required between like-minded providers

Although communications developments, such as fax, email and mobile phones, have added a new dimension to communications they have also added complexity. In November 1996, BT Laboratories at Martlesham approached Minima for industrial design input with an internet telephony project. BT engineers had developed software and hardware solutions which combined the benefits of personal numbering, and universal messaging to deliver voice, fax and email messages to a single mailbox. Messages could be retrieved and managed easily by telephone, or via an "easy to use" web site.

The aim of the project was to produce three working models of the "phone" for display at BT's 'Innovation 97' exhibition at BT Laboratories. Two variants were required based upon a modular build of plastic mouldings designed by Minima using 3D CAD software. One version was to be the "business" version and would consist of charcoal grey coloured mouldings utilising a 10 inch adjustable colour LCD screen along with a retractable full QWERTY keyboard. The second was to be the domestic version with white coloured mouldings and integral colour LCD touch screen and retractable QWERTY keyboard for use in the home.

The project had to be completed in less than 4 months from concepts to prototype. From the outset it had been decided by Minima that stereolithography models and subsequent vacuum castings of the plastic parts was the only process that could deliver the accuracy and high quality finish necessary to achieve a successful outcome in such a short time frame.
Annex

B.12 Operating standards

The Issue
Typically, the UK product development sector was served by clusters of RPD supplier companies offering specialist high-value-added products and services. Each supplier company had its own operating standard which could vary considerably between "like" providers. This confuses the user company and the right quality and service may not be provided, thereby devaluing the customer's perception of the RPD sector. The creation and implementation of sector industry standards may help to give customers a better perception of a high value of service provision.

Customer Response
70 per cent of user companies thought that operating standards would improve the service and the perceived value of the UK Rapid Product Development sector.

Action Group Discussion & Recommendations
The principle of operating standards did not pose a threat to the more established companies. In general, most of the action group members thought that standards were good, even if the actual delivery of such would be difficult in current market conditions. Appropriate ISO standards were considered to provide the most logical basis for creating operating standards. It was also considered that a trade association would be best placed to develop the correct standards.

B.13 Audited benchmarking

The Issue
An initiative was needed to present technological solutions to the sector and users in a factual and audited fashion. Thereby removing the potentially high-risk strategy of implementing inappropriate or sub-standard technological solutions.

Customer Response
67 per cent of user companies thought that benchmarking was a positive move.

Action Group Discussion & Recommendations
Benchmarking was considered to be a useful tool that was best carried out via collaborative programmes that were organised through a recognised trade association. It was considered necessary to undertake a benchmarking exercise to determine how the UK Rapid Product Development sector stands up to overseas competition.

Continued communication was seen as necessary - through regular meetings and an exchange of ideas. Indeed, it was argued that this feasibility study was an example of the kind of regular exchanges needed.

Benchmarking is needed to determine how the UK RPD sector performs in comparison to overseas competition.

ISO standards provide the best foundation for quality and overall operating standards.

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Case Study: GPT 'Payphone'

AMSYS

Liverpool-based GPT Payphone Systems is a company at the forefront of the rapidly evolving global telecommunications industry, designing, manufacturing and supplying state-of-the-art public payphone systems to markets across the Americas, Europe, the Far East and the Middle East.

Ken Francis, of the company's Mechanical Design Department, has little doubt that state-of-the-art rapid prototyping and tooling services offer organisations many advantages, fundamentally reducing the whole product-to-market lifecycle and delivering major cost savings. He said: "Rapid prototyping and tooling enable us to create fully functional models as early as possible in the design process. These can then be assessed and evaluated before committing to final production. It allows us to stay on track with new product development and customer service and remain one step ahead of the competition in the markets we serve."

A long time user of SLA (Stereolithography) techniques, Ken was only recently introduced to AMSYS SLS. He was very impressed with the company's one stop service when a new project landed on his desk as part of a major order to supply payphones to Thailand. The project required GPT to convert a four coin handling mechanism for a public payphone into one that would take six coins using the same space envelope. The Mechanical Design Department had just 17 weeks in which to design, prototype, prove and manufacture in volume a new coin runway component.

"SLS was new ground for us," said Ken Francis, "I was impressed with the potential of SLS, particularly the fact that we could produce tough and durable fully functional prototypes that would withstand hard testing. Ken Francis also became aware of other perceived advantages he would obtain by using AMSYS; notably that the company could provide rapid prototyping, rapid tooling and a low volume moulding service as a totally integrated package.

Ken Francis: "AMSYS produced first off which fell within design tolerance constraints first time around. It meant that I had samples six weeks ahead of schedule. This enabled us to produce 10 complete pre-production payphones and shipped them out for field trials in Thailand ahead of schedule." The success of the field trials confirmed that both the design and tooling tolerances were correct and that the new mechanism worked properly.
Sector identity is vital in securing a network of service suppliers.

B.14 Audited technology transfer activity

The Issue
An initiative was required to provide technological solutions and management principles to the sector. This would improve the operational and technological competence of the sector.

Customer Response
60 per cent of user companies thought that audited technology transfer activities were necessary.

Action Group Discussion & Recommendations
Technology transfer activities were generally considered to be a mixed blessing. In part, good work had come from some of the activities but there appeared to be little enthusiasm to generate more "grey material" (i.e. unsubstantiated claims and counter claims of technical performance).

In common with the sentiment from the learning curve trial issue, there was a call for companies to stand on their own feet and know their subject.

B.15 Audited 'New Technology' evaluation programme

The Issue
There was a need to audit emerging and experimental technologies to reduce "hype" and the confusion surrounding many technological solutions targeted at the sector. This would reduce the risk of implementing new solutions and improve the take-up of emerging technologies. An 'accreditation' process must be undertaken and endorsed to ensure that only robust and proven technological solutions were encouraged.

Customer Response
62 per cent of the user companies thought that an audited technological evaluation programme was desirable.

Action Group Discussion & Recommendations
There was concern relating to the possible imposition of formal procedures (perceived as "red tape") and the policing of any programme of evaluation. The RPD sector companies thought that it was best to evaluate the commercially viable technologies as they appeared in the market place. Because the solutions would have to pass any sector standards as a matter of course, it was considered that a link to sector operating standards would safeguard the interests of user companies.

B.16 Guide to Rapid Product Development services

The Issue
In order to provide impartial information and guidance regarding Rapid Product Development services an audited guide - both electronic and printed - should be developed.

Customer Response
This was readily acceptable to the user companies who gave it 74 per cent level of their support.

Action Group Discussion & Recommendations
This was considered to be a very useful tool that could easily raise the profile and awareness of the sector. The guide could link to existing documents and initiatives, such as the GTMA Toolmaker Guide, to provide a comprehensive listing of all product development related services (rapid and traditional).

B.17 'World-class' Rapid Product Development practitioner profile

The Issue
To assist practitioners improve their services and operations, in common with the GTMA world-class toolmaker profile, there was a need for a world-class Rapid Product Development practitioner profile. The profile would also assist user companies to benchmark and rank potential supplier companies.

Customer Response
This was well received by the user companies who rated the proposal with a support of 69 per cent.

Action Group Discussion & Recommendations
This issue was considered to link directly to industry operating standards and the need for a sector specific trade association. It was considered that the development of a "profile" could be carried out in association with other organisations, such as the GTMA. But having a sector identity was also considered to be of vital importance in securing a network of service providers.
B.18 Industry standard apprentice schemes

The Issue
Lack of suitably skilled people within the sector was perceived to be a major limiting factor to growth and sustainability. There was a need for a national industry-standard apprentice scheme covering the particular specialities and fundamental aspects of the sector.

Customer Response
76 per cent of user companies were in favour of more and improved apprentice schemes.

Action Group Discussion & Recommendations
Many of the action group participants thought that current apprentice schemes lacked credibility within industry. This was not however to suggest that there was no need for apprentice schemes, but rather the contrary. Most participants thought that many more apprentices were needed across the whole range of skills and disciplines of Rapid Product Development. Lack of substance and skills training were cited as the main areas for concern and there was a call for new schemes to be developed.

B.19 Industry academic qualifications

The Issue
The product development process embraces many aspects of 'engineering' and 'design'. However, the fundamental level of understanding and appreciation of product development by graduate engineers was generally low. This was due to the traditional nature and format of established engineering degree courses. Therefore, academic training and qualifications that align more closely to the sector were necessary.

Customer Response
67 per cent of the user companies thought that more applicable academic courses were necessary for the future growth of the sector.

Action Group Discussion & Recommendations
It was noted that some newer degree courses provide more specialist knowledge of RPD, these were product design degrees which were sufficiently promoted and well known to RPD supplier companies. The major consensus of the group argued for a need for courses, both under-graduate and post-graduate, that link a good fundamental foundation study with the intricacies of Rapid Product Development. There was a call for good sandwich courses that were supported by company placements. Company placements were considered vital and would be useful to the company as well as to the student. Institutional accreditation was also considered necessary.

B.20 Industry professional qualifications

The Issue
If the sector was to grow and add wealth, then recognition of the professional value of the sector’s practitioners was necessary. There was an immense 'knowledge base' within the product development sector. However, this knowledge did not necessarily match the requirements of standard 'professional' qualifications - despite the growing universal demand for professionally recognised practitioners. Therefore, appropriate qualifications must be developed and applied.

Customer Response
The user companies did not rate the proposal as highly as the apprentice or academic issues. However, the proposal still had a support of 64 per cent.

Action Group Discussion & Recommendations
It was pointed out that professional qualifications and accreditation already exist and were controlled through certain professional institutions, such as the Institution of Engineering Designers. However, it was agreed that there was a case for better signposting and promotion. There was a strong view that any professional qualification or accreditation must be linked to Continued Professional Development (CPD) and that many companies should be encouraging this activity within their own organisations.

B.21 Sector Trade Association

The Issue
A sector trade association was needed that covers the needs of the whole Rapid Product Development sector.

Customer Response
72 per cent of the user companies agreed that a sector specific trade association would help to boost the image and "presence" of the sector.

Action Group Discussion & Recommendations
In principle all participants of the action group meetings agreed that there should be a trade association. There were two basic schools of thought regarding a trade association, these were:
- **Affiliate to an existing body**
- **Create a new body**

It was considered that affiliation to an existing body had some merit insofar as the charter and operating principles were already established. There were however genuine fears that the sector could be overpowered by existing trade bodies and, as a result, the core principles of the Rapid Product

Many more apprentices are needed across the RPD sector

Professional qualifications and accreditation should be linked to CPD and companies to encourage staff participation

Work placement in companies during academic courses is necessary
Development sector (i.e. rapid, responsive and customer focused service) would be lost.

The majority of the participants of the action group were however strongly in favour of developing a new association. It was proposed that a body be established that was focused on the core principles of Rapid Product Development. It would not however preclude companies affiliating to other appropriate technology-led bodies.

It was recommended that the new body focus on developing the identity of the sector and working with government to establish the business benefits in the boardrooms of UK industry. Likewise, the body should work on educational and operational standards to secure the future of the sector and thereby that of UK manufacturing industry.

The possibility of merging the new association with an existing one was not ruled out, once the image and direction of the sector had been established firmly and a level of credibility reached.

B.22 Licence to practice

The Issue
There was a call to issue ‘licences to practice’ for both user companies and their employees. Supplier companies argued that this would raise standards and increase the level of perceived value within the sector.

Customer Response
This proposal was not particularly well received by the user companies who only gave it 56 per cent support. This score appears to be partly due to a fear of "over-kill" - leading to additional costs.

Action Group Discussion & Recommendations
On reflection, the action groups were in agreement that, in the short-term, enforced licences were more of a hindrance to the sector than a benefit. This response was a reflection on the comparatively young nature of the sector and the need for other issues, such as the trade association, to be dealt with in the first instance.

However, it was pointed out that individual licences already exist via the Institution of Engineering Designers’ (IED) ‘Design Register’. It was agreed that this needs to be promoted and encouraged further.

It was also considered that corporate licences could be eventually linked to operating standards - similar to ISO standards.

B.23 Supply Chain education

The Issue
A process of continued education was necessary, both formal and informal, for user companies. The dissemination of knowledge will highlight the ‘value-added’ nature of Rapid Product Development. This activity should link directly to the benchmarking and evaluation programmes.

Customer Response
70 per cent of the user companies agreed with the proposal for supply chain education.

Action Group Discussion & Recommendations
Supply chain education and the boardroom education (see Section 9.24) were considered to be key action points from the feasibility study. It was considered that, if education was well provided for, then the rest would follow.

It was agreed that an umbrella organisation be established (a new trade association) whose main aim would be to promote the RPD sector through targeting key people within manufacturing industry. This target group would include business decision-makers such as directors, senior managers and purchasing personnel, and include people not necessarily familiar with the sector. This should be undertaken in association with the media and linked to equivalent ‘professional’ associations such as the IOD and CBI. The action should be lead by government ministers and captains of industry.

B.24 Boardroom education

The Issue
An initiative was needed to educate senior decision-makers in the benefits of Rapid Product Development and the nature and ethos of manufacturing products with a high value-added content.

Customer Response
70 per cent of the user companies agreed with the proposal for supply chain education.

Action Group Discussion & Recommendations
In common with the supply chain education issue (see Section 9.23), the "boardroom education" was considered to be of critical importance to the future competitiveness of UK industry. There were calls for the Government to action this initiative with immediate effect.
B.25 Active 'signposting' mechanism

The Issue
A body was needed that was independent of all regional and national affiliations, and who were conversant with all aspects of Rapid Product Development, to 'signpost' (i.e. direct) interested parties to the relevant service providers.

Customer Response
65 per cent of the user companies thought that better 'signposting' was needed for the products and services provided by the Rapid Product Development sector.

Action Group Discussion & Recommendations
The action group participants considered this activity to be necessary, but that it would be best provided through a trade association. Once the identity of the RPD sector had been established, the groups also considered that a network of activities linked through existing providers would also provide benefit.

B.26 Web-site locator of services

The Issue
A web-site should be established (which was aligned with the 'signposting' activity) covering the sector and linking to the web-site home pages of the RPD providers.

Customer Response
82 per cent of the user companies thought that a web-site based product and service locator would be of use.

Action Group Discussion & Recommendations
There was no negative reaction to the principle of a web-based product and service locator, the only issues were the management of the web site. Once again emphasis was given to the need to establish a trade association in the first instance.

C.1 Feasibility Study Directors
Lee E J Styger
STYLES Precision Components
Unit 79
Sadler Forster Way
Teesside Industrial Estate
TS17 9JY
Tel: 01642 769930
Fax: 01642 762352
E-mail: lee.styger@styles.co.uk

Mike Osborne
The Institution of Engineering Designers
Courtleigh
Westbury Leigh
Westbury
Wiltshire
BA13 3TA
Tel: 01373 822 801
Fax: 01373 858 285
E-mail: ied@inst-engg-design.demon.co.uk

C.2 Participants in the Feasibility Study
Hugh Smith
Albyn
Spurrihilllock Industrial Estate
Stonehaven
AB39 2NH
Tel: 01569 763 320
Fax: 01569 766 464

Dion Griffith
AMSYS Rapid Prototyping
Sunderland Enterprise Centre
Wessington Way
Sunderland
Tyne & Wear
SR5 3XB
Tel: 0191 515 3333
Fax: 0191 515 3334

Peter Rawson
Arrk Europe Ltd
Unit 11
Commercial Way
Abbey Road
Greater London
NW10 7XF
Tel: 0181 961 6366
Fax: 0181 965 0201

Mike Bourne
Bourne Tools
Clayhanger Road
Brownhills
Walsall
West Midlands
WS8 7BL
Tel: 01543 378 123
Fax: 01543 360 070

Russ Harris
De Montfort University
Dept. of Mechanical & Manufacturing Engineering
Queens Building
The Gateway
Leicester
LE1 9BH
Tel: 0116 255 1551
Fax: 0116 255 7025

Peter Dallaway
Department of Trade and Industry
151 Buckingham Palace Road
London SW17 9SS
Tel: 0171 215 1534
Fax: 0171 215 1518

Trevor Thompson
Diametric Ltd
Ramshill
Petersfield
Hampshire
GU31 4AT
Tel: 01730 262511
Fax: 01730 268 708

Tom Bainbridge
Douglas Plastics
Douglas Industrial Estate
Douglas
Lanarkshire
ML11 0RA
Tel: 01555 851 398
Fax: 01555 851 065

Mark Hadlum
BSc(Hons), CEng, FIMechE
Engineering Services Manager
Edwards High Vacuum International
Dolphin Road
Shoreham by Sea
West Sussex
BN43 6PY
Tel: 01273 444330
Fax: 01273 440 365

Brian Wilson
Express Group
Express Holdings (Thompson) Ltd
Express Technical Centre
Kingsway South, Team Valley
Gateshead
Tyne & Wear
NE11 0JL
Tel: 0191 491 4400
Fax: 0191 491 4286

Irvine Manning
Fletcher and Hamilton Group Ltd
Grove Street
Cheltenham
GL50 3LZ
Tel: 01242 514 619
Fax: 01242 226464
Annex

Burton Steele
Greencroft Graphics
3 Willow Drive
Blantyre
Glasgow
G72 9HE
Tel: 01698 825138
Fax: 01698 825138

Steve Eyles
GTMA
3 Forge House
Summerleys Road
Princes Risborough
Bucks
HP27 9DT
Tel: 01844 274 222
Fax: 01844 274 227

J Geoff Allison IEng, FIED
Hon. Secretary North East Branch
Institution of Engineering Designers
8 Watson Road
Newton Aycliffe
Co. Durham
DL5 5JX
Tel: 01325 312764

Jerome D. Poole
IEng, REngDes, FIED, MIMgt
Chairman of Council
Institution of Engineering Designers
13 Humphrey Burton’s Road
Coventry
CV3 6HW

Ross Nichols
Malcolm Nicholls Ltd
Waterloo Industrial Estate
Biddford-on-Avon
Warwickshire
B50 4JH
Tel: 01789 490 382
Fax: 01789 490 130

Martin Peters
Martello
21 Albany Business Park
Cabot Lane
Poole
Dorset
BH17 7BX
Tel: 01202 659 494
Fax: 01202 659 495

Gary Collins
Ogle Design Limited
Birds Hill
Letchworth
Hertfordshire
SG6 1JA
Tel: 01462 682661
Fax: 01462 674814

Tim Cole
RP Solutions
Unit 20
Coventry Canal Warehouse
Leicester Row
Coventry
CV1 4LH
Tel: 01203 632 120
Fax: 01203 632131

David Royle
RPD Design
3 Van Dyke Road
Oadby
Leicester
LE2 5UB
Tel: 0116 271 7838
Fax: 0116 271 7838
E-mail: Lion57@aol.com

Louise O Gorman
RTC North Ltd
1 Hylton Park
Wessington Way
Sunderland
Tyne & Wear
SR5 3SD
Tel: 0191 516 4400
Fax: 0191 516 4401

Mike Gilman
Rugby Design Group
9 Summers Road
Summers Road Industrial Estate
Rugby
Warwickshire
CV22 7DB
Tel: 01788 572 841
Fax: 01788 578 609

Tony Sanders
Sanders Associates Ltd
1 Mill Lane
Redworth
Newton Aycliffe
Co. Durham
DL5 6NP
Tel: 01388 773007
Fax: 01388 773007

Stanley Oliver
University Of Sunderland
Automotive & Ergonomics Research Group
Engineering & Adv. Technology
Edinburgh Building
Chester Road
Sunderland
SR5 3SD
Tel: 0191 515 2868
Fax: 0191 515 2631

Andrew Chantrill
T2M
Sandpipers
Waterloo Close
St. Mawes
TR2 5BD
Tel: 01326 270 712
Fax: 01326 270 102

Dave Wimpenny
ATC
University of Warwick
Coventry
CV4 7AL
Tel: 01203 524 722
Fax: 01203 524 878

C.3 Acknowledgments

The sponsors and organisers would like to register their thanks to the following individuals and organisations for their support and assistance during the execution of the feasibility study:

John McRae
John McRae Marketing Consultancy
176 New Bridge Street
Newcastle upon Tyne
NE1 2TE
Tel: 0191 209 0080
Fax: 0191 209 0079

Bruce Hunter
Parametric Technology (UK) Ltd.
Block A
Fifth Avenue Plaza
Queensway North
Gateshead
Tyne & Wear
NE11 0HF
Tel: 0191 491 5665
Fax: 0191 491 4888

Allison Griffiths
STYLES Precision Components

Becky Phelps
STYLES Precision Components

Karen Sweet
STYLES Precision Components

Barry Dagger
Editor: 'Engineering Designer' journal
Institution of Engineering Designers
Feasibility Study Director
Mike J Osborne
Secretary
The Institution of Engineering Designers

Mike Osborne was appointed Deputy Secretary of the Institution of Engineering Designers in April 1982 with the intention that he would succeed the then Secretary. He formally took over the office of Secretary of the Institution on 1 May 1988.

Following a three year engineering apprenticeship from 1952 to 1955 he began his career in the Royal Electrical and Mechanical Engineers as an Aircraft Technician, which was followed by a varied life in the Army Air Corps responsible for the maintenance supervision of aircraft in many parts of the World. He was commissioned in 1969 becoming an Officer Commanding various detachments and workshops, following which he spent 2 years developing aircraft training courses for officers from overseas. He left the service in 1976 in the rank of Major, his last appointment being the commander of a unit for soldiers undertaking mechanical training courses.

On leaving the Army and prior to joining the Institution he worked in several different roles for a pyrotechnic company, first as a Sales Co-ordinator, then Military Sales Executive and finally Sales Administrative Manager, supplying safety pyrotechnics and related equipment worldwide to civil and military authorities. This work took him to many different countries throughout Europe, the Middle East and North America.

On joining the Institution he settled into the rather different world of Professional Association business bringing both management and supervisory skills on top of his engineering background, sales promotion and public relations understanding.

Mike built up, almost from scratch, the Institution’s Register of Engineering Designers, played a key role in the early computerisation of the Institution’s administrative work, development of the Institution’s headquarters premises, and launched a series of design related Courses, Seminars and Conferences.

He also played a lead role in setting up the Institution’s Continuing Professional Development scheme which was established in April 1991 which is open not only to members but also companies with design departments.

Mike is a Fellow of the Society of Association Executives and Member of the IED.

Feasibility Study Initiator and Director
Lee E J Styger
Executive Manager: Technology & International Special Projects
STYLES Precision Components Ltd.

Lee originally qualified in Three Dimensional Design and was awarded a second diploma in Product Design. He subsequently completed a MSc in Engineering (RPD) and became an Incorporated Engineer. He is a Senior Member of the Society of Manufacturing Engineers (Hong Kong Chapter), a Member of the Institution of Engineering Designers and an Associate of the Institute of Materials.

Lee has a broad experience of industry, with a particular emphasis on Rapid Product Development from both a practical and consultancy stance. Lee was a member of a traditional OEM product development team, before spearheading the development and introduction of new, radical and rapid product development techniques into the same and other organisations. He was later a consultant to companies from around the globe and trained their personnel.

The resumé of Lee’s work illustrates clearly that he is very much regarded as one of the founding fathers of Rapid Product Development in Europe. He holds a strong vision of the future of the Rapid Product Development industry.

Because the STYLES Precision Components’ Executive Team required a new member who was able to carry out much needed technological development and special project activities that were critical to our future development, I approached Lee to join STYLES in July 1997.

In the first 10 months of joining the Company, Lee introduced a new RIM moulding technology, a lost core moulding system and a system for injection moulding short runs of plastic components from a stereolithography pattern. Other areas of work included an IT and year 2000 review, CAE benchmarking and selection, plus negotiation with various government bodies.

Lee has also carried out a 5-month search and selection procedure for potential sites and partners in Europe for the development of the STYLES business. His work in Europe has also included negotiation with state, regional and local government offices and service providers along with establishing an innovative training framework with local government offices and academic providers.

Since joining STYLES, Lee has acted very much as the facilitator of the executive group, “a fixer” helping the members crystallise their vision of the future. Although Lee’s role has been strictly non-operational, the Company has benefited greatly from that approach. The fast growth of any company relies as much on outsiders such as support agencies, suppliers, associates and “friends” as it does on internal operational people. Lee will continue to seek out and build these relationships and do what he does best, handle and deliver new assignments, critical to the long-term future of the sector.

G Styles
Managing Director
STYLES Precision Components Ltd.
Adding Value through Product Development

Lee Styger MSc IEng MIED SnrMemSME AMIM

Introduction
The recently published Bortun Group report states that top executives of manufacturing industry have identified 'product time-to-market' as one of the top three pressures on their business. 'Cost-down' was reported to be the most important issue followed by increasing 'shareholder value'. The report goes on to suggest that only 10 percent of industry is achieving 'great success' in new product introduction, with most companies being disappointed or unsuccessful in key aspects of their innovation.

Companies may have the right products, in the right markets, at the right time. The European Union (EU) represents the largest single market in the world. There are however a plethora of economic reports that state that volume manufacturing is migrating to emerging economies where the total fixed cost is considerably lower than that in the EU. Indeed it is not uncommon to find the quoted financial overhead figures as low as one-tenth the average EU rate. What is more, figures of similar size are also cited from the emerging economies of the old USSR i.e. right on the doorstep of the European Union.

Put simply the engineering and manufacturing organisations of the European Union cannot compete globally on price alone.

Competitiveness through Value-added
The value-added of a product can be thought of as being the extra (tangible or intangible) worth it has above and beyond its market rivals. For example, the superior attributes of performance or quality of a vehicle, the unique colour or material combination of a fitted kitchen or the better service provided by one bank over another. If the European Union's engineering and manufacturing organisations cannot compete globally on price alone, then they can compete successfully on value-added products and services. And, certain sectors of the market command greater value-added and thereby create greater profit margins. Market opportunities in these value-added sectors are also continually improving.

In order to sustain a competitive advantage, manufacturing organisations in the EU must engineer and manufacture products that exploit value-added opportunities. They must therefore develop and implement strategies that satisfy the punishing demands of the "value-added" approach to new product development.

Profit through Value-added
Any company that can get their product to market first will win the majority share of the profit from that market segment and set the pace of change - in short, to add value\(^4\). Companies entering the market later will have to compete on price to win market share and as such will be unable to achieve the same potential total profit over the lifespan of the product's market. Also, the company that is first to market will have developed much knowledge and skill in producing the product using the most efficient and effective manufacturing processes. The company has in effect become well trained and "practised" at manufacturing that particular product - it has become "fit". Fit companies are able to reduce manufacturing costs and thereby increase profit margins and/or reduce sales price despite the competition from products that enter the market later. At the point in time when a second company enters the market with a competing product it is not as "fit" as the pioneering first-to-market company. Manufacturing costs in "follower" companies tend to be higher and productivity lower at the point of product launch. To gain market share, the follower company must also enter the market with a lower cost and higher "perceived value" of its product. In consequence, profit margins are usually lower.

In the design process (i.e. the place where "value and cost" are set for the product) corners cannot be cut and unsatisfactory low cost engineering design options chosen. You get what you pay for and in the case of product development the "price" may have no relationship to the actual "cost".

Product design and development have become boardroom issues that need to be understood and valued during all stages of formulating and following the company's business strategy. Also, if industry is truly going to be able to increase its profitability through value-added products and services, then strategic decision making on the sole basis of anticipated selling price behind the resourcing of product design and development must be changed.

Product Half-life
It is generally recognised by most companies in the EU that they cannot compete on price with the lower cost nations of Eastern Europe or the Asia Pacific Rim. The U.K. Government have proposed the principle of a "knowledge based economy". Whereas, because of the "knowledge, quality and extras" put into them, companies are able to compete by creating products and services that have a higher "value".

If the proposal of value-added products and services through a knowledge based economy is accepted and that the route to this is through manufacturing industry's new product development, then companies (and designers in particular) are faced with the burning issue of product half-life (i.e. the shelf-life or potential window of sale for any product).

There are various theories concerning the calculation of product half-life. But what is actually happening is that it is shortening at a phenomenal rate. One recent estimate stated that the need for new products would double in the next five years. This is coupled to an increase in product range (niche production/ mass customisation) and complexity. The reality is that any truly competitive company must be able to develop a new replacement product in the salable life of the existing one, that is:

Company Risk = Development Time + Market Exposure of the product + Product Replacement Development Time

However, if market exposure time is reduced (the product's market lifespan), then the company must be capable of reducing its design process and product development time accordingly. This may be achieved through increases in capacity, productivity gains etc. This is also where so called "rapid technologies" assist greatly.

However, this approach does not necessarily take into account greater product diversity and complexity i.e. the need for more sooner. The tools and aids to the product development process (CAD, rapid prototyping, high speed machining etc.) can be easily purchased by any forward looking organisation. These tools offer the possibility of great improvements to the speed of product development. But, the ability to utilise these tools and deliver more products to market more quickly is in the hands of people. The fact is that the skilled people concerned, especially engineering designers and product developers, are hard to find and take a long time to educate and train.

Where Have All the Engineers Gone?
The current available evidence suggests that the industrial base of the EU has a major opportunity in the fast, dynamic economy of high valued-added products and services. If exploiting the skills of designers and engineers is critical to the future success of EU industry, then the knowledge base of these people is the fundamental to its future. However, the statistical data does not necessarily match with much of the evidence (government, industrial and academic) that indicates that there will not be enough skilled people capable of driving this process.

Many companies have set ideas about the “right” people and those who will "fit in". The profile of good engineering designers and product developers does not always match with many people’s perception of a "company man". The profile of good engineering designers and product developers does not necessarily match with the usual and more accepted profile of "company people". For example, real "value-adders" will have the ability to:

- Thrive in chaos
- Thrive in disorder
- Excel at off-the-wall projects
- Excel in challenging environments
- Embrace anything new
The Value-added Providers

The "value" of a product is typically determined at the design stage, for example, where product cost can be "engineered out" and extra value and functionality incorporated. The role of product development and indeed that of engineering and product designers is therefore becoming more and more critical for success.

Manning claims that many of the companies involved in the product development sector employ less than 50 people. He also claims that it is these companies who provide the foundation of manufacturing industry by supporting and supplying high value-added products and services to the first tier supplier (typically employing >500 people) who in turn supply the assemblies and systems to the OEM (typically employing >5000 people).

Value-added Providers

<table>
<thead>
<tr>
<th>Products</th>
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</thead>
<tbody>
<tr>
<td>Innovators &amp; Developers (50 People Centres)</td>
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</table>

Therefore, the knowledge base (value) is housed and managed within the "front end" activities of manufacturing (i.e. Rapit Product Development), be it internal or external supply. Any design constraints, project mismanagement or malpractice will have a direct effect on the viability of any given product. Ultimately these limitations will affect the profitability and competitiveness of the company.

The Culture of Price and Cost

Industry located within the EU must reduce cost where it can, but it must also learn to invest properly where it should in order to increase the value of its products. Effective and professionally managed design and product development will add value to any product. Ineffective, mismanaged design and product development will limit the value of the product and the performance of an otherwise highly profitable manufacturing organisation will thereby be eroded.

The managers concerned are not quality managers or process managers because, by their very nature, they seek to change products and processes as soon as they come into contact with them. However, design and development managers are in the business of seeking, developing and productionising innovative ideas and should be respected and valued for this ability.

Innovative ideas are what is needed from the top to the bottom, and the bottom to the top of organisations. However, innovative professionals will only become proficient through a combined process of exemplary training, coaching and appropriate industrial managerial responsibility.

Training for Value-added Manufacturing

The traditional and well-publicised view of training provides a profile like a thin "T" that is overburdened with excess "management and business" training. This is shown below.

Management Training

Whereas a more effective training profile for designers and product developers places a strong emphasis on professionally relevant training with a less burdening amount of "management and business" training. This is shown below.

Management Training

Technical Competence

Manufacturing Technology / Product Development

Traditional view of the importance of technology in a manufacturing company

Designers / Engineers

Product Development / Business Process

Whereas the real value can only be properly achieved in the product development process by turning the triangle upside-down which can be represented as:

Manufacturing Technology / Product Development

An alternative scenario of the importance of people within the product development process

Designers / Engineers

Product Development / Business Process
Real product value can best be added by an organisation as a result of giving priority to exploiting the skills of its product design and development people and subsequently applying the right technologies to make product development rapid and responsive.

Conclusions

The drive for operational efficiency can often starve a company of necessary resources and therefore lead to corporate stagnation. Executives must continue to focus on increasing shareholder value and this can be achieved, in part, through an exercise of reducing manufacturing and operating costs. However, value-up is more important and value-added can best be achieved through a comprehensive knowledge base and the ability of an organisation to transfer that knowledge into value-added products and services. Value-added is therefore a people issue, because it is the product design and development professionals who are able to add value to products and take cost out. Engineering and product designers are "value-adding" and need to become accepted within the organisation as such. To achieve this, full commitment and investment must become a board level issue because:

no knowledge base = no value-added = no ability to compete

Lee Styger is International Projects Director with Styles Rapid Prototyping Limited who specialise in the rapid production of prototypes and short-run plastic components. Lee is Chairman of the IoM Plastics Design Committee. For more information contact: Lee Styger, Styles Rapid Prototyping Limited, Unit 79, Sadler Forester Way, Teesside Industrial Estate, Thornaby, Cleveland TS17 9LY, Tel: +44(0)1642 769930, Fax: +44(0)1642 762352, Email: rapid.prototyping@styles.co.uk.

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Integrated education and the rapid product development sector

L E J STYGER
STYLES Rapid Product Development, Teesside, UK

SYNOPSIS

Standard academic products such as the MSc and PhD are well suited for those destined to enter into research based careers, but not particularly appropriate for design engineers following a career in product development. Today’s commercial environment demands that good product development practitioners will be well trained and proficient in a broad range of subjects, however, there are no standard “qualifications” for the “professional RPD engineer”. This paper outlines the trends of the sector, provides a proposed framework for formal and professional recognition and finally, an over the horizon forecast on the future trends offered.

1. INTRODUCTION

In his opening remarks of the Mouldmaking 2K conference, D Barlow stated that he could be “presiding on the last meeting of a sector in terminal decline”1. The comment was made specifically with the UK toolmaking industry in mind and in this context was just and applicable. There is however a much larger question of total sector definition, change in market requirements and the longer-term prognosis of potential inherent opportunity.

Toolmaking is one of the sub-sections of the Rapid Product Development sector (RPD). The sector has massive potential when viewed in a holistic manner, yet the EU RPD sector currently lacks visibility and coverage, especially in the provision of applicable skills and education.

This paper covers three areas:

- A definition of the Rapid Product Development sector, industry trends and sector growth
- A proposed framework for a holistic educational and training system
- An over-the-horizon forecast on the future of the rapid product development sector without a holistic educational and training system
2. A DEFINITION OF THE RAPID PRODUCT DEVELOPMENT SECTOR, INDUSTRY TRENDS AND SECTOR GROWTH

2.1 A Brief History of the Rapid Product Development Sector
The origins of the RPD sector can be traced back to the late ‘80’s. The RPD sector evolved primarily as a business process (supported by advanced technology) for designing and developing products rapidly. The key to the sector was the ability to "productionise" craft skills brought together from traditionally isolated specialist services such as engineering design, drafting, model and patternmaking and toolmaking etc.

Much time has been given to the technical aspects of RPD. It is however sufficient to state that the core driver for the RPD sector is CAE technology, but as with the traditional services, people remain the real issue for continued success.

There are some unique dynamics within the RPD sector. For example order books are typically short, debtor days (payment after delivery to the client) are long. Accurate business predictions are therefore impossible and the management of cashflow is primary. There is always a major conflict between workshop capacity and cyclicity of the marketplace. There is little understanding for the management of this type of business outside of the sector.

2.2 Definition of the Rapid Product Development Sector
The European Rapid Product Development sector is defined as those companies that are providing services involving the rapid design and development of products for a third party manufacturing organisation. The sector may include organisations practicing any and/or all of the following activities:

• Conceptual design
• Engineering design
• Test and analysis
• Modelmaking
• Prototyping
• Short-run or bridge production
• Value-added/niche manufacture, etc.

The distinguishing features of a “Rapid Product Development service provider” are:

• Rapid and responsive
• Customer focused
• Fast and efficient electronic communication
2.3 Industry Trends

Most EU RPD service supplier companies are SMEs that typically provide products and services to most of the OEMs and first tier suppliers throughout the EU. The client base is now demanding that RPD service companies offer a total service combining the major process and technical elements of product development (i.e. an “all under one roof service”).

The new demands being placed upon the sector is forcing a change in paradigm that includes:

- New business processes
- New skills
- New technologies

Traditionally the RPD sector has placed great reliance on leading edge technologies. It is however the considered opinion of industry is that business process of RPD and most importantly people and skills are the key factors to future success of the sector.

If we make a comparison between the old and new paradigms of product development it is easy to understand why Barlow (2000) made his remarks concerning the “terminal decline” of toolmaking. A comparison between the old and the new paradigms of product development is shown in the table below.

Table 1 A Comparison Between the Old and New Paradigms of Product Development

<table>
<thead>
<tr>
<th>Old Paradigm</th>
<th>New Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly fragmented industry</td>
<td>All under one roof</td>
</tr>
<tr>
<td>No urgency or project management skills</td>
<td>Rapid culture</td>
</tr>
<tr>
<td>A craft industry</td>
<td>High project management</td>
</tr>
<tr>
<td>The 'Black Art' of product development</td>
<td>Continual communication</td>
</tr>
<tr>
<td>2D Specifications</td>
<td>Paperless - 3D Solid Model CAE</td>
</tr>
<tr>
<td>Outdated technology</td>
<td>Productionised manufacture</td>
</tr>
<tr>
<td>Little or no investment and development</td>
<td>Investment at a 'critical' scale</td>
</tr>
</tbody>
</table>

2.4 Sector Growth

In 1998, the EU RPD sector was valued at £30bn. During this period government estimates predicted that the market value of the sector would double by 2003. Current commercial indicators suggest that the predictions are on target.

Within the RPD sector, more revenue is usually generated from activities that are further along the process chain. Activities early in the process chain however allow client capture and feed the “productionised” functions that typically generate more revenue.
The diagram below illustrates the typical revenue differentials for the RPD sector.

Fig. 1 The Typical Revenue Differentials for the RPD Sector

The diagram below illustrates the typical monetary values the RPD sector.

Fig. 2 Key Monetary Values for the EU RPD Sector

Despite the high monetary value of the RPD sector, there is a general lack of sector visibility throughout the EU. The sector is therefore fragmented and undervalued by the customer base.
Importantly, the RPD sector currently employs 2.6 million high-skilled professionals (i.e. people with formal higher-educational qualifications). It is expected that the RPD practitioner base will rise to 4 million to coincide with the market expansion.

Although there is no definitive work relating to the number of people currently employed in the EU RPD sector, a reasonable estimate may be provided as follows:

Table 2 Formulation for the Estimate of the Number of Sustained Skilled, High-Value Jobs in the EU RPD Sector

<table>
<thead>
<tr>
<th>Formulation for the Estimate of the Number of Sustained Skilled, High-Value Jobs in the EU RPD Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are approximately 200k CAE seats in the UK (assume 1 operator per-seat)²</td>
</tr>
<tr>
<td>There are approximately 1200 toolmaking companies in the UK. Each company has an average of 40 employees, therefore 1200 x 40 = 48k</td>
</tr>
<tr>
<td>Note this does not include any other portion of the RPD sector. However, let us assume that there are only 250k skilled people employed in the UK RPD sector (a probable gross underestimate)</td>
</tr>
<tr>
<td>The German market size is 2.5 times that of the UK⁷</td>
</tr>
<tr>
<td>Therefore we may assume that there are approximately 625k employed in the German RPD sector</td>
</tr>
<tr>
<td>We may assume that the rest of the EU is approximately 3 times the UK and German totals</td>
</tr>
<tr>
<td>(i.e. 3 x 875)</td>
</tr>
<tr>
<td>Therefore the current number of high-value jobs within the EU RPD sector is: 2.625m</td>
</tr>
<tr>
<td>Note: this number is prior to any addition to cover the predicted doubling of the market size</td>
</tr>
</tbody>
</table>

There are concerns that there will be a chronic shortage of practitioners entering the sector with the right level of skills and qualifications. The lack of a skilled work-force will cause some companies to look further afield for expansion opportunities.

3. A PROPOSED FRAMEWORK FOR A HOLISTIC EDUCATIONAL AND TRAINING SYSTEM

Research is often wrongly confused with development⁹. Research activities generate knowledge as its final product, whereas development activities use knowledge to generate product.

The RPD sector does not typically become involved in contract research but rather contract development. However, whereas research training is well catered for in the standard academic products such as the masters and doctorate programmes, that typically demand a focused understanding on a single detailed subject, established educational providers do not typically cover development training in a logical or holistic manner.
The development engineer or scientist can require a broader base of understanding and learning, for example, design engineering, materials science and manufacturing systems engineering. As careers progress management and commercial training will also be necessary.

Companies involved in the Rapid Product Development Sector match the EU and UK government strategies of competitive high-value-added service organisations. Yet there are no standard "qualifications" and no recognised career path for the "professional RPD engineer".

There is a need for a multi-band educational and training standard for the RPD sector. Areas of technical speciality must be catered for alongside core general subjects. Importantly, there must be a "cradle to grave" approach to the whole process of learning and personal professional development that is transparent, recognised universally and transportable between institutions and geographic locations. A model framework is illustrated below.

**Fig.3 Model for Holistic Educational and Professional Development**

The model will naturally become quite complex because individuals will enter the framework at different points. For example one would not expect an individual with three A levels to embark upon a four-year apprentice scheme but rather enter into the relevant degree and then into an industrial post. However, technical competence will still be a paramount requirement.

It may be argued that this model already exists in standard mechanical engineering and design engineering courses. However, the fact remains that traditional courses do not cover the core aspects of RPD, also a logical progression of learning and development is not always possible. Typically little thought and provision is given to those who progress "up the ranks" (a key
element in this sector) and professional recognition does not always have parity with that of the academic world.

Time and flexibility of timing are important issues for the practising professionals that want to continue to attain further qualifications. As such there is a great need for further part-time, distance and "own speed learning" schemes. Perhaps following the Open University model or similar. However, these types of courses will still need to be accredited and recognised both within academia and indeed industry.

There is a need for accredited courses that have been designed by the sector and/or companies with core elements of in company assignment and industrial relevance.

There appear to be two camps within the engineering educational establishment:

- Pure Engineering
- Applied Engineering

Whereas the academic focus would appear to be fixed on the pure engineering subjects, the needs of industry are such that preference is usually given to people who have a track record of applied subjects. The problem is that there are not as yet any formal applied RPD engineering or RPD design engineering qualifications. Many may claim to be doing it, many may think that they are indeed doing it but there is no constant and no formal holistic route for RPD that links visibly (cradle to grave) the academic, professional and CPD elements critical to the individual and company.

4. AN OVER-THE-HORIZON FORECAST ON THE FUTURE OF THE RAPID PRODUCT DEVELOPMENT SECTOR WITHOUT A HOLISTIC EDUCATIONAL AND TRAINING SYSTEM.

There is a major opportunity in development, or more correctly the Rapid Product Development sector, for both the educational providers and the industrial practitioners. Government trends indicate a doubling of the market value from £30bn to £60bn within a five to ten year time scale. The employed based (those with formal higher-educational qualifications) will rise from 2.6million to 4million. There will be a chronic shortage of practitioners entering the sector with the right level of skills and qualifications. High-skilled and qualified people will stand a 100% chance of employment within the sector. Educational establishments offering the right training and qualifications will stand a 100% chance of fully funded courses applicable to industrial requirements and fully subscribed by high-caliber students.

There is little that can be done to stop the movement of low-value-added manufacturing to low-cost geographical locations. We must therefore expect to see a greater exodus eastward as new site selection is based on decisions of low-labour cost, infrastructure and high government incentives packages. We should indeed be pragmatic and question if we truly want to keep and artificially sustain low-value work in the EU.
However, the EU Rapid Product Development sector faces different growth and expansion problems. Questions of infrastructure, incentives and proximity to major clients will become incidental to successful growth. As a direct result of the lack of suitably skilled people, expansion and new site selection decisions will be based on the ability of an organisation to strategically acquire existing competitors in order to guarantee a critical mass of skilled people in one location.

5. CONCLUSIONS

There is considerable opportunity for both commercial and academic organisations within the European Rapid Product Development sector. There is however a tendency to focus on technical matters rather than the key driving issue of the sector, i.e. that of skilled people. The sector is not well catered for in terms of holistic or indeed focused qualifications. The lack of focus from the training providers will continue to compound the major concern of the RPD sector, that is the scarce number of good professionals and lack of new talent. Overall the lack of skilled professionals will cause companies to limit growth and/or acquire companies in order to grow. The process of acquisition will introduce further non-standard dynamics into the sector and add even further to the list specialist knowledge and skills needed for successful operation.

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(6) Telephone interview with N Ballard, Rambash, 12th May 1999
SPECIAL FEATURE

Education and Training in RP&M

Dr. Neil Hopkinson & Lee E J Styger

This special feature article from two members of the TCT Europe Editorial Advisory Board takes a look at some pressing issues that concern the Rapid Prototyping & Manufacturing sector and manufacturing industry. Once again the issue of general awareness throughout industry is highlighted as a barrier in the uptake of time-compression technologies, specifically rapid prototyping and manufacturing. However, the article focuses on addressing the issues of education and training in these areas in order for companies to fully realise the benefits that are on offer. Various opportunities for companies to gain more insight through education and specific training courses and seminars are also highlighted.

Introduction

This article concentrates on discussing the broadly available education and training courses available in the Rapid Prototyping and Manufacturing (RP&M) sector. However, before discussing the type of courses that are available, it is worth looking at the potential effects of letting the current expert knowledge in the RP&M sector slip and the resultant effect that this will have on the economy of the EU.

The Importance of Education and Training in RP&M

Manufacturing in the West has seen a large amount of low-value work go to the cheaper markets in the East; however, expertise in engineering (that is, product design, product development, etc.) is still predominant in the West. It would seem prudent to maintain the existing strengths in the higher value end of design and manufacture i.e. the product development phase, rather than to fight to win back the lower technology end. In order to do this, a well-educated trained workforce in RP&M is vital.

The competitive battle for companies in the EU over the next fifty years will be in their ability to recruit, train, and sustain their skilled workforces. The decision to locate a site, expand a site, or indeed close a site will be made on the availability of the skilled workforce. A skilled workforce needs training and retraining and this costs time, money, and a firm commitment from senior managers within the company.

Education versus Training

An organisation taking on a new technology or process such as RP will generally have needs for both training and education. Two examples to illustrate the need for both education and training are given below.

1. A RP&M company's staff will need education

A provider of RP&M services will clearly require training for its staff to effectively operate a range of machines necessary to deliver the service offered. However, being able to operate a machine effectively which requires training is a different issue from getting the best out the technology. Getting the best out of the technology requires that the company's staff are educated in a manner that means that they can recognise a customer's needs, identify possible benefits not known by the customer, and provide alternative solutions which may be preferable.

2. A customer will benefit from training

From the other side of the fence, a customer of a RP&M company will need firstly to be aware of the available technology and secondly educated sufficiently to appreciate the potential alternative solutions and their associated benefits. However, some training at this point can go a long way in developing that customer's understanding of the technology, as a customer who understands the technical process from a hands on level will be able to make decisions or hold meaningful discussions with the company regarding issues such as orientation, finishing, etc. This will invariably result in the customer receiving a solution that is closely as possible matches the necessary requirements.

What is Needed?

One organisation's requirement in terms of education and training will vary greatly from another company's requirements; however, being
education and training are overlooked at individual levels, there is another major issue that affects a broad range of companies - awareness. Most of the people that have been consulted regarding education and training in RF&M for this article, generally professionals within the RF&M sector, mention the lack of general awareness of the technologies before anything else. In the world of product development there is a huge number of people who simply do not know anything about RF&M associated technologies, and the related benefits. Marshall Burn, of Emex Corporation, who has presented a number of talks in the industry world wide, comments that when it comes to Rapid Prototyping machines, "Most people have no idea that they exist outside of science fiction."

The lack of awareness problem has also been noted by many individuals who are still amazed at how many potential customers in the manufacturing field still do not know very much about RF&M.

A much greater general awareness throughout the manufacturing industry is needed.

Having tackled the initial awareness hurdle with individual companies there are a number of preconceptions which often need to be eliminated. As an industry, we are still left with the legacy of the term "Rapid Prototyping" and so the idea of using laser manufacturing technologies for anything other than prototypes requires something of a conceptual leap. Again, Marshall Burn observes, "Most people who do know, do not know their place, they are simply asked to make prototypes and nothing more, he continues by saying that in the future, the technology, "will be used for making actual end state products used by people."

For staff who are aware of the technology available and its potential uses, the next biggest issue is to understand the range of processes available. This is a constant requirement for staff in this field given the rapid pace of change with new processes, materials and applications. There is evidence that many leading industrialists and RF&M practitioners would welcome the availability of a short induction course (1-2 weeks) on RF&M, primarily to send new and existing employees on as appropriate. These people would also welcome better informed customers.

The second point illustrates how the relationship between the supplier and customer can be criticised when both sides come from a more knowledgeable standpoint; this provides an example where a company's customers will benefit from some sort of direct training as mentioned earlier.

Accreditation

Another issue that most be addressed is that of accreditation of education and training programmes within the field of RF&M. The rapid growth and frequent changes within the industry have resulted in a somewhat fragmented market in terms of training and education - this is particularly true for people with a skills-based rather than an academic background. In order to give true value to courses and to encourage attendance, some form of accreditation is necessary. Furthermore, the ability to transport the accreditation between training providers would be beneficial.

Addressing the Initial Awareness Issue

The main problem of initial awareness may be addressed in a number of ways, however a catalyst in the form of a champion of new technology within an organisation is almost always required. Trade shows, guest speakers, vendor demonstrations, and conferences are all ways in which people may become acquainted with a new technology, but to turn up to such an event usually requires some external forcing influence. De Montfort University's Rapid Manufacturing Consortium attempts to help its members companies address the issue of RF&M awareness by issuing the award of a 'champion' in each company. The role of the champion is to promote awareness within the industry through internal news letters, seminars, and word of mouth, etc. It is vital that the champion is a good communicator and can identify and explain where new technology can and cannot be applied within a company. This person is usually the key to promoting awareness among a wide range of people within a company.

As Marshall Burn pointed out, awareness of the available technologies needs to be backed up by knowledge of how it may be used, real examples are probably the best way to prove the value of adopting technology. This may be exemplified by certain UK training providers, now offering "live shows" where over a short length of time, say two hours, attendees are shown the completed part constructed from their own CAD file. This type of programme helps to both demonstrate the potential of the technology and dispel any potential scepticism among the audience.

Vendor based Training

In its very nature, training in Rapid Prototyping is closely associated with a certain product or process and is usually provided by the vendor for that process. All the major Rapid Prototyping machine vendors provide training for new users of their products. In many cases basic training to get
customers started is followed up with more in-depth training to get the best use out of the equipment. A particularly useful continuation from initial training is on certain vendors' equipment at the user group meeting. User group meetings are a unique opportunity to show and learn various 'tricks of the trade' for getting more out of the machines. Initially the concept may seem limited because owners of certain types of machines (who may often be competitors) might want to keep quiet about any advantages that they have developed with new, non-standard working practices. However, this is seldom a problem with participants, who are in the main, happy to share a great deal of useful information to push the technology forward. This spirit of openness may be attributed to an individual's (organisation's) desire to promote the technology through their organisation. The fact that giving information might help to promote the technology in another organisation does not seem to be a major problem.

Specialist Courses

Designed to meet industry needs, specialist courses have been developed particularly by institutions born out of academic research groups. For example, De Montfort University’s Rapid Manufacturing Consortium runs day-long Rapid Manufacturing awareness seminars and is about to launch a series of short courses in Rapid Product Development comprising a week’s in-depth study into a variety of subjects supplemented by distance learning. The Centre for Rapid Design and Manufacture (CRDM) offers short training courses and seminars for various time-compression technologies, including rapid prototyping. The Innovative Manufacturing Centre (IMC) at Nottingham offers a range of CAD, RP and new product development training programmes, as do the RP&I Centre and PDR. Other institutions throughout Europe offering similar courses include the Fraunhofer IPA organisations across Germany, and the IEP Institute at the University of Stuttgart.

Although not exhaustive, these examples provide an insight into the type of innovative approach that is now becoming available within the RP&M field. As with other sources of training and education, these courses give candidates the opportunity not only to receive education and training but also to make contacts with other people in their field of work.

University Courses

The growth of RP&M as a recognised industrial sector, particularly for product development, has resulted in its inclusion in various engineering and design courses at universities. This inclusion in university courses is mirrored by the dedication of more space to the emerging technology in recognised texts in the field of manufacturing technology.

Recent developments in the growth of RP&M in academic circles include new validated MSc courses based around RP&M technologies. These include the new MSc in Rapid Product Development at De Montfort University which is biased towards manufacturing, and the MSc in Product Design Strategies and Digital Prototyping based at the University of Leeds which focuses more on the marketing aspects of
"Awareness of the available technology needs to be backed up by knowledge of how it may be used; real examples are probably the best way to prove the value of adopting technology."

Tailor Made Courses

Probabil the most appropriate way to gain and spread in-depth information that is specific to an organisation is to arrange for a consultant to give a tailored presentation. Industry consultants frequently give corporate seminars presentations tailored to each company's specific needs and interests. The obvious advantage of this approach is that the consultant will research the exact requirements and then report on the opportunities available to the organisation which should maximise the potential to exploit the technology. One disadvantage of going down this road is that a company may end up relying on the opinions of one person when a broader perspective may be preferable.

Conclusion

The most valuable asset of any high value added sector such as RP&M is its people. In an area that involves high technology one might think that the technology itself is of a higher priority. This is most certainly not the case as it is the people in RP&M who drive the technology forward and not vice versa.