AN ENTREPRENEURIAL FRAMEWORK FOR DECIDING ON THE IMPLEMENTATION OF LARGE FORMAT DIGITAL PRINTING INTERNATIONALLY

BY

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CERTIFICATION OF OWN WORK

The writer hereby declares that the work in this thesis is of his own original and that it has not before been handed in at any university for reasons obtaining a degree.

C.M. ADENDORFF

22 August 2002

ABSTRACT

This study focuses on entrepreneurs within the SME sector using large format digital printing (LFDP) because of the changes in technology that influences the decision-making processes of the entrepreneur in the purchasing of a new LFDP. These fast changes are likely to continue and can cause technologies to become obsolete overnight.

The entrepreneurs within the LFDP industry find themselves in the midst of these fast changes and are faced with a dilemma. On the one hand, they need to make sure that the technology used produces consistent and quality products. On the other hand, the entrepreneur needs to ensure an optimal return on investments.

From the literature and the findings of the study, the researcher recommends a change to an existing model on a consultant involvement purchase of high technology products, which is then adapted to integrate resource-forecasting areas together with timing and type of information required as well as external environment scanning.

The existing model's focus is on the individual's ability to make decisions based on their own knowledge. However, by integrating technology forecasting components, and scanning the business environment and resource forecasting needed the decision-maker will be better equipped to make decisions that also takes into account the external environment. This will also allow them to plan and manage growth in a systematic way. Therefore the proposed model takes into account individual capabilities and technology forecasting components that can facilitate the decision-making process.

The adapted model on decision-making clearly delineates that the combination of entrepreneurial qualities and technology forecasting techniques in the LFDP industry will ultimately assist the entrepreneur on various levels in deciding on a new LFDP.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Recent acquisitions among the large and extra-large format digital press suppliers have consolidated the market into the hands of three main groups. The extra-large format arena in Europe is now dominated by Belgium-based NUR, United Sates (US) firm now Vutek, and the Israeli prepress and print group, Scitex, which claims to have the largest hold on the European wide format digital market with some 85 installations. Scitex's interest in the digital print market grew substantially when it bought the super-wide format printer, the GrandJet, from Matan. Until then, Scitex had focused on the wide format screen print market with the Idanit 162-Ad. With the GrandJet acquisition, Scitex's technology now spans both the large and extra-large formats.

Other suppliers have also been aiming to cover the range of formats available. One of Vutek's selling points is that, because its printers have a higher resolution of 300dpi, its machines can be used for both outdoor and indoor production. As for NUR, its acquisition of Meital during June1999 gave it the drop-on-demand technology it needed to develop the newly launched wide format NUR Fresco. NUR's output had been limited to the extra-large format market through its Blueboard machines, based on continuous inkjet technology (Sign & Graphics, February 1999, p. 28).

The acquisitions by Scitex and NUR reflect what is happening among many digital printers. More and more customers have both types of machines because the market requires that advertising campaigns incorporate very large format posters, as well as billboards. All the machines have strong selling points. However, the final choice comes down to priorities of the entrepreneur (Sign & Graphics, February 1999, p. 29).

However, it has been more difficult to develop the market for extra wide formats, which is still finding new applications. While growth has been steady in countries like the UK and France, large-format digital printing (LFDP) still has some way to go in Germany, where quality is much more of an issue. Digital print does not match the quality of screen print on very large formats. The digital market still has some way to go in terms of raising awareness and improvements to technology although the strides that have been made so far are improving on a daily basis (SignCraft number 108, October 1999, p. 85).

Large format digital printing, in its own right, is a relatively new industry (approximately 3 years old). Currently no form of global research has been done on what is to offer and the comparisons of such technologies. The large format digital printing industry is currently going through fast changes because of the fast rate of technological research and development in this industry. These fast changes are likely to stay for the future and can cause technologies to become obsolete overnight. It can also influence competition severely in that a competitor can obtain new technology at a lower cost, which produces better quality at lower costs. The latter can result in a business going bankrupt.

The entrepreneur within the large format digital printing industry finds himself in the midst of these fast changes and is faced with two dilemmas. On the one hand, he needs to make sure that the technology he is using produces consistent and quality products. Investment in the best available technology is needed for that purpose but, as technology is constantly changing, costs for new models can be high. On the other hand, the entrepreneur needs to ensure an optimal return on his investments to achieve his personal goals. The problem becomes not only purchasing the best equipment, but also managing and exploiting opportunities to achieve personal goals. The entrepreneur, therefore, needs to balance technology with entrepreneurial considerations in order to reach personal goals.

1.2 STATEMENT OF THE PROBLEM

The research problem following the preceding section is stated as follows:

- To establish a framework which can assist entrepreneurs to optimise their investment in large format digital printing (LFDP).

1.3 THE SUB-PROBLEMS

In order to solve the above research problem, the following sub-problems must be solved:

- To identify the entrepreneurial factors that inhibit performance (in terms of decision-making) at individual, group, and organizational levels relating to large format digital printing businesses;
- To identify the critical success factors in selecting the correct large format digital printer based on technical terms; and
- To develop an integrated framework of entrepreneurial and technical decision-making issues.

1.4 DELIMITATION OF RESEARCH

This study will focus on entrepreneurs within the SME sector using large format digital printing. Due to the nature of this industry (very small and therefore very secretive) the focus of this study will be dealt with in a national and international context.

1.5 DEFINITION OF CONCEPTS

Due to the technical nature of this research proposal it is necessary to provide background in certain terminology. These are discussed in the following paragraphs:

1.5.1 Classifying digital systems

There are many different types of digital systems, and a few different ways to classify them. One-way is to divide the systems into two broad categories: continuous inkjet systems and drop-on-demand systems. Continuous inkjet systems utilise a constant stream of ink droplets. Using positive and negative electrostatic charges, some of the droplets are deflected into a gutter, while the remaining droplets are deflected to the print surface. The ink, which is directed into the gutter, is typically reticulated. In contrast, drop-on demand systems do not use a guttering system to reticulate the ink. Drop-on-demand systems include thermal inkjet, piezo-electric systems and spray (valve) jet systems.

1.5.2 Inkjet Printers

Inkjet systems print by spraying ink onto a substrate, without making contact with the print. Earlier units offered a minimal number of print heads. Today's more sophisticated units are designed with more nozzles, which greatly improve production times. Engineering changes in the design of the print heads have also improved print quality. More importantly, different inks can be used with the newer print heads, resulting in greater outdoor durability.

1.5.3 Thermal Transfer Printers

In explaining the operation of thermal transfer printers, these systems are sometimes compared to typewriters. Both uses coloured ribbons, and both transfer colours onto a substrate. The similarity ends there. Thermal transfer technology is much more sophisticated. As the name implies, thermal transfer printers use heat in the printing process. The print heads contain multiple heating elements, each of which rapidly turns on and off to control the printing process. In some systems, the print head extends the entire width of the print substrate. In other systems, the print heads move back and forth across the web.

Thermal transfer systems use a cartridge with a printing ribbon. One side of the ribbon is lightly coated with coloured wax or resin. During the printing process, the coated side of the ribbon makes contact with the print media. The print head pressed on the uncoated side of the ribbon. As the resistors heat up, drops of the coating melt and transfer to the print substrate.

Although the cost of printing cartridges may seem high, thermal transfer printing systems do not require the more expensive top-coated print media or over laminating films. The competitive cost of the finished product, the relatively good photo-realistic output and good outdoor durability of the finished print, make thermal transfer printing systems a viable digital printing option for sign makers.

1.5.4 Electrostatic Printers

Electrostatic printers operate similarly to the office copier. Printing is usually a two-step process. The image is first printed, in reverse, on a special paper. Then the image is transferred from the paper to the substrate, using a lamination process. Newer electrostatic printers allow for direct printing of pressure-sensitive vinyl. Electrostatic technology works on the principle that opposite electrical charges attract. The system's print head consists of thousands of electrical wires, which deliver or deposit electrical charges to the paper. As the paper passes over pigmented particles with an opposite electrical charge, the particles are transferred to the paper. The paper is then laminated to the substrate and, in a heating process, the particles are deposited and fused to the substrate.

1.5.5 Spray Jet Systems

Spray jet systems are sometimes described as large computerised airbrush machines. A spray jet system is a gigantic inkjet machine. These units can measure up to 10 meters wide. As the valve of the spray jet print head opens and closed, air propels the solvent-based ink. The resolution of these grand format printers has improved greatly, from the nine to 30 dots per inch (dpi) ranges in previous years, to the 200 to 300 dpi range recently. Although the resolution of these systems is often not so high as other types of digital printers, their prints are usually viewed from a distance. They suited for outdoor advertising, because their output exhibits strong contrast between highlights and shadows. A high-resolution print viewed at a distance might appear to have soft edges.

1.6 ASSUMPTIONS

This study rests on various assumptions. These assumptions are as follows:

- The first assumption is that technology is bringing digital printing and imaging (DPI) and screen-printing markets closer to one another. A printer that can be manufactured to have a dual purpose in this regard will assumedly be the answer.
- The second assumption is that entrepreneurship in large format digital printing can accelerate because of the development of better quality and more user-friendly technology.
- The third assumption is that thermal transfer or inkjet will replace screen-printing for high volume vinyl graphics. It is already changing the sign and screen print industries in that it has opened new markets, because it can do what screen-printing cannot. It has given the sign maker and screen printer the ability to satisfy the customer demand for short-run jobs involving highly complex graphics. Digital printing also opens the door to new competitors, such as quick printers, exhibits and display companies, photo-labs, service bureaus, and repro-graphics (architectural blueprint) businesses.

Other assumptions will be clarified in the text where needed.

1.7 JUSTIFICATION OF METHODOLOGY

In this study two major components are combined namely entrepreneurship and LFDPs (see Table 1.1).

Table 1.1. Research approach

Research framework	**Detail**
1. Introduction	Background regarding this study
2. Theory	Theory on:

	• Entrepreneurship • LFDPs
3. Integration	Decision making model for entrepreneurs in the LFDP domain
4. Research methodology	Research methodology: testing of model and comparison with a case study
5. Results	Results and limitations
6. Discussion and recommendations	Discussion and recommendations
7. Conclusion	Comparison of results with main research problem

In terms of the above, information must first be obtained on the two broad issues (entrepreneurship and LFDPs) before it can be combined into a joint decision framework. Primary and secondary data will be used during this process. Primary data must be generated in these early stages because of the relative newness of this study field, which resulted in the scarcity of available secondary date. From this phase an integrated decision framework will be developed for entrepreneurs in the LFDP business. The decision framework will then be tested by means of a case study in a LFDP company.

1.8 DOCUMENT OUTLINE

In order to address the study in a logical sequence (see Table 1.1) this document can be divided into three sections namely the first section that will deal with entrepreneurial and LFDP issues; the section that will deal with the research and case study; and the last section that will deal with interpretations and conclusions. Therefor, the detailed outline of chapters are as follows:

Chapter 1: Introduction

This chapter will provide a broad overview of this study and how it will be conducted.

Chapter 2: Entrepreneurship

This chapter discusses the nature of entrepreneurship and the diversions that provide a useful organizing framework to view the complex forces and interactions that produce entrepreneurship activity.

Chapter 3: Entrepreneurship and growth

Growth is a very important part of entrepreneurship. Therefore, the focus in this chapter is the identification of the entrepreneurial manager and how they manage growth.

Chapter 4: Large Format Digital Printers

This chapter provides an overview of the LFDP industry.

Chapter 5: Decision making and Entrepreneurship

This chapter examines six contemporary decision-making models with the final view of matching appropriate decision-making models with different situations decision makers may encounter.

Chapter 6: Research Methodology

This chapter will discuss the research design and its various elements.

Chapter 7: Results and Discussion

The results and inferences from the questionnaire are discussed in this chapter.

Chapter 8: Case Study - Alfresco Full Colour Outdoor Graphics

This chapter deals with a case study that are devise to further test the framework, which can assist entrepreneurs to optimise their investment, in large format digital printing (LFDP).

Chapter 9: Recommendations and Conclusions

This chapter will outline an adapted model that can be used in practice by LFDP entrepreneurs. The shortcomings of the model will follow the discussion of the adapted model. Finally, directions for future research will be provided in this chapter.

CHAPTER 2

ENTREPRENEURSHIP

2.1 INTRODUCTION

In paragraph 1.1 it is already stated that entrepreneurs are influenced by fast changes caused by, inter alia, research and development in technology. In this regard Handy (1990) has identified several of these fast changes that are already implemented or will be in the near future. Some of these changes are as follows: portable phones linked to faxes and laptop computers will turn cars, trains, and airport terminals into offices; monoclonal antibodies and scavenger proteins designed to locate blood fats, cancers, and viruses will be available, prolonging life and the quality of life; genetically engineered crops will be able to take nitrogen directly from the air instead of the ground, reducing the need for most fertiliser and increasing usable acreage immensely; microbes that can change waste materials into energy sources are under investigation; computerised medical expert systems will be available to all physicians; expert systems will increase the productivity of all professionals, technicians, and even the supermarkets' purchasing department; and voice-sensitive computers will make keyboards and keyboarding skills irrelevant.

It is generally accepted that entrepreneurs are the force behind the continuous identification of new opportunities such as listed by Handy (1990) and the subsequent creation of innovative products and services. In this regard, entrepreneurship can be regarded as a self-perpetuating phenomenon. Boyette and Conn (1991) support this by arguing that entrepreneurship not only affects lives through innovation but also represents the working future for many.

Another push factor regarding entrepreneurship is the pattern of retrenchment by large corporations. As large corporations continue to lay off managers to realise their goals, some will go into businesses for themselves. They will fill the niches and markets such as servicing their former employers by providing consulting, after sales service, and other support functions. These former mangers will operate small entrepreneurial firms that provide high quality products/services and value to their customers in a way that working inside the bureaucracy of a large corporation made impossible. This can lead to a burst of growth in small, medium and micro businesses (SMEs). In addition to SMEs, there will be more corporate-backed entrepreneurial ventures: spin-offs, joint ventures, intrapreneurial units, and collaborating arrangements. Although these organisations originate in larger corporations, they are being formed specifically to stay entrepreneurial, to avoid bureaucracy, and to maintain their innovative edge. This view is supported by Boyette and Conn (1991: 218) as follows:

"Companies will be looking for business opportunities. Many companies will provide financial backing for innovative employees who are willing to take a risk and develop an idea for a new product or service … [people with] the greatest chance of developing an idea that can turn into a growth business will be those who get wide exposure … [and this exposure] will greatly increase the chance that they will identify an emerging trend or market niche that can be filled with a start-up business."

Deduced from above, entrepreneurs can be regarded as the pillar of innovation and socio-economic growth. This chapter, therefore, will provide a broad overview of what this entrepreneurial phenomenon is.

2.2 WHAT IS ENTREPRENEURSHIP?

There are as many definitions of entrepreneurship as there have been writers on the subject (see Table 2.1). It has been suggested that trying to define entrepreneurship may be fruitless because the term is too vague and imprecise to be useful (Low and MacMillan, 1988).

Table 2.1. Definitions of Entrepreneurship

SOURCE	DEFINITION
Knight (1921)	Profits from bearing uncertainty and risk
Schumpeter (1934)	Carrying out of new combinations of firm organisation – new products, new services, new sources of raw material, new methods of production, new markets, new forms of organisation
Hoselitz (1952)	Uncertainty bearing … co-ordination of productive resources … introduction of innovations and the provision of capital
Cole (1959)	Purposeful activity to initiate and develop a profit-oriented business
McClelland (1961)	Moderate risk taking
Casson (1982)	Decisions and judgements about the co-ordination of scarce resources
Gartner (1985)	Creation of new organisations
Stevenson, Roberts & Grousbeck (1989)	The pursuit of opportunity without regard to resources currently controlled
Fox and Maas (1999)	Entrepreneurs are people who identify opportunities and utilise them to their own and the internal and external environments benefit.

Deduced from the definitions in Table 2.1, the following common characteristics are identified:

- Creativity and innovation
- Resource gathering and the founding of an economic organisation
- The chance for gain (or increase) under risk and uncertainty

For the purpose of this study, entrepreneurship, then, can be defined as an innovative economic organisation (or network of organisations) for the purpose of gain or growth under conditions of risk and uncertainty. This definition is further discussed in the following sub-paragraphs.

2.2.1 Innovative

The term creation or identify implies a founding and an origin. Therefore, technically speaking, the purchase of an existing firm or its transfer to new owners does not represent entrepreneurship. As one group of authors point out, if founding were the only criterion for entrepreneurship, then neither Watson of IBM nor Kroc of McDonald's would qualify

(Stevenson, Roberts, Grousbeck: 1989). It is rare for an organisation to change ownership without a change in its management and resource configuration. However, the degree of change and innovation determines whether entrepreneurship is present. In this regard Schumpeter (1990) has identified various categories to highlight the magnitude of change:

- Is a new product or service offered?
- Is a new method or technology employed?
- Is a new market targeted and opened?
- Is a new source of supply of raw materials and resources used?
- Is a new form of industrial organisation created?

In the context of this study, the definition of entrepreneurship does not only represent an act of creation, but also includes a broader focus as highlighted by the above questions of Schumpeter.

2.2.2 Economic Organisation

The term economic organisation means an organisation whose purpose is to allocate scarce resources with the aim of achieving its goals (Baumol, 1967). In addition to this definition, Haberberg and Rieple (2001:4) define an entrepreneurial organisation as bodies of people who are brought together by an entrepreneur who sees an opportunity to meet an unfulfilled need in the market place. Both definitions can also be interpreted as a business unit within a firm, a network of independent organisations, or a not-for-profit organisation (NPO). In what may seem paradoxical, even governments can act entrepreneurial under the right conditions in order to be efficient and effective. Some businesses do not seek growth, which distinguishes entrepreneurial firms from small businesses (Carland, 1984). NPOs also seek gain and growth in terms of, inter alia, more members, more services performed, more clients served. In the context of this study, the economic organisation will refer to those that seek gain and growth.

2.2.3 Risk and Uncertainty

Entrepreneurship exists under conditions of risk and uncertainty. The two terms are not the same. Risk refers to the variability of outcomes (or returns). A firm operating in a risk-free environment would continue to expand forever, since a negative outcome could not occur. Therefore, risk is a limit to ever-expanding entrepreneurship (Penrose, 1959). Uncertainty refers to the confidence entrepreneurs have in their estimates of how the world works, their understanding of the causes and effects in the environment. If there is no uncertainty, then the environment can be perfectly known. If this is true, then everyone can know it, and it could be a source of lasting profit for anyone (Fox and Maas, 1999).

2.2.4 Conditions for Entrepreneurship

The definition of entrepreneurship defined in paragraph 2.2, can only flourish in an environment that stimulates entrepreneurship. In this regard, two conditions must exist in order for entrepreneurship to flourish. First, there must be freedom: freedom to establish an economic venture, and freedom to be creative and innovative with that enterprise. Second, there must be prosperity: favourable economic conditions that give an entrepreneurial organisation the opportunity to gain and grow (Fox and Maas, 1999).

The Index of Economic Freedom (Holmes, 1996) examines 150 countries in order to rank them according to their level of economic freedom. In the 1997 edition, Hong Kong was rated the economically freest country in the world. This ranking was based on conditions evaluated before the 30 June, 1997 return of Hong Kong to the PRC. Other countries included in the top ten Index of Economic Freedom included Singapore, Bahrain, New Zealand, Switzerland, the United States, the United Kingdom, Taiwan, the Bahamas and the Netherlands. The ten countries with the lowest level of economic freedom were Angola, Azerbaijan, Iran, Libya, Somalia, Vietnam, Iraq, Cuba and Laos, with North Korea being the country rated with the least amount of economic freedom. Data collected by the Index supports several conclusions that are important for entrepreneurs and the study of entrepreneurship. First, the study demonstrates there is a strong correlation between a high level of economic freedom and a high standard of living. Second, a comparison of Index data over several years indicates that as wealthy countries become richer, they often impose fiscal restrictions that reduce economic freedom, such as higher taxation and social welfare programs. Four of the top ten countries in the 1996 Index (Switzerland, the Netherlands, Denmark, and Luxembourg) had lower ranking scores in the 1997 index for this reason. The Index data also suggests that countries are not poor because their wealthier neighbours fail to provide aid programs and investment capital. These countries are poor because their governments limit the economic freedom, which would allow free enterprise to prosper. While the Index does not evaluate political freedom, many of the countries at the bottom of the economic freedom ranking also have a poor record on human rights.

2.3 A CONTEXTUAL MODEL FOR ENTREPRENEURSHIP

Entrepreneurship is accepted as one of the instruments able to generate prosperity in a rapidly changing environment. Entrepreneurship continually identifies and exploits opportunities. This leads to, among other things, job creation. In turn, job creation can lead to prosperity for the entrepreneur and the organisation's employees with additional, positive benefits accruing to the broader environment.

Entrepreneurship is not a single system. It comprises several subsystems. If a subsystem, e.g. the qualities of an entrepreneur, is stressed at the expense of others, the system of entrepreneurship could be rendered ineffective (Fox and Maas, 1997:8). To address several subsystems, different questions have to be asked and answered. For example:

- What are the qualities of the environment in which the individual have to act?
- What attributes should a person have to perform successfully in that environment?
- What processes can the person use to ensure success?
- How is the ideal entrepreneurial organisation structured?

To answer the above questions, an adaptation of Pettigrew's model (1987) is used as the basis for further discussion (see Figure 2.1).

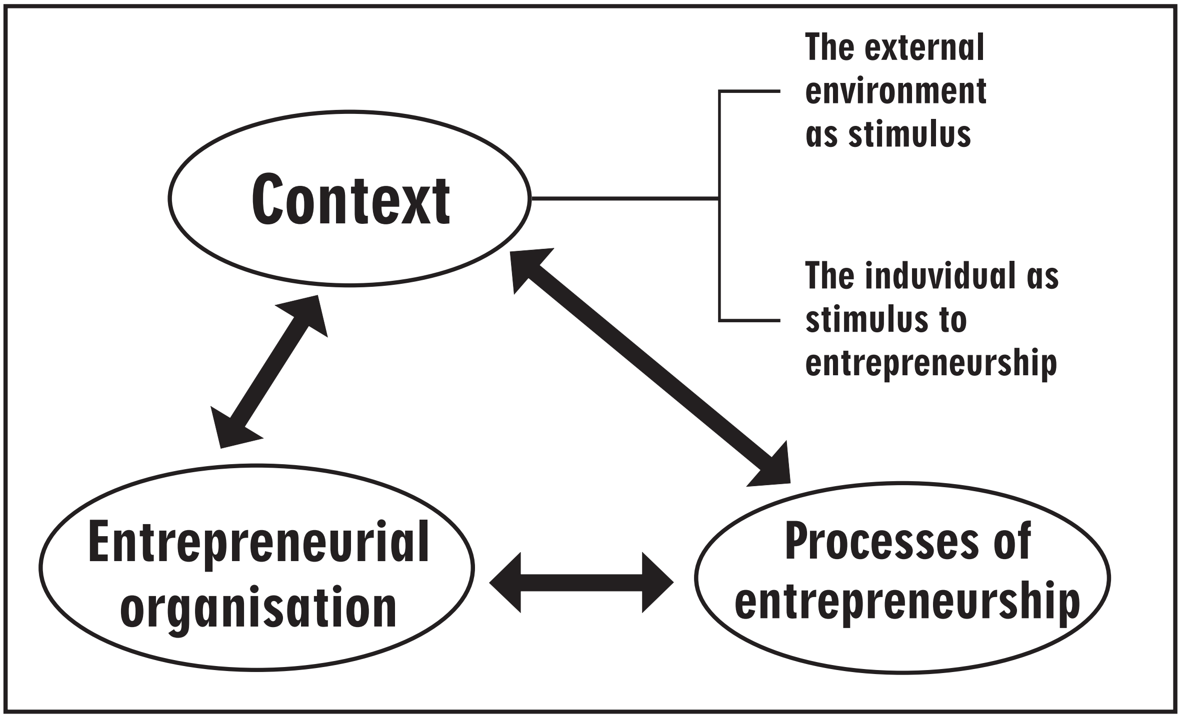


Figure 2.1. Model for discussing entrepreneurship

Source: Adapted from Fox and Maas, 1997:9

The context refers to the external environment that helps to stimulate entrepreneurship. This can be in the form of push factors such as unemployment and pull factors such as self-realisation. Within this context, the individual needs to find creative ways to exploit and manage opportunities.

The processes refer to those processes that can help an entrepreneur to survive in a rapidly changing environment.

The entrepreneurial organisation must be created in order to ensure the successful implementation and control of entrepreneurial ideas.

The different categories of this model will be discussed in the following paragraphs.

2.4 THE EXTERNAL ENVIRONMENT AS STIMULUS

Fox and Maas (1997:8) referred to a rapidly changing environment that makes certain, unique demands on the individual such as skills needed to utilise a specific opportunity. Even the criteria for an organisation's success can change. An alternative criterion measuring an organisation's success could measure how fast it reacts to its changing environment. Ford and Gioia (1995:5) add as follows to this:

"The contract between individuals and organisations also is changing – focusing less on security and more on personal skill development. Success often will be measured by involvement in successful new projects."

This criterion requires an entrepreneurial organisation to change fast when needed. It is common knowledge that the world is experiencing an information revolution. It can be argued that there is an oversupply of information. However, information is not available to only one organisation – competitors have access to the same information, and this affects the nature of competitiveness. The course of technological change to some degree can be linked to information – new information can lead to the creation of new technologies. The dynamism of the computer industry is a typical example of organisations being subject to rapidly changing technology.

Several other factors, including the globalisation of markets and changing values, can effect the acceleration of the environment. What are important is that a rapidly changing environment generates more opportunities, and that they can be utilised by entrepreneurs. However, this exploitation requires entrepreneurs to be adequately prepared (Fox and Maas, 1997:11).

2.5 THE INDIVIDUAL ENTREPRENEUR

Several researchers such as Bhide (1994:160), Timmons (1990:166) and Banfe (1991:7) have listed characteristics of entrepreneurs. The combination of personal characteristics playing a central role in successful entrepreneurship has not been determined beyond doubt. Kroon and Moolman (1992) and De Coning (in Maas and Fox, 1997:15) review various South African findings in this regard and list the following characteristics such as:

Motivation: The need to achieve is one of the entrepreneur's outstanding characteristics. It is evident in successful scientists, sportsmen and women, politicians and managers of large enterprises. McClelland (1985:254) found that the association of a high need to succeed and entrepreneurship occurred across cultures. Some of his other findings indicate that training in the need for achievement improved the entrepreneurs' performances.

Drive, perseverance and energy: Drive, perseverance and energy refer to internal sources of motivation and include expectations, needs, drives and objectives. These are all related to the individual's ability to persevere with a particular activity. It is not easy to distinguish between drive and motivation. Drive can be described as the ability of individuals to cause things to happen. Drive can be found in people who have a need to achieve rather than a fear of failure. What is important is that a high degree of drive appears to be a prerequisite for entrepreneurship.

Role orientation and purposiveness: People can play the roles befitting their desired circumstances only when they are certain of their goals. Role orientation requires a drive towards opportunities instead of a focus on problems. Purposiveness does not imply only committed behaviour and an ability to set objectives. It also demands sufficient insight to formulate clearly attainable, challenging and measurable objectives.

Time perspective: A well-developed sense of time and an aptitude for using time effectively are characteristics of many entrepreneurs. Because they regard time as extremely valuable, they operate in a planned and orderly way. They see time as a scarce resource and have little patience with those who waste it. Entrepreneurs are future oriented and tend to finalise tasks without procrastination or self-doubt.

Internal locus of control: Entrepreneurs believe in their own ability to direct their activities towards success, despite obstacles. Because they have an implicit belief in their own abilities, they are also aware of their limitations. Therefore, they do not deny that they will make mistakes. They however, will regard a mistake as an opportunity for learning and are unlikely to repeat the error.

Handling uncertainty: A further character trait found in entrepreneurs is their ability to handle and endure uncertainty without compromising effectiveness and efficiency. They sometimes have to make decisions in times of uncertainty or based on limited information.

Risk taking: Entrepreneurs are prepared to take calculated or reasonable risks. Based on their powers of judgement successfully influencing the results of a task, they are realistic in their commitment to their undertakings. Depending on their circumstances, they accept that decision-making always carries an element of risk. The entrepreneur tries to qualify and quantify risks before starting a new project.

Confidence and self-image: Self-confidence is a characteristic directly related to self-image, but a person's other qualities also combine to create his or her self-image. Research indicates that, in general, entrepreneurs have a high self-image. Furthermore, this self-image is related to performance motivation and the drive to be successful.

Creativity, innovative ability and vision: Researchers emphasise that creativity and innovative ability forms the basis for creating new enterprises. It is accepted that everybody is creative. It is also accepted that creativity and innovation can be stimulated by, inter alia, training. Ford and Gioia (1995:4) define creativity as a core necessity for success in a profoundly changing organisational world. Vision refers to an almost instinctive leadership characteristic that is apparent in charisma and daring, and which is infectious. A creative and clearly articulated vision acts as a focal point. It becomes a motivator for the entrepreneurial team and the organisation.

Ethics and integrity: The successful way to build a career, specifically and entrepreneurial career, is to maintain high ethical standards. Timmons (1990:291) holds that success without the highest measure of integrity and reliability is failure.

Holistic approach: Beside the need for intelligence, the entrepreneur must be able to observe an event and its environment, anticipating the effect that a change in the one element will have on the other. This approach is rooted in sound conceptual skills.

Value system: Entrepreneurs are more realistic about their abilities and there objectives than other people are. When they need help, they tend to consult experts rather than talk to friends and family. They have contacts that can help them when they are exploiting opportunities. For the entrepreneur, networking is a very important activity. Their goal tends to be the exploitation of opportunity rather than the control of resources. Entrepreneurs are optimistic in uncertainty and believe that their own abilities will lead them to success (Fox and Maas, 1997:15).

2.6 PROCESSES OF ENTREPRENEURSHIP

The definition of the concept entrepreneurship indicates that entrepreneurs focus on identifying and exploiting ideas. To a degree, the character traits of the entrepreneur provide the foundation for processes used to exploit ideas. In this section, the process is clearly identified and discussed (see figure 2.2).

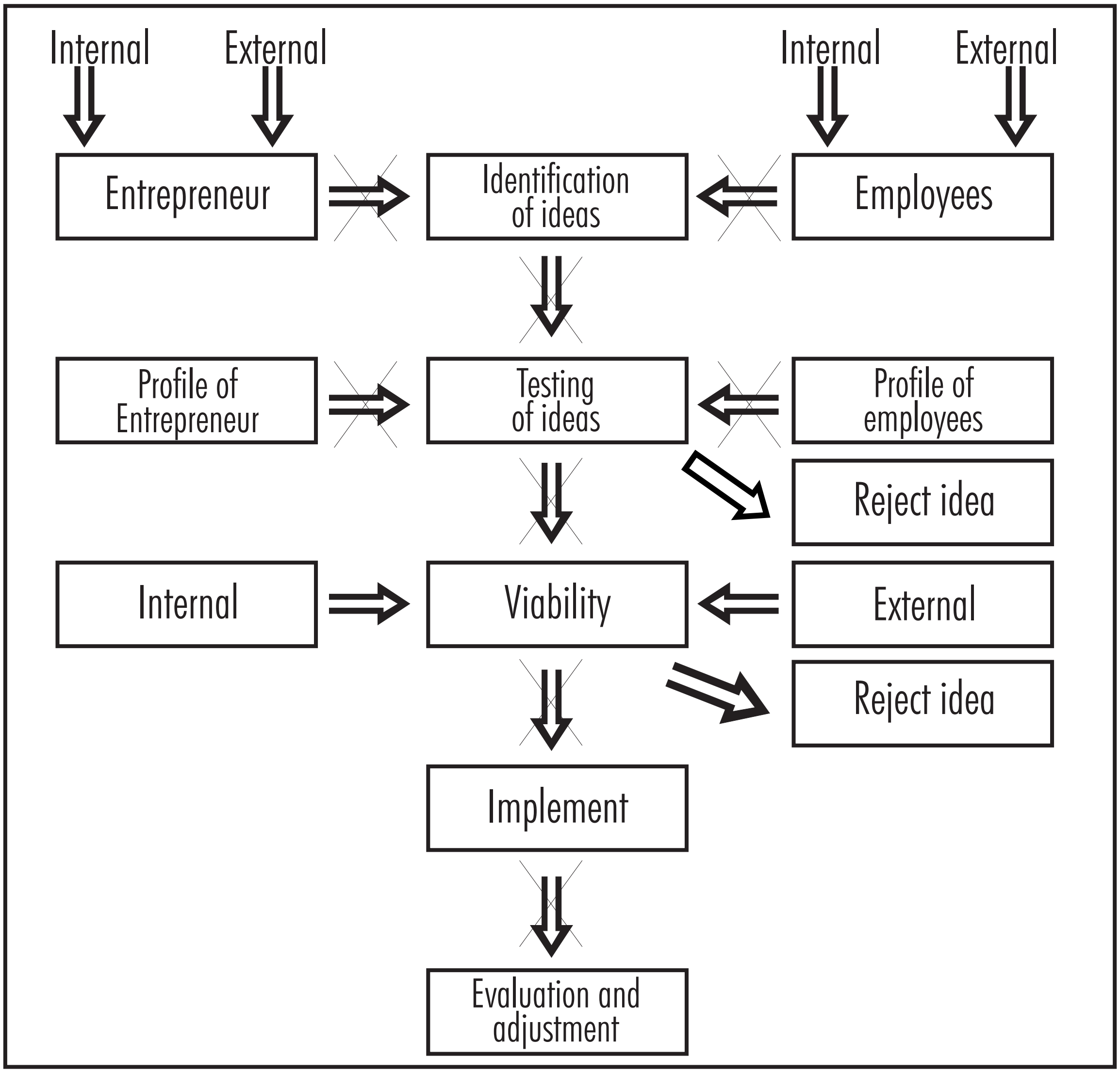


Figure 2.2. The entrepreneurial process

Source: Maas, 1996:16

2.6.1 Identification of Ideas

Idea identification comes primarily from two sources, the entrepreneur and the employee. In a changing environment bombarded by information, it is impossible for one person to keep up to date with fresh information, new trends and evolving opportunities. Employees should therefore involve themselves in identifying opportunities.

The entrepreneur and employees get information from two places, internal and external sources. External sources can result from liaising with parties outside the organisation, e.g. consumers. The identification of new consumer needs comes form external sources. Internal sources are developed over time and through the knowledge and experience of the entrepreneur and/or employees.

Creative techniques can be used to stimulate the identification of ideas. A group of employees can, for instance, generate new ideas in think tanks. However, knowledge of environmental trends (information) remains a very important prerequisite to the generation of ideas.

2.6.2 Testing ideas

Each of the identified ideas should be analysed in terms of critical success factors. What should be done to ensure that the ideas are implemented successfully? These critical success factors are compared with the profile of the entrepreneur and employees to determine the degree to which they match. If there is no match, it must be decided whether anything can be done about it. If nothing can be done, the idea should be rejected. If the match can be improved, or if a certain degree of matching does exist, the idea is then subjected to viability studies.

2.6.3 Viability study

The viability study comprises two broad categories, namely an internal and external category. The internal category focuses on the organisation's financial resources. Questions need to be asked and answered such as what will it cost to exploit the opportunity? When will the project break even? What will the organisation's cash receipts and payments be over time?

The external category should address other questions. What size is the potential market? What are the consumer's specific needs? How many competitors are there? What will their reactions be? The external and internal analyses should be compared with each other to ascertain whether it is viable to exploit the opportunity.

There are many important evaluation-related questions that should be asked during this phase. According to Birch (1986) there are ten sets of preliminary questions that can be used to screen an idea. These questions are as follows:

- Is it a new product-service idea? Is it proprietary? Can it be patented or copyrighted? Is it unique enough to get a significant head start on the competition? Or can it be easily copied?
- Has a prototype been tested by independent testers who try to blow the system or rip the product to shreds? What are its weak points? Will it stand up? What level of research and development should it receive over the next five years? If it is a service, has it been tested on guinea pig customers? Will they pay their hard-earned money for it?
- Has it been taken to trade shows? If so, what reactions did it receive? Were any sales made? Has it been taken to distributors? Have they placed any orders?
- Is the product or service easily understood by customers, bankers, venture capitalists, accountants, lawyers, and insurance agents?
- What is the overall market? What is the market segments? Can the product penetrate these segments? Are there special niches that can be exploited?
- Has the market research been conducted? Who else is in the market? How big is the market? How fast is it growing? What are the trends? What is the projected life cycle of the product or service? What degree of penetration can be achieved? Are there any testimonials from customers and purchasing agents? What type of advertising and promotion plan will be used?
- What distribution and sales methods will be used – jobbers, independent sales representatives, company sales force, direct mail, door-to-door sales, supermarkets, service stations, company-owned stores? How will the product be transported: company owned trucks, common carriers, postal service, or airfreight?
- How will the product be made? How much will it cost? For example, will it be produced in-house, or by others? Will production be by job, shop or continuous process? What is the present capacity of company facilities? What is the break-even point?

- Will the business concept be developed and licensed to others, or developed and sold away?
- Can the company get – or has it already lined up – the necessary skills to operate the business venture? Who will be the workers? Are they dependable and competent? How much capital will be needed now? How much more in the future? Have major stages in financing been developed?

A single strategic variable seldom shapes the ultimate success or failure of a new venture. In most situations a combination of variables influences the outcome. Thus it is important that these variables be identified and investigated before the new idea is put into practice. The results of a profile analysis enable the entrepreneur to judge the potential of business.

Another method, according to Baty (1974) is the feasibility criteria approach, developed as a criteria selection list from which entrepreneurs can gain insights into the viability of their venture, and is based on the following questions:

- Is it proprietary? The product does not have to be patented, but it should be sufficiently proprietary to permit a long head start against competitors and a period of extraordinary profits early in the venture to offset start-up costs.
- Are the initial production costs realistic? Most estimates are too low. A careful, detailed analysis should be made so that there are no large unexpected expenses.
- Is the initial marketing cost realistic? This answer requires the venture to identify target markets, market channels, and promotion strategy.
- Does the product have potential for very high margins? This is almost a necessity for a fledgling company. Gross margins are one thing that the financial community understands. Without them, funding can be difficult.
- Is the time required to get to market and to reach break-even realistic? In most cases, the faster, the better. In all cases, the venture plan will be tied to this answer, and an error here can spell trouble later on.
- Is the potential market large? In determining the potential market, one must look three to five years into the future because some markets take this long to emerge.

- Is the product the first of a growing family? If it is, the venture is more attractive to investors. If they do not make a large return on the first product, they might on the second, third, or fourth.
- Is there an initial customer? It is certainly impressive to financial backers when a venture can list its first 10 customers by name. This pent-up demand also means that the first quarter's results are likely to be good and the focus of attention can be directed to later quarters.
- Are the development costs and calendar times realistic? Preferably, they are zero. A ready-to-go product gives the venture a big advantage over competitors. If there are costs, they should be complete and detailed and tied to a month-by-month schedule.
- Is this a growing industry? This is not absolutely essential if the profits and company growth are there. In a growing industry, good companies do even better.
- Can the product and the need for it be understood by the financial community? If the financiers can grasp the concept and its value, the chances for funding will increase.

This criteria selection approach provides a means of analysing the internal strengths and weaknesses that exist in a new venture by focusing on the marketing potential and industry potential that are critical to assessment. If the new venture meets fewer than six of these criteria, it typically lacks feasibility for funding. If the new venture meets seven or more of the criteria, it may stand a good chance of being funded.

A more comprehensive and systematic feasibility analysis, a comprehensive feasibility approach, would incorporate external factors in addition to those in the questions above. Figure 2.3 presents a breakdown of the factors involved in a critical feasibility study of a new venture – technical, market, financial, organisational, competitive.

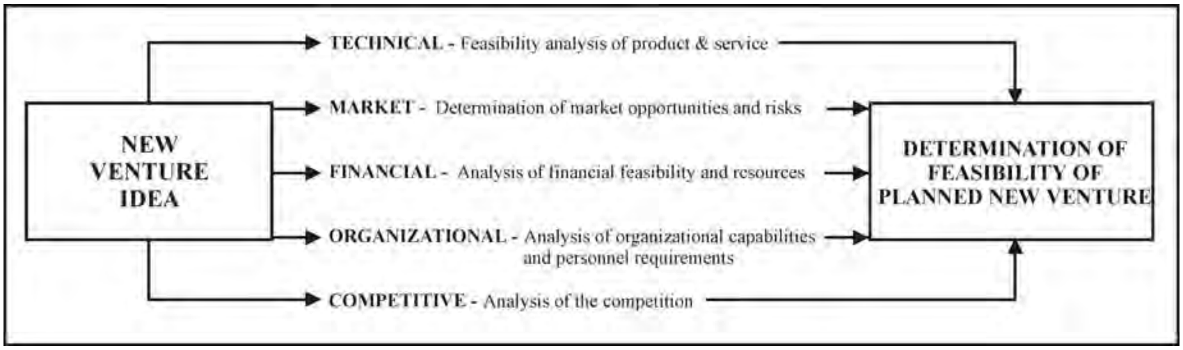


Figure 2.3. Key areas in assessing the feasibility of a new venture
(Source: Dollinger, 1996)

The evaluation of a new-venture idea should start with identifying the technical requirements, the technical feasibility, for producing a product or service that will satisfy the expectations of potential customers. Assembling and analysing relevant information about the marketability of a new venture is vital in judging its potential success. Financial considerations will be the costs involved, the organisational issues relating to whether the right profile exists in the organisation to exploit the opportunity, and lastly in indication who the competitors are and how they would react to the threat of a new opportunity.

2.6.4 Implementation

Implementing the opportunity should be planned carefully so that it occurs in the right place at the right time, with the right quantity. A business plan can lend support in this regard.

2.6.5 Evaluation

Success is not automatically ensured if the preliminary phases are carried out correctly. However, the probability of success is increased. Unforeseen environmental trends or variables can affect the implemented product or service, and can decide its success or failure. For this reason, evaluation is essential so that timeous adjustments can be made.

2.6.6 Control

The processes of entrepreneurship do not originate spontaneously. Nor do they always remain on track. For this reason, it is essential that controls be applied throughout the process – from the firs phase to the last. Control measures must focus on all subsystems. In this way, a total entrepreneurial effort is managed – not only elements of it.

2.6.7 Obstacles

In Figure 2.2 'X' represents obstacles that could inhibit the entrepreneurial process. These obstacles can be contextual, content related or of a process nature. Poor management training or a lack of experience, are contextual obstacles. A bureaucratic organisational structure that negates entrepreneurial action signals content related obstacles. When methods of generating ideas are not tested or experimented with, there are process obstacles to be dealt with. Obstacles should be identified and evaluated continually to make needed corrections timeously (Fox and Maas, 1997:19).

2.7 THE ENTREPRENEURIAL ORGANISATION

The entrepreneur is the individual (or team) that identifies the opportunity, gathers the necessary resources, creates and is ultimately responsible for the consequences of the organisation. Therefore, entrepreneurship is the means by which new organisations are formed and therefore the means with which wealth and job creation mechanisms are initiated (Carton et al. 1998)

Decision-making capabilities go hand in hand with the power, power structures and power relationships that are a part of any organisation. They are, in fact, an essential part. The manifestation of the power in the organisation is, however, critical in determining the organisational culture and the degree to which employees and their skills will be used to the best advantage of the organisation. Empowerment and the consequential willing and enthusiastic participation of employees in the evolution of the organisation should be goals that are espoused by managers who embrace the philosophy of an entrepreneurial organisation. Unfortunately, reality appears to show a different story, with management of companies apparently unable to accept the principle of true empowerment (Gierczycki, 1998).

Smaller organisations, on the other hand, appear to have a flexibility and willingness and ability to adopt a management style conducive to the fostering of entrepreneurism. The different manifestation and perception of power in these organisations may be the key factor that allows them to develop and prosper in a constantly changing macro-environment (Gierczycki, 1998).

2.8 MEASURING ENTREPRENEURIAL PERFORMANCE

The elements outlined in Figure 2.1 are the most important issues regarding entrepreneurship. However, the mere presence of these elements do not ensure automatic successes. Various reasons exist why entrepreneurial ventures fail and must be taken into consideration when an entrepreneurial culture is created.

Dollinger (1996) found that the factors underlying the failure of new ventures are within the control of the entrepreneur. The major reasons for the failure of new ventures according to Dollinger (1996) are as follows: inadequate market knowledge; faulty product performance; ineffective marketing and sales efforts; inadequate awareness of competitive pressures; rapid product obsolescence; poor timing for the start of the new venture; and under capitalisation, unforeseen operating expenses, excessive investments in fixed assets, and related financial difficulties.

More recently, Bruno, Leidecker and Harder (1996) examined 250 high-tech firms and found three major categories of causes for failure:

- Product or market problems
- Financial difficulties
- Managerial problems

Ten of these firms were studied in depth. Figure 2.4 presents the major and minor reasons for the failures of these ten, as cited by their founders. These three major categories had similarities with the reasons above. For example, under product/market there were the following factors: poor timing; product design problems; inappropriate distribution strategy; unclear business definition; over-reliance on one customer.

	Case Number									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Product/Market										
Timing	○	○						●		●
Design	●	●	○			○				
Distribution/Selling	●			○	○		●			
Business definition							●		○	
Too great a reliance on one customer					●	●		○	○	
Financial										
Initial Undercapitalization				●	●			●		
Assuming debt too early		●	●	●						
Venture capital relationship		●	●	●		●				
Managerial/Key employee										
Ineffective team	●	○	●	●	●		●*	○	●*	●
Personal Problems		●				○	●			○

● MAJOR REASON

○ MINOR REASON

* TEAM PROBLEMS DEVELOPED PRIMARY AFTER MERGER

Figure 2.4. Reason for Cited Failure

Source: Dollinger (1996:73)

Under the financial heading, there were the following factors: initial under capitalisation; assuming debt too early; venture capital relationship problems. Under managerial problems, there were two important factors: concept of team approach (e.g. hiring and promotions based on nepotism rather than qualifications; poor relationship with parent companies and venture capitalists; founders who focused on their weaknesses rather than their strengths; and incompetent support professionals); and human resource problems (e.g. kickbacks and subsequent firings that resulted in an almost total loss of customers; deceit on the part of a venture capitalist in one case and on the part of the company president in another; verbal agreements between the entrepreneur and the venture capitalists that were not honoured; and protracted lawsuits around the time of discontinuance) (Bruno, Leidecker and Harder, 1987).

According to Dollinger (1997) there are also six pitfalls commonly encountered in the process of selecting a new venture. They are: lack of objective evaluation; no real insight into the market; inadequate understanding of technical requirements; poor financial understanding; lack of venture uniqueness; ignorance of legal issues.

Above pitfalls can be avoided through proper evaluation of the idea as a whole. Therefore, a critical task in starting a new business enterprise is solid analysis and evaluation of the feasibility of the product-service idea. Entrepreneurs must put their ideas through this analysis in order to discover if they contain any fatal flaws.

2.9 SUMMARY

Chapter 2 provided the framework for the study of entrepreneurship, beginning with the theme that entrepreneurs succeed because of the opportunities that they exploit and the strategies they employ. The future is full of entrepreneurial opportunities, and new venture creation and entrepreneurship are changing the face of the world's businesses and economies. Historically, entrepreneurship has taken many different turns. In today's market-based economies, new venture creation is the key to technological and economic progress.

With regards to this study, the most important findings of this chapter are:

- A true definition of entrepreneurship is difficult to present, but from the various studies the common characteristics identified include creativity and innovation, resource gathering, opportunities, and the risk and uncertainty associated with entrepreneurship.
- Entrepreneurship is an accepted instrument that leads to job creation and prosperity in a constantly changing environment.

- Entrepreneurship is a process comprising of several subsystems that must work in tandem. The subsystems include the entrepreneurial organisation, processes of entrepreneurship, the individual, and the external environment as stimuli to entrepreneurship.
- Factors underlying the failure of new ventures are often within the control of the entrepreneur and for high-tech firms the problems can be categorised into product or market problems, financial difficulties, and managerial problems.
- Key aspects in assessing the viability of a new venture include technical analysis, market analysis, financial analysis, organisational, and competitive analyses.

CHAPTER 3

ENTREPRENEURSHIP AND GROWTH

3.1 INTRODUCTION

There is a distinction between the person or entrepreneur who wishes to go into self-employment to pursue their own interests (and perhaps enters self-employment because there is no more or little alternative) and the person or entrepreneur that enters small business ownership because they have desires to develop their businesses, to achieve growth, expand employment and grow into a medium-sized or large firm. The former type of small business owner has very different managerial objectives from the latter. The objectives of the first will be concerned with survival and maintenance of life-style, whereas those of the second type will be concerned with growth and expansion with the entrepreneur eventually owning several companies.

There has been much speculation about whether entrepreneurial firms can be identified ex ante, that is, before they achieve growth, rather than ex post, after they have demonstrated growth. This presents a problem for researchers and policy makers and for investors such as venture capitalists who will want to identify high growth and high performer firms. It is a classical adverse selection problem created by uncertainty and limited (if not asymmetric) information. Despite the inherent built-in difficulties of identifying such growth firms, this has not stopped policy makers from establishing agencies such as the Business Links Association to support existing small and medium-sized firms that have the potential for growth (Stewart, 1985:94). This problem has also not stopped researchers from attempting to identify the characteristics and features of such growth firms and their entrepreneurs.

There is no agreement on exactly what measure to use to distinguish a high performing firm. Attention has rather focused on identifying constraints, which may block the growth potential of many entrepreneurs and small firms (Stewart, 1985:96). The inherent problem for policy makers, however, is that environments that favour the expansion of some firms do not remain stable. There are windows of marketing opportunity that can lead to success of entrepreneurs and to growth firms. The right timing has proved to be crucial in many circumstances, even if other equally crucial factors might be in place.

However, the process of growth and growth firms themselves, have been and remain a focus of research in entrepreneurship and small firms. The focus is further heightened by the contention that only a small number of small firms enjoy the bulk of growth in any given period. According to Storey and Johnson (1987) "… job creation amongst small firms is heavily concentrated within very few such firms." This view, drawing impetus and support from the work of Gallagher and Stewart (1985), Doyle and Gallagher (1987), Gallagher and Miller (1991), in effect, has become accepted wisdom in the small firms literature.

Given limited resources and the desire to maximise returns or minimise losses, the attraction of a satisfactory predictive model, or growth theory, to policy makers, financial institutions, support services, and potential investors are clear. As a result, a number of research project have attempted to articulate the process of growth or identify those characteristics, which distinguish growth firms from their stable or declining counterparts. The purpose of this chapter is therefore, to review issues and factors that affect growth.

3.2 CONVERGING ON THE ENTREPRENEURIAL MANAGER

There are convergent pressures on being an entrepreneur and being a manger as a venture accelerates and grows beyond founder-driven and founder-dominated survival. Key to achieving longer-term sustained growth, and an eventual harvest, is the ability of an entrepreneur to have or develop competencies as an entrepreneurial manager. Further, it has long been thought that the entrepreneur who clings to the lead role too long during the maturation process will subsequently limit company growth, if not seriously retard it. As Galbraith (1971:187) explained it that, the great entrepreneur must, in fact, be compared in life with the male 'apis mellifera.' He accomplishes his act of conception at the price of his own extinction.

Increasingly, however, evidence suggests that entrepreneurs who are also effective managers can head new ventures that flourish beyond start-up and grow to become substantial, successful enterprises. A survey by Inc. magazine (1983) of the heads of the top 100 new ventures showed that the majority of these companies had founders who were still chief executive officers after several years and after their companies had attained sales of at least $50 million and some as much as $50 million or more. Testing conventional wisdom, two researchers empirically studied the tenure of 54 Fortune 1,000 corporations' founders. They assumed that there are three reasons why founders have to adapt: (1) shift from creation to exploitation, (2) shift from passionate commitment to dispassionate objectivity, and (3) shift from direct personal control over organisational actions to indirect impersonal control. Taking into account the growth rate, the timing of the initial public offering, the founder's age, education, and other factors, this 1990 study found the following:

- If the firm grows relatively slowly, and the founder is capable of some adaptation, then the firm can become quite large.
- Founders with scientific or engineering backgrounds remain in control of the companies they found for shorter periods than do founders whose academic focus was business.
- The founder's tenure will typically be longer in family dominated firms (Rubenson and Gupta, 1990:69).

More recently, Churchill (1990:177-178) observed that many founders can and do manage growth successfully. According to Williard, Krueger and Feeser (1989:157) the applicability of conventional wisdom regarding the leadership crisis in rapid-growth entrepreneurial firms may no longer be valid.

These and other data seem to defy the notion that entrepreneurs can start but cannot manage growing companies. While the truth is probably somewhere in between, one thing is apparent: growing a higher potential venture requires different management skills.

Clearly, a complex set of factors goes into making someone a successful entrepreneurial manager. Launching a new venture and then managing rapid growth involves managerial roles and tasks not found in most mature or stable environments. Further, one of the greatest strengths of successful entrepreneurs is that they know what they do and do not know. They have disciplined intellectual honesty, which prevents their optimism from becoming myopic delusion and their dreams from becoming blind ambition. No individual has all these skills, nor does the presence or absence of any single skill guarantee success or failure. That an entrepreneur knows that he or she needs a certain skill and knows where to get it is clearly as valuable as knowing whether he or she already has it (Timmons, 1999:240).

3.3 STAGE MODELS OF GROWTH

During the 1970s and early 1980s, much of the theoretical and empirical work attempted to conceptualise the growth models in terms of stage, or lifecycle, or models of firm growth (Penrose, 1995:216). These models, normally incorporating five stages, envisage a gradual movement along a known growth trajectory (see Figure 3.1).

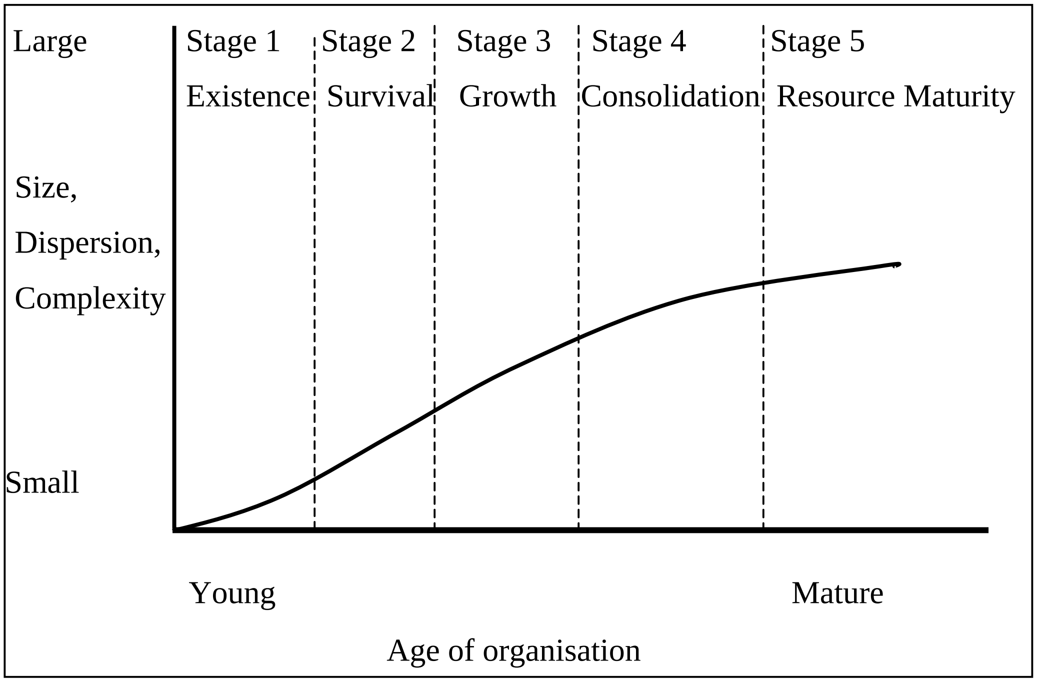


Figure 3.1. Lifecycle growth models

Source Deakins, 1990: 203

At each stage the organisation undergoes changes in management practices and style, organisational structure, degree of internal formality of systems and strategy, in such a way that the Stage 5 firm is truly distinct from the Stage 1 firm from which it derived.

Two models of Greiner (1991:207), Churchill (1989:67) and Lewis (1991:134) also discuss the growth phenomena. Taking them chronologically, the Greiner model posits a linear, continuous relationship between time and growth postulating periods of incremental, trouble-free growth (evolution) punctuated by explicitly defined crises (revolution). Each period of evolution has a clear set of attributes, which characterise it, and each stage, which ultimately degenerates into crises, is a solution to the crisis of the previous stage, as shown in Table 3.1.

Table 3.1. Greiner's stage model of growth

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Attribute	**Creativity**	**Direction**	**Delegation**	**Co-ordination**	**Collaboration**
Management focus	Make & sell	Efficiency of operations	Expansion of market	Consolidation of market	Problem solving and innovation
Organisation structure	Informal	Centralised and functional	Decentralised and geographical	Line staff and product groups	Matrix of teams
Top management style	Individualistic	Directive	Delagative	Watchdog	Participative and entrepreneurial
Control systems	Market results	Standards and cost centres	Reports and profit centres	Plans and investment	Mutual goal setting
Management reward emphasis	Ownership	Salary and merit increases	Individual bonus	Profit sharing and stock options	Team bonus
Crisis	Crisis of leadership	Crisis of autonomy	Crisis of control	Crisis of red tape	Crisis of ?

Source: Greiner, 1991:207

The crises according to Greiner (1991:207) model are as follows:

Crisis of leadership: The shift from a Phase 1 firm to a Phase 2 firm is triggered by a crisis of leadership. More sophisticated knowledge and competencies are required to operate larger production runs and manage an increasing workforce. Capital must be secured to underpin further growth and financial controls must be put in place. The company must hire additional executive resources and restructure to meet these challenges.

Crisis of autonomy: The control mechanisms implemented because of the first crisis become less appropriate as the physical size of the company increases. Line employees and line managers become frustrated with the bureaucracy attendant upon a centralised hierarchy. Line staff are more familiar with markets and machinery than executives and become torn between following procedures and taking initiative. It has become necessary for the company to delegate to allow sufficient discretion in operating decision-making.

Crisis of control: Top executives begin to perceive a loss of control because of excessive discretion resting with middle and lower managers. There exists little co-ordination across divisions, plants, or functions. Top management must seek to regain control, not through decentralisation, but by undefined special co-ordination techniques.

Crisis of red tape: The watchdog approach adopted by senior management, in Phase 4, and the proliferation of systems and programmes leads to a crisis of confidence and red tape. Line managers object to excessive direction and senior managers view line mangers as uncooperative and disruptive. Both groups are unhappy with the cumbersome paper system, which evolved to meet the challenges of the previous period. The company has become too large and complex to be managed through an extensive framework of formal procedures and controls. Movement to Phase 5 requires a shift to interpersonal collaboration.

Crisis of ?: The crisis into which Phase 5 degenerates remains undefined in Greiner's model. He can find no consistent empirical evidence that points to the nature of this crisis and the subsequent Phase 6. However, he hypothesises that this crisis will revolve around the psychological saturation of employees, which will occur as a logical result of the information age. Consequently, organisations will evolve with dual structures of habit and reflection, allowing employees to move periodically between the two for periods of rest or some alternative format whereby spent staff can refuel their energies.

The revolutionary components of Greiner's paradigm are perhaps atypical of the broader set of stage models although Scott's (1987:45-52) and Bruce's (1987:45-52) five stages of growth in small business imply a similar set of crisis triggers. By contrast, Churchill (1989:58) and Lewis (1990:97) although commenting upon Greiner (1991:127), present a more general depiction of growth models where transition from stage to stage has no explicit trigger, as shown in Table 3.2. Further, Churchill and Lewis include a sixth stage by dividing the standard success or growth stage into growth firms and what may be described as comfort firms (stage 3-D) which, having achieved economic viability and chosen not to proactively seek further growth, can be assured of average or above-average profits in the long run, providing management and the environment does not change to destroy their market niche.

In addition to those represented in Table 3.2, Churchill and Lewis include a further two factors in their paradigm which do not allow for easy tabulation of the organisation, business, and owner. Addressing organisation first, the authors posit an internal organisational structure of progressively increasing horizontal and vertical complexity, thus allowing for greater managerial sophistication and delegation. Secondly, the business and owner factor tracks the importance of the original owner-manager from an initially increasing central role to an eventual peripheral capacity when the organisation has reached resource maturity (Greiner, 1991).

Table 3.2. Churchill and Lewis: lifecycle growth model

	Stage 1	Stage 2	Stage 3-D	Stage 3-G	Stage 4	Stage 5
	Existence	**Survival**	**Success-Disengage**	**Success-Growth**	**Take-off**	**Maturity**
Management style	Direct supervision	Supervised supervision	Functional	Functional	Divisional	Line & staff
Extent of formal systems	Minimal to non-existent	Minimal	Basic	Developing	Maturing	Extensive
Major strategy	Existence	Survival	Get profitable	Maintaining status quo	Growth resources for growth	ROI

Source: Greiner, 1991:52

Following tables 3.1 and 3.2, along individual rows from left to right, a logical progression in the sophistication of the individual is observed. From this it can be deduced that firms move from an informal and ad hoc birth, through a quasi-functional state, culminating in the highest level of managerial and organisational refinement. These growth models are intended to facilitate owner-managers in recognising the stage at which their organisation stands and consequently identifying the skills required for further progression or, in the case of Greiner (1992:53), the likely impending crises. Yet whilst these models have the advantage of highlighting the notion that managerial skill requirements are not of a once and for all time nature, there are fundamental flaws associated with the rigidity of them. Researchers such as Storey (1994:194), Burns (1992:57), Harrison (1996:267), Burns (1993:78) and Dewhurst (1994:147) have the following critique at the Greiner and Churchill and Lewis models:

- Most firms experience little or no growth and therefore are unlikely ever to reach Stages 3, 4 or 5. Whilst Greiner allows the conscious decision to remain in a particular stage and Churchill and Lewis provide numerous break-off paths for disengagement or failure, it nonetheless remains implicit that the norm for growth firms is to follow and complete the process.

- The models do not allow for a backward movement along the continuum or for the skipping of stages. It is surely conceivable that many firms will reach take-off, only to find themselves plunged back into a struggle for survival due to unexpected changes in markets, technology or consumer preferences. In addition, the requirement for the firm to complete each stage before moving forward to that stage immediately following seems excessively limiting.
- Perhaps most significantly, the models do not permit firms to exhibit characteristics from one or more stages, to become hybrids.
- The idea that firms are occasionally able to learn and adjust with greater effect in response to crises than in periods of relative stability seems entirely plausible, yet that crises occur in the non-random manner suggested, given the inherent uncertainty within which firms operate, is far less credible. It is conceivable that some firms will lurch from crisis to crisis and that these crises will not be of leadership, autonomy, control and red tape, but of market stagnation, market saturation, technology, finance or skills. It is further conceivable that other firms will enjoy smooth growth over a relatively uninterrupted horizon.

3.4 PREDICTIVE MODELLING OF GROWTH

In his final criticism of stage models, Storey (1994:122) notes that the models describe, rather than predict. An approach that can compliment that can be predictive modelling. These models are described in the following sub-paragraphs.

3.4.1 Financial Models

The early work undertaken by Storey et al. (1987:67) concentrated on the role of standard financial variables in predicting successful small firms. This method, adapted from use with large corporations, adopted an inverted approach to predicting small firm success, failure and identifying success by implication. After initial testing of univariate ratio analysis (consideration of individual financial ratios in progression rather than as a composite) proved inappropriate, Storey (1987) and colleagues shifted their focus towards methods of multivariate inquiry. From the research low profitability and high gearing ratios were positive correlates of small firms failure. The researchers' optimum multivariate model utilised cash flow and asset structure variable as their primary predictors. Based on this final model Storey et al. (1987) claimed a 75% success rate in distinguishing between failed firms and survivors.

Several criticisms can be levelled at Storey's (1987) technique. Firstly, the technique offers no historical insight. There is little consistent evidence to suggest that the variables alter significantly as the companies approach failure, nor is there any indication of the underlying causes of failure. Secondly, as a predictive model for rapid growth firms the technique would appear inadequate. Since its purpose is to identify firms, which will fail, the model is unable to distinguish between the small proportion of growth firms and the bulk of failures. Finally, the model takes little account of the human capital factors, which play a considerable role in determining survival and growth (Hall, 1995:51; Gallagher, 1996:178 and Robson, 1996:178).

3.4.2 Characteristics Approach

Research efforts to distinguish growth firms from their stable or declining contemporaries have tended focus on non-financial characteristic of the owner-manager and the firm. In this regard, Storey (1994:122) postulates that small firm growth is driven by three integral component sets: characteristics of the entrepreneur (identifiable at pre-start), characteristics of the firm (identifiable at start) and characteristics of the corporate strategy (identifiable at post start). From the empirical studies reviewed, Storey (1994:122) isolates those factors where consistent evidence of influence was available (see Table 3.3).

Table 3.3. The characteristics approach to growth

The entrepreneur	**The firm**	**Strategy**
Motivation	Age	External equity

Education	Legal status	Market positioning
Managerial experience	Location	New product introduction
Teams	Age & size	Management recruitment
Age	Market/Industry sector	
	Ownership	

Source: Storey, 1994:122

3.4.2.1 The Entrepreneur:

Motivation: It is suggested that individuals who are pulled into business ownership, and whose motivation is consequently positive, are more likely to develop growth firms. However, in common with other areas of entrepreneurship, motivation is likely to be a more complex process, often the result of interplay of factors (Freel, 1998:173). Simplifying motivation into an artificial dichotomy of 'pull' and 'push' factors can be misleading.

Education: There are two contrasting hypotheses presented for this factor. Firstly, ignoring any relationship between education and competency, it may be argued that education provides a foundation from which the entrepreneur can undertake the personal and professional development necessary for successful entrepreneurship and that education will endow the entrepreneur with greater confidence in dealing with bankers, customers and suppliers. It may also be argued that on aggregate education can be taken as a fallible proxy for intelligence. Conversely, it may be argued that business ownership is not an intellectual activity (Freel, 1998:129) and that the educated entrepreneur will quickly become wearied with in many tedious tasks, which form the remit of most owner-managers. In Storey's review, evidence is found to support the former hypothesis in preference to the latter. From his work on a database of surveyed Nat West Bank clients, Cressy (1996:219) suggests that whilst a first degree in a science or engineering subject may be most appropriate for high technology entrepreneurs, it is more likely that a trade qualification is optimal for mainstream firms. Logic would dictate that education, not to a level but of a type, would influence the entrepreneur's ability in the given environment and, consequently, the firm's chances of growth. Yet as a component of a predictive model, relative consistency is a prerequisite. On the eighteen studies reviewed by Storey (1994:129), nine show no impact and eight show some form of positive relationship. For Storey, this provides consistent support. However, since little effort is made to explain the effect education has on firm processes one cannot explain why various types or levels of education occasionally influence growth. For instance, Barkham et al. (1996:140), in their four-region study of the determinants of growth, note that education matters but in an indirect way, and the disadvantage of poorer education can be overcome by those who adopt similar strategies. The authors further suggest that education per se does not influence growth, but rather education influences strategic choice, which, in turn, influences growth. Accordingly, there seems very little basis for prediction, other than excessively subjective prediction, using this variable.

Managerial Experience: It is conjectured that in all but the very smallest firms the principal activity of the entrepreneur is the co-ordination of the work of other individuals. Hence, prior managerial experience and, consequently, experience in the co-ordination role will allow the entrepreneur to attend more effectively to his remit and subsequently meet business objectives. There is also a parallel argument regarding the higher minimum wages those with managerial experience are likely to have. Individuals with high minimum income are unlikely to enter into self-employment without a corresponding high degree of confidence in a successful outcome. To counter this hypothesis, small firms are emphatically not large firms and managing in a small firm is likely to require a very different set of skills than the other functional competencies required for large firm management. Thus managing in a large firm, whilst raising minimum income requirements, is unlikely to represent a dependable proving ground for small firm owner-management. Given the high levels of uncertainty in which small firms operate and accepting the axiom that small firms are not homogeneous, Burns (1996:5) highlights that each small firm is different and has special characteristics. It is unlikely that any acceptable consistency will be detected in the influence of this factor. The consistency Storey (1994:130) notes is that, of eleven studies, four have a positive impact, six have no impact and one has a negative impact. As with most of these factors, the contention is not that here is no impact. Rather the consistency and degree of influence of this factor are subject to levels of variation, which negate prediction.

Teams: In light of the evidence discussed in the above paragraph, it is postulated by Storey (1994:130) that since the management of a business requires a range of skills businesses owned by more than a single individual are more likely to grow than businesses owned by a single person.

This view is often taken to be axiomatic. However, from his research with high technology firms (often viewed as the industrial sector representing greatest growth potential) Oakey (1995:16) noted that rapid firm growth is strongly related to single founder businesses. On a different note, but perhaps significant, Vyakarnam et al. (1996:187) argue that the core competence of successful entrepreneurs is the ability to build and manage effective teams - not the team itself. This hypothesis would appear to offer scope for team dynamics and the evolution of the team from start-up. It is further argued by Vyakarnam et al. (1996:189) that the team-building process itself is non-linear, chaotic, and unique thus negating the possibility of artificially manufacturing teams as a policy measure (Timmons 1999:57).

Age: In support of the evidence viewed by Storey (1994:197), he argues that the critical characteristics of growth firms are associated with human capital variables most significantly founder(s) age and team size. With regards to age, it would seem clear that, since time is not simply time elapsed but has a chronology and a history (Costello, 1996:591-597), and being of a certain age cannot, in itself, act as a predictor of growth. It is the substance of an individual’s life not the accumulated number of years that is important. Thus, any paradigm, which incorporated an age component, would be subject to inconsistency.

3.4.2.2 The Firm

Legal Status: In his review, Storey (1994:140) finds overwhelming support for the contention that United Kingdom studies consistently point to more rapid growth being experienced by limited companies. Credibility with customers, suppliers, and financial institutions is argued to be the principal benefit of incorporation. Although limited liability is often circumvented through the provision of personal guarantees to funding providers, it is difficult in the face of predictive modelling. It should be noted that legal form is, by no means, stationary. As Storey (1994:141) points out, that current legal status rather than a cause of growth cannot be rejected as a hypothesis.

Age and Size: The issues of firm size and age may be dealt with concurrently as they are often related variables. Whilst the relationship between size and age is by no means linear, Jensen and Mcguckin (1997:649-670) suggest that in aggregate the more a firm grows the bigger the turnover becomes. From the point of view of policy, logic would seem to endorse the support of small, new firms as a means to achieving employment policy objectives. On a cautionary note, it should be understood that studies deal with changing rates of growth and not with absolute growth. An additional caveat would be to a tendency to overestimate small firm growth rates in relation to their larger counterparts (Jovanovic, 1982:649-670). Further, as recent research has noted, employment growth within the small firm sector is primarily a result of existing business expansion rather than new firm creation (The European Observatory for SMEs, 1994 and Smallbone and North, 1995:47-64.). Indirectly allied to this is the notion that the probability of a firm failing falls as it increases in size and as it increases in age (Hall, 1995:17).

Location: Storey (1994:358) suggests that location will be a factor influencing firm performance. However, recent work by Westhead (1995:367-380) found that “the majority of firms suggested more than half their customers were located outside the county region of the businesses main operating premises’ and that “urban firms had recorded the largest absolute and standardised employment increases since business start-up.” The literature is decidedly equivocal on this point. Even the studies reviewed by Storey fail to reach consensus. Regardless, this factor does little to enhance a better understanding of cause and effect. Location itself does not directly influence growth, rather infrastructure, resource munificence and availability of skilled labour, are the true factors for which location acts as a fallible proxy variable.

Market/Industry sector: Concerning the industrial sector, high technology small firms are often viewed as a corrective for unemployment caused by the decline in traditional industries, which has marked the past twenty years. This view is reflected in the plethora of policy initiatives directed at this sector of the economy. However, as Oakey (1995:311) stresses, what little evidence is available to support this contention has been extrapolated from mainly American data. Contextual issues remain over the ability to replicate this phenomenon.

Ownership: It is hypothesised that a considerable amount of small firm growth is inorganic, i.e., growth through acquisition and through the development, by individual entrepreneurs, of other distinct business. The latter notion, often called portfolio entrepreneurship, has enjoyed a surge in popularity recently according to Birley and Westhead (1994:42).

3.4.2.3 The Strategy

External equity: Logically, the sources of finance accessed and the corresponding financial structures of small firms will influence their propensity to grow. The firm's reliance on short-term debt finance is clearly sub-optimal concerning long-term growth (Deakins and Hussain, 1994:24-31.). The argument advanced by Storey (1995:157) is that those firms who have either shared external equity or have been willing to allow an external holding in their company are more likely to grow than those who have, or are, not. Thus, capital for equity allows firms to circumvent the constraint imposed by short-term debt funding. However, there is a need for caution. Firstly, Storey (1995) suggests that it may be that the only firms that attract external equity are those, which have grown or exhibit obvious potential for growth. Consequently, there is no indication of the direction of causation. Secondly, it is unlikely according to Storey (1995) that such a questionable measure as willingness to share equity has been included in research studies. Thirdly, most small firms researchers would be able to provide anecdotal evidence of a firm, which stated its willingness to share equity, yet when the occasion arose either procrastinated or declined the opportunity. Correspondingly, there remains the much cited equity gap according to Murray (1994:58-76) whereby small firms, regardless of desire and strategic stance, are unable to obtain equity funding.

Market positioning: The temptation has always existed to characterise small firm competition as pure or perfect competition according to Storey and Sykes (1996:197). In this way firms become price takers and are bereft of any market power, consequently unable to adopt price competition strategies, erect entry barriers and are overly vulnerable to the vagaries of the ensuing market uncertainty. Since perfect competition requires, inter alia, perfect knowledge about present and future states, perfect factor mobility, and perfectly rational maximising factors, this has always been a surprising and implausible assertion. Pure competition, which does not require the first and second of these assumptions to hold true, is slightly more credible and is attractive given that, superficially, one can identify in many industries or markets a large number of small competing. The argument then, for market positioning, is that growth firms overcome this lack of market power and pricing discretion by inhabiting niches. Competition becomes monopolistic and the firm is able to make above normal profits to finance growth and to increase relative market share, thus reducing uncertainty. Yet, intuitively, price competition is becoming less common. It is likely that most firms undertake some form of differentiation strategy, be it direct product characteristics, customer demographics or product quality. It is also possible for firms inadvertently to occupy market niches. Geography, rather than conscious market positioning, has allowed the shop owner a degree of discretion when setting prices. Although a niche strategy is undoubtedly advantageous, on aggregate it is likely to be neither a sufficient nor, indeed, a necessary condition for growth. There is a further concern over the appropriateness of niches to sustainable growth. For instance, Storey and Sykes (1996:15-16) suggest that "The challenge facing the growing firm can be stated in terms of a move from relatively narrow market niches in which it exploits a narrow range of distinctive assets into a situation in which it serves a larger number of market segments with a much broader skills and knowledge base."

Another related component of market position involves competitor characteristics. It may be plausibly argued that fast growth firms, occupying market niches, see their primary competitors as other small firms occupying the same or adjacent niches according to Storey and Sykes (1996). Conversely, poorer performing firms would be in direct competition with large firms where no niche exists. Accordingly, the large firms are able to take advantage of a relatively large market share to the detriment of the small firms. Whilst there is an internal logic to this argument, the empirical evidence is, once again, inconclusive. For instance, Westhead and Birley (1995:11-34) note that "[Growth] firms are associated with a strategic stance of competing with large employment sized firms rather than a decision to operate in markets saturated by fellow new and small firms."

New Product Introduction: New product introduction is, as a means of differentiating on firm's products from another's, related to the above discussion of product differentiation and market niches. It is not clear whether the measure addresses products new to the market and industry or simply those new to the firm (i.e. an extension of an individual firms product range).

Management recruitment: According to stage models, as the firm grows, the managerial function becomes progressively more complex. The manager can no longer maintain effective control over the minutiae of day-to-day operations and is required to delegate. The owner-manager's task becomes the identification or recruitment and motivation of suitable individuals who can manage in his / her stead. This is supported by Penrose (1971:152) who argued that the presence of sufficiently experienced executive resource was required for confident planning and subsequent growth. However, in the Penrose model executive resource would ideally be internally experienced, whereas Storey (1995:56) suggests that growth firms are more likely to recruit managers externally. Regardless, as Storey (1995:71) notes, there has been insufficient research in this area. It is likely that management recruitment is both a consequence and a cause of growth and any subsequent growth will be significantly influenced, not by the presence of, but by the efficacy of, new management.

Storey (1995:119-121) notes the importance of the wish to grow in achieving growth. This conjecture is supported by Smallbone and North (1995:59) and Leigh and North (1995: 44-62.) who contend “one of the most important factors [in influencing growth] is the commitment of the leader of the company to achieving growth.”

3.5 GROWTH BARRIERS

At the same time as the predictive modelling literature has grown, the argument has been that the focus of research and policy should be towards relieving barriers to growth for small firms rather than identifying generic characteristics or sets of characteristics (Freel, 1998:19-32). Although such an approach does not concern itself directly with growth theories, it has merits. The suggestion that artificial barriers to growth exist and that firms may grow more readily were these barriers to be removed, may be viewed from a different perspective. Implicitly this approach suggests that a particular external state or internal structure is more appropriate for growth than that which prevails in the absence of suggested interventions.

Barber, Metcalfe, and Porteous, (1989) summarising the literature, suggest that these constraints consist of three types: management and motivation; resources; and market opportunities and structure. Specifically those would include, inter alia, lack of management training, relatively low qualifications, reluctance to delegate, and the need for new management skills and techniques as the organisation grows; access to finance, access to skilled labour and access to technology; market growth rates, size and frequency of purchases, degree of segmentation and opportunities for collaboration or merger. Many of the factors in this list are complementary, or related, to variables discussed in the previous sections. For example, lack of management training may equate with prior management experience, low qualifications with education, degree of segmentation with market positioning. The variable, which sits least comfortably, although arguably loosely related to the earlier discussion of external equity, is that of access to finance. This is also the most commonly cited and vigorously debated barrier to growth. However, there exists little empirical evidence that access to finance represents a significant barrier to growth (Cressy, 1996).

On a more general note, there exists a counter argument to the suggested lifting of presumed barriers of growth. It is implied that entrepreneurs, or small business owner-managers, trading in hostile environments are more likely to develop the characteristics of self-alliance and determination required to succeed (Dewhurst, 1996). Consequently, policy should avoid lowering barriers or providing incentives, which dull the development of these attributes. This is a generally untested hypothesis built upon principally anecdotal and ad hoc observations and it is doubtful whether such an extreme position would be of value in the generality of policy. Whilst one might feel a policy of erecting or maintaining barriers is a step too far, Cressy's (1996:1253-1270) suggestion that one should adopt a stricter German model which, by making start-up more difficult, aims at raising the threshold quality of new ventures seems eminently sensible.

3.6 SUMMARY

This chapter has contented itself with presenting the three strands which have had greatest influence on public policy and mainstream academic debate. Whilst implausibly rigid, stage models are truly process oriented and grant due attention to the role of history in determining the actions and structures of firms. However, the researcher concurs with Storey; the models describe rather than predict or, more significantly, explain.

On the other hand, the characteristics or predictive modelling approach to small firm growth has, itself, reached an impasse. The factors influencing growth are innumerable and are likely to defy classification in a simple, usable model. Attempting to isolate those where evidence of effect is consistent appears fruitless.

More recently, emphasis has begun to shift from static analysis of categorical, often binary, variables towards a more dynamic analysis of the processes of adaptation and learning. Simplistically, it may be suggested that, since growth necessitates change, those firms, which were most receptive to change and/or have managed change most effectively, were more successful. Within this context, learning is seen as a process of adaptation to changes in internal and external environments. Such a shift in focus is consistent with the current fashion for learning organisations; growth theory and education – all of which seek to emphasise the pivotal role played by human capital in the development of firms. The aim of such research is to discover and delineate the underlying processes of adaptive learning and growth, irrespective of context, or to determine whether such processes exist. Unfortunately, no coherent testable model has been developed to date. The development of a suitable process theory of [small] firm growth remains one of the major challenges in entrepreneurship and the wider social sciences.

With regards to this study, the most important findings of this chapter are:

- There are a number of venture growth models, which incorporate the following stages, existence, survival, growth, consolidation, and resource maturity;
- Each stage in models has a clear set of attributes such as management practices and style, organisational structure, formality of systems, and strategy that characterise it;
- A weakness in stage models is that they describe rather than predict the venture's growth pattern. Predictive modelling by using financial models, characteristics approach (the entrepreneur, teams, age) alleviate this problem;
- From the literature, growth constraints consist of three types- management, resources, market opportunities, and structure; and
- Not every entrepreneur wants to grow and it is difficult to identify those organisations that have growth potential from those where the entrepreneur is in business to sustain him and his family.

CHAPTER 4

LARGE FORMAT DIGITAL PRINTERS

4.1 INTRODUCTION

The digital printing industry is a rapidly changing and revolving industry, as is the terminology that is used. Digital printing is defined by Bruno (1993:172) as "printing from digitally produced plates." In some cases Bureaux consider inkjets, colour copiers and traditional proofing devices to be part of digital printing. Ray (1994:199) defines digital printing systems as processes which, "can produce prints directly from digital data without the use of intermediate films or plates." Examples of such printing systems include high-speed copiers, electrophotographic, magnetographic, and iondeposition printers, and inkjet printing (Ray, 1994:199).

This definition, however, does not include the hybrid photographic processes such as digital enlargers. Mortimer (1991:148) places inkjet, thermal wax transfers, thermal dye sublimation, photography and electrophotography into the proofing category and calls them " digital data colour proofing devices."

LFDP is a general term to anything printed bigger than A3 from computer files onto a digital machine. These machines are neither complicated nor the latest in technology as some printers suppliers may inform you (Redgrave, 2000).

The terminology is therefore rather confusing, as there is no agreement on a definition of proofing, print-on-demand, digital printing, electronic printing and on-demand printing. As graphic designed applications can make use of digital printing, large format digital printing and printing-on-demand, the general term, digital printing can be used in this document.

This chapter provides an overview of the LFDP industry.

4.2 LARGE FORMAT DIGITAL PRINTERS

When research started on companies who manufactured and supplied LFDPs, the researcher supplied a University of Limerick project team with an extensive list of web sites of such companies. Each web site was examined extensively and the project group searched the Internet for web sites of more companies who manufacture and supply LFPD's. Each company that had any connection with LFPD's were contacted by e-mail, but the response rate was poor and again stresses the secret nature of this industry. The resultant decision was to pick the top companies and proceed with the research from there. After contacting these companies, it was decided that it was not feasible to research all the printers these companies produced. A final selection list of LFPD's was made by picking each company's widest format printers, the project title being Research on Large Format Digital Printer's (University of Limerick, May 2000).

The aim of this project was to identify large format digital printers available currently on the market during time of the research (for more information see Annexure A).

The most important findings from this investigation are that the various companies identified each offer product and services that attempt to differentiate from competitors and that due to the constantly changing environment, companies are always searching for means to improve their products and service. The number of LFDPs again underlined the dilemma of an entrepreneur in this industry i.e. which LFDP to select and to make sure that the investment in this LFDP is optimised.

4.3 PREPARATION FOR PRINTING

An image viewed by a graphic designer on a computer screen goes through a number of stages before it can be printed. There are many software programs available to the graphic artist who can use them to create images or to manipulate existing images. A small sample of the software programs that are available, are Adobe PhotoShop, Adobe Illustrator, Macromedia Freehand, QuarkXpress, Adobe PageMaker, Fractal Design Painter and Corel Draw.

Some programs create images as vector graphics where each point on a line or curve would be defined by a mathematical description. Printers are not capable of understanding of printing this type of information and so all vector images must be converted to bitmapped or raster images in order to be printed. A bitmap image consists of a grid made up of pixels. Each pixel has a location and can be assigned a colour value. Bitmap images are very commonly used to produce imagery, because they can represent subtleties of tone and gradations of colour accurately. Raster Image Processors (RIP) is needed to process all vector images into bitmapped images. Some RIP is built into the printers themselves as print controllers. Others are purchased separately and can act as document servicer RIP, or stand-alone RIP software can be installed into an existing workstation. The workstation can also be used to run other application.

RIP has four main functions: rasterizing images for output, scaling images, controlling colour and driving one or more output devices. The first step in the process is to separate the image into the appropriate colour values. These can be CMYK for most inkjets, RGB for digital enlargers and other variations for extended gamut inkjets.

Unlike traditional printing processes, most digital printing does not require images to be screened. However, because most digital printers build up an image by laying down minute dots, images are broken up into dot patterns. The system used to control this is called dithering. The most common form of dithering is stochastic screening; it can also be called frequency modulated (FM) screening. The stochastic screening system relies on using very small dots of the same size to build up an image and varying the spaces in-between the dots, thereby producing a seemingly random pattern. Second order FM screens vary both the dot sizes and the spaces between the dots in a random pattern (Somerville, 1999:1).

RIP have colour management software built into them and can transform images to match the ink limitations of specific devices. When a dot is printed onto a substrate, the substrate's absorbency will significantly effect the size and density of the dot achieved, dot gain or dot loss will occur. When processing images, RIP can be instructed to take the final output media into account and will therefore make adjustments regarding dot gain. RIP control how solid black is printed, using pure black ink or building it up as a combination of black and the other inks, the latter takes less time to print and improves drying times and finishing capabilities. Specific image characteristics can also be taken into consideration when images are processed, for instance, if the image is photographic or contains process colours; the RIP will make appropriate adjustments to achieve the best results.

The digital printers (see Annexure A) can roughly be categorised into printers that spray ink, printer that use heat to melt inks (dye sublimation and thermal wax), printers that use hybrid photographic processes and those that use charged toner particles to form a colour image. The printers all have their specific limitations for instance the laser, colour copier, phase-change inkjet, dye sublimation and thermal wax printers are all limited, in the size of the print that can be made, to approximately 1300mm. Other inkjet printers range from small desktop models to huge super wide models that are over 6.5 meters wide. The technique that each printer uses to create colour influences the quality or the resolution of the image, what inks can be used on what substrates, what colour gamut and tonal range can be achieved and the permanence of the image. The actual appearance and qualities of the prints made out by these machines are tested and discussed in Annexure C where print anomalies are identified.

4.4 OUTSIDE FACTORS INFLUENCING DIGITAL PRINTING QUALITY

The entrepreneur needs to have a sound understanding of colour communication, measurement, and control as well as external factors such as hardware, operators, and software in order to ensure that their product and service is consistent (see Annexure E). The key point is that if the entrepreneur can measure colour, then they will be able to control colour. Without measurement, describing and verifying colour can be ambiguous and unreliable. With numerical measurement data, however, colours can be described and verified with precision and confidence. It can be seen from the scope of factors addressed in Annexure E, that to achieve perfect print quality is the goals of numerous manufacturers of materials, hardware and software, as well as groups of experts in the fields of colour standardisation. The input stage is critical as it is highly influential in determining the colour balance, tonal range, highlight and shadow detail, sharpness, resolution and the size of the final print. Additional aspects, such as corrections made by the print operator, or automatically by colour management software will also affect print quality. If the operating entrepreneur wants to achieve print accuracy, Annexure E emphasises that all the equipment used must be correctly calibrated.

4.5 COMMERCIAL APPLICATIONS OF LARGE FORMAT DIGITAL PRINTING

The commercial application of large format digital prints is a constantly evolving market. As new processes, substrates and inks enter the arena, new applications are found for them. Up to this stage a number of commercial uses for digital prints have evolved. Jordaan (1999:2) lists them as follows:
"Uses: retail merchandising, trade show exhibits, service firms/utilities, public spaces/event promotion, corporate spaces/exhibits, point-of-purchase advertising, recreation and entertainment, automotive, architecture/construction, convention displays, presentations/seminars, grocery, restaurants/fast food, shopping mall/centres, [sic], medical/scientific/engineering, museums/galleries."

Other uses include photographic prints and enlargements, business-, greeting- and post cards, proofing, publishing, printing onto fabric, and film positives for traditional printing processes. Prints serve a wide range of applications, from prints used to decorate snowboards, to prints on mesh, which can be used to cover buildings or construction sites.

Because of the wide range of applications and printing processes, most digital print bureaux accept work from a broad range of clients. These can include advertising agencies, architects, trade show designers, corporate and retail graphic design departments, photographers and publishing print shops. These clients design posters, displays, billboards, murals, stage sets, vehicle markings, and signage, postcards, brochures and many other images. Their designs generally include text, renderings or illustrations and photographs. In terms of computer software a huge range of design products can be used. This range of input formats, images and display criteria constantly challenge the bureau to offer unique solutions for each designer's needs.

4.5.1 Commercial Applications examples

Commercial applications of hybrid photographic processes such as image setters to print, film recorder to print and digital enlargers are vast. Photographers for instance can make use of these facilities for retouching and the restoration of photographic images. However this type of retouching is, for the bureau, labour intensive, and not a very profitable area, as print quantities are generally small. It is far more profitable for both bureau and client to use the large format digital negative or positive to print quantities of between 10 to 1000. These images are then used as postcards, business cards, posters or catalogue sheets. This route is cheaper than traditional printing methods especially if print quantities are low (Berg, 1997:28 – 32). Film recorders writing to transparency film are used extensively to produce slides for large format printing presentation. Once again clients often combine graphics, text and photographic images and these designs are sometimes printed to colour copy machines for handouts, as well as being used to generate the slides. Some companies such as RB Images of Hollywood print 1700 – 2500 sliders per month, with a turnaround time of three hours (Brown, 1997:39).

Digital enlargers offer the option of printing onto any type of photographic material, from backlit transparency film to black and white resin coated photo-gloss paper. Material such as Ilford's Ilfochrome, colour reversal, translucent material or a RA-4 translucent material is ideal for the display of photographic-type images. It is being used quite extensively by fast food area franchises such as McDonalds to display current products.

Medium sized (101 x 127 cm) prints, in quantities of between 15 and 120 can be printed more economically than on regular offset presses. The prints are displayed in light boxes and require longevity qualities in the photographic materials used. The images are used to promote special offers on certain ranges of food and drink. Digital enlargers render the bright colours, fine text and photographic images of these pieces exceptionally well.

Dole was one of the first photographers to make use of digital printing for self-promotion. In 1996 Dole produced a number of large-scale images on the Xerox Versatec electrostatic printer. His aim was to show a prospective client a series of impressive posters that would illustrate his photographic skills. His decision to use digital printing to make the images was dictated by two aspects, firstly, that the computer offered very accurate adjustment controls and secondly the particularly attractive print characteristics of the Versatec. Davis (1993:46) points out that Dole chose the electrostatic machine because of its ability to "quickly turn out a large, museum-quality, four-colour print – all without entering a darkroom."

The different types of large format inkjets have a wide range of commercial applications. For instance, aerosol inkjet prints have been used on promotional billboards to advertise popular TV shows. Eggers (1996:38) describes how "during promotional periods in some major markets, billboards for Oprah Winfrey were being changed very day. Each afternoon, the topic for the next day went up. Only the actual topic panel was changed, but it was being done on a daily basis. Making frequent changes like that before the days of digital printing, would have made such output impractical, if not impossible."

In Pretoria (South Africa) inkjet prints on billboards were used to cover three sides of a fire gutted building. The two 21 m long by 17 m high images and one 42 m long image were used to promote local TV stations (Davidson, 1999:1 – 2). Inkjet prints on the appropriate outdoor substrates are also used on bus shelters, taxis, trucks, delivery vehicles and busses.

Why commercial clients use large format digital prints can be narrowed down to the following reasons.

- Images can be changed in the middle of a print run. For instance three posters with the same image can be printed, text changes made and further prints made at very little additional cost.
- Turnaround times are very short, in some cases a poster can be delivered to the client within a few hours.
- Scale is not a limiting factor and billboards of enormous sizes can be printed.
- Colours are vibrant and text is sharply defined.
- Images can be transferred on to almost any surface.

Jordaan (1997:7) lists the customer’s requirements as “large format, Post Script, [sic] photographic quality, colour range, ease of use, fast production (quick turnaround), low cost, volume, media range, various substrates…”

4.5.2 Fine art applications of digital printing

In 1995 the magazine Leonardo published examples of digital images that were part of an exhibition “Art as Signal: Inside the Loop,” curated for the Krannert Art Museum, University of Illinois at Urbana-Champaign. The examples depict two-dimensional computer artwork and include examples of dye sublimation, Cibachrome (Ilfochrome), from film recorder transparency, colour laser and inkjet prints (Chmelewski, Goggin, Squire, 1995:85 – 92). When looking at what artists use digital printing for, it must be noted that some artists in America have been involved with digital printing for at least the past fifteen years (Moore, 1999:20). This has not been the case in South Africa, where many artists have only started to use digital media quite recently. However, these artists have already exhibited work and made use of a variety of media.

4.5.3 A comparison of commercial and fine art applications

An installation of images for promotion in a fast food restaurant does not differ vastly from an installation of a backlit fine art image. Many artists are still quite conservative in terms of how they see the application of digital prints. This is possible linked more to cost and access than lack of ideas. Some artists push the boundaries of the digital print media then mix them with traditional fine art techniques. As Lowe (1995:8) points out, "artists are always pushing the parameters of what a print engine can technically achieve and are mixing aspects of different processes together to exploit the potential offered by this diversity." They do not however have the budgets that commercial clients have and this could limit the type of applications that they would like to achieve, and the amount of experimentation that they could do.

One major factor when it comes to the application of commercial work is the fact that images are most often required to last only a few months at the most, while most fine artists would like their images to last for as long a possible. This has a limited effect on the choices that a fine artist can make when selecting printing processes, inks and substrates.

4.5.4 Permanence issues

Entrepreneurs, using the first large format digital prints, were dismayed at how rapidly the inks faded. This resulted in the medium acquiring a poor reputation. Recent industry efforts to improve the longevity of large format digital prints have substantially changed the attitudes of operators and entrepreneurs. The George Eastman House started collecting small-scale digital prints in 1993. Therese Mulligan, the curator at George Eastman House, explains that "due to the rapidly changing nature of the digital medium, entities like galleries and auction houses are moving towards a greater acceptance of the medium" (Leslie, 1998).

For the operator there are a number of routes that they can take when printing for permanence, most importantly, the medium chosen should be suitable for the application. A dye sublimation print's longevity characteristic is vastly different to a platinum print made from a digital negative. There is also the option of offering to provide the file of an image on a relatively indestructible medium, such as a good quality CD or magneto optical Disc. This means that the image could be printed again if any noticeable fading occurs, or if new and improved materials become available. There are certain drawbacks to this process. Some mediums, such as thermal wax prints, may be phased out in the future and the printers and materials will no longer be available. It might take a skilled operator to duplicate the original print when new materials; technology and software may cause subtle changes. Another issue mentioned by Henry Wilhelm is that the hardware and software for certain storage media may not be available in the future (Wilhelm, 1999).

From a curator's point of view, digital prints do not differ vastly from other art media in terms of conservation; especially with current art trends where graphic and signage specialist artists incorporate natural products into their work. Cannon-Brookes (1983:34) refers to "the total freedom now enjoyed by the artist presents formidable problems for the museum curator and his conservator, problems which are often little understood by either the graphic artist or the curator".

Leslie (1998) adds to the above by highlighting that if you are for a digital print like you do any other work on paper, thinking in terms of preservation when storing or displaying work, understanding all of its physical attributes, then you can be pretty certain of its longevity (Leslie, 1998). As more products come onto the market, it is exceptionally difficult for operators or graphic artists to keep up with how long the images printed on the new materials will last. Fortunately, a number of organisations are testing digital printing products for permanence and frequently publish these results.

Considering that most digital printers were designed as proofing devices, permanence was not always considered a crucial factor when it came to creating substrates and inks. Wilhelm (1999) points out that "Iris never conceived of their printer being used to produce a work of art that might hang on a wall. It was designed for digital pre-press work and industrial-designing work, where permanence was not an issue." The situation that exists today is that some prints such as dye sublimation, thermal wax and some inkjet printers offer quick output, but are not always designed for permanence. Other machines such as the Giclée machines do not have the same print speed, but can offer high quality, long lasting images.

Fortunately, most manufacturers have attempted to improve the permanence of prints, largely because of demands made by their commercial clients. The permanence of inkjet inks and substrates has improved vastly over the past three years and photographic materials continue to improve in terms of longevity.

4.5.5 Factors influencing the permanence of large format digital prints

A number of factors appear to influence the permanence of digital prints. Generally, concerns are about inks fading, though realistically the influence of substrates cannot be ignored. Browning (1977:316) points out how important the permanence of paper is when intended for use in legal records, documents, art works, and library books of permanent value. He goes on to say that because of paper's complex make up, the factors influencing permanence have not yet been fully established (Browning, 1977:317). Not only will the paper on its own influence how long an image lasts, but the reaction of ink to substrate will also be a deciding factor. Many manufacturers will only guarantee their products when the appropriate ink is used with a specified substrate.

Other factors influencing image permanence are the finishing and presentation of images. Often images are laminated or mounted onto different surfaces and in some cases these surfaces can adversely affect the images. Otsuki (2000) claims that:

"Most colour changes are due to oxidation of the dyes or pigments. This oxidation can occur due to ultra violet (U/V) radiation, a natural reaction with the paper, laminate, glue, etc., exposure to acid in the air (pollution), or just about any other cause."

Exposure to visible and UV wavelengths, the pH balance of substrates, exposure to water, after treatment, such as lamination and mounting will all influence how quickly prints fade. A number of individuals at large format digital print bureaux, claim that testing done in America and Europe, has little bearing on South African or Australian outdoor conditions, where fading appears to occur at a more rapid rate (Franco, 2000).

4.5.6 Testing the longevity qualities of digital prints

Although most manufactures give statistics as to how long prints will last indoors or outdoors, these statistics are generally considered to be inaccurate. Concerns are often voiced regarding how tests are conducted and how they are evaluated. There is at least one independent organisation conducting tests for longevity on large format digital prints. The Rochester Institute of Technology (RIT) has an image permanence section that will run tests for industry clients. The Wilhelm Imaging Research Inc. in Grinnell Iowa has conducted testing on certain processes. Wilhelm is recognised as an expert in this field and was a founding member of the ANSI subcommittee on developing standards for testing the stability of colour photographs (Postcards, 1999: 65).

The Grinnell testing is done under lighting conditions that mimic standard indoor display illumination with a relative humidity of 60% (Wilhelm, 1999); this factor has received some criticism. Otsuki (2000) points out that it is often impossible to duplicate the conditions in which the commercial print will be exhibited and that at present there is no impartial organisation doing comprehensive outdoor testing. This was confirmed in a presentation on the status of standards for outdoor graphics at the Big Picture Conference (Piekara, 1999).

Another aggravating factor is that new media or ink is released every few weeks; a good testing programme is just not possible (Otsuki, 2000). Otsuki's (2000) assessment of longevity, based on his experience in the commercial printing market is far more conservative than that of Wilhelm's institute. For instance he quotes photographic prints as having a ten-year indoor life and six months to one-year outdoor life. Un-laminated inkjets using dye-based inks, he assesses as one to two months indoors (Otsuki, 2000). His assessment is purely from the viewpoint of a graphic producer and vendor, based on eleven years of running a digital output business.

Wilhelm (1999) also outlined some of the aspects that his organisation looks at when determining the longevity of digital prints. These include setting up test files that illustrate a comprehensive range of colours and tones, as uneven fading of certain inks is often only noticeable in the grey areas. Other tests evaluate the effect of humidity and heat on colour densities and bleeding. It must be pointed out that although these tests do not satisfy all possible large format digital print applications, they are however conducted with all applications in mind. The test results can therefore be of great help to both entrepreneurs and operators as an indication of how long it will take for large format digital prints to fade in outdoor environments.

4.6 SUMMARY

This chapter outlined the technical considerations of LFDPs. This not only outlines the technical expertise that a LFDP entrepreneur needs but also to a certain degree the complexities of the industry. When deciding on a LFDP the entrepreneur is faced with various decisions such as quality, longevity, and costs of the equipment. Therefore, the most important issues discussed in this chapter can be segmented as follows:

- The digital industry is a rapidly changing and revolving industry
- Digital printers are categorised by their technique used to produce images namely, as those that spray ink, that use heat to melt inks, those that use hybrid photographic processes, and those that use charged toner particles
- Quality of print is influenced by the technique used by the printer
- The commercial application of large format digital printers is also evolving with the market
- For commercial purposes there is a need to ensure that images last for a few months while artist would like the images to last much longer
- This longevity of printed images will influence the choice of printer
- Initially permanence was not considered a crucial factor in the industry, but over time this has changed which necessitated changes in the ink and substrates markets
- The reaction of ink to substrate also influences how long the image would last
- An aggravating fact is the frequent release of new media or ink thus impacting on the testing techniques

- Tests do not satisfy all possible applications, however, they are conducted with the application in mind

CHAPTER 5

DECISION MAKING AND ENTREPRENEURSHIP

5.1 INTRODUCTION

In Chapters 2 and 3 the entrepreneur was discussed followed by technical considerations in Chapter 4. The entrepreneur within the LFDP field needs to combine issues from these chapters in order to optimise his investment. This chapter therefore deals with decision-making within this environment.

Decision-making, whether rational or deliberate occurs in every organisation although the situation may vary. There is no single best approach in making effective decisions; some approaches are more effective than others are (Tarter and Hoy, 1998). According to Heracleous, (1994:16) "decision-making is one of the most central processes and a basic task of management at all levels." Small businesses in comparison to large organisations have the owner or manager at the heart of decision-making while in larger firms, there may be more people involved in the process. According to Culkin and Smith (2000:148) an "understanding of the context, attitudes and behaviour of the individual businessperson becomes equally as important as understanding their business" (also see figure 2.1).

This chapter firstly examines six contemporary decision-making models with the final view of matching appropriate decision-making models with different situations decision-makers may encounter. Secondly the chapter reviews the process of technological forecasting used for decision-making in business. More specifically, it discusses various methods of making educated guesses as to what will happen to important business/technological-related variables at some future time. Forecasting is necessary so that entrepreneurs can make both plans for the future and those decisions that must be faced in an atmosphere of uncertainty relating technology.

Lastly the chapter proceeds to integrate entrepreneurship into the decision-making process where the context for entrepreneurial decision-making is examined, and finally an entrepreneurial decision-making model is presented.

5.2 CONTEMPORARY DECISION-MAKING MODELS

There are a number of decision-making models available to the entrepreneur. For the purpose of this study, six contemporary models as well as a discussion of technological forecasting will be presented.

5.2.1 The Rational Decision-making Model

This model suggests that making a decision is straightforward – there is one best solution. The model is based on classical economic theory and has a number of assumptions that form the foundation for the model. The first assumption is that the decision-makers have clear goals and unambiguous understanding of the nature of the problem (Heracleous, 1994; Tarter and Hoy, 1998). The next assumption is that decision makers have complete information and the final assumption is that decision makers have the cognitive capacity to analyse the problem at hand (Tarter and Hoy, 1998:212). The rational decision making model presented by Heracleous (1994:17) is a series of sequential steps:

1. Problem identification
2. Identification of objectives with respect to problem
3. Comprehensive search for alternative courses of action
4. Objective evaluation of alternatives
5. Selection of alternative most likely to achieve objectives
6. Implementation of chosen course of action
7. Monitoring consequences with respect to objectives
8. If unsatisfactory, repeat process as necessary

The classical economics foundation for this model draws a number of criticisms. Firstly, the conditions under which decisions are made are largely influenced by the environmental forces that individuals cannot control (Tarter and Hoy, 1998). Decision-makers encounter the problem of uncertainty and this problem is compounded because there is no generally accepted measure for dealing with uncertainty. As a result, uncertainty makes rational decision-making impossible (Tarter and Hoy, 1998).

The second criticism according to Tarter and Hoy (1998:213) is that the model “makes demands on human cognition that simply cannot be met.” The third criticism focuses on step three of the process. Empirical studies have shown that decision makers initially use their memory to search for alternatives and only when the problem persists do they engage in a comprehensive search (Heracleous, 1994). There are a number of reasons decision-makers do not initially engage in a comprehensive search. Firstly, it is not feasible given the ill-structured and multi-faceted nature of problems and secondly a comprehensive search required time and money, which may not be readily available to the decision-maker (Heracleous, 1994:18).

The fourth criticism focuses on steps four, five, and six of the rational decision-making process. Empirical studies indicate that evaluating the limited set of alternatives does not follow formal analysis but rather determined by managerial experience, judgement, and political bargaining (Heracleous, 1994). Time constraints make it unlikely for decision-makers to consider a wide range of alternatives. The model’s sequential process of identification of alternatives, selection from alternatives, and implementation of chosen course of action, does not occur in practice (Heracleous, 1994:18). Heracleous (1994:18) suggests a fuzzier process conditioned by cognitive limitations and socio-political process as being realistic. The fifth and final criticism focuses on step seven of the rational decision-making process of monitoring consequences. It is unlikely that the decision-maker will obtain clear and unambiguous information on the outcomes of the chosen course of action. The reason for this is that feedback is often delayed and ambiguous (Heracleous, 1994).

5.2.2 The Bounded Rationality Model

Simon (cited in Tarter and Hoy, 1998:214) introduced the concept of satisficing to offer a modified version of the rational decision making model. The factors influencing a satisficing decision include limited search, inadequate information, and information processing bias by the decision-maker (Tarter and Hoy, 1998). Decision-makers seek to satisfice because they lack adequate knowledge, ability, or capacity and look for solutions that are good enough (Tarter and Hoy, 1998:213). Decision-makers compare the ideal outcome with a real outcome and as they receive new information, they may redefine the problem. Comparing the rational and the bounded rationality decision making models, both depend on a means-ends analysis but the difference is that with the bounded rationality model, objectives may be changed thus the ends are not necessarily final. The problem of uncertainty requires flexibility and the bounded rationality model offers this attribute to the decision-maker (Tarter and Hoy, 1998:214).

5.2.3 The Incremental Model

This model for decision-making accommodates managers who need to make small incremental changes when alternatives are almost impossible to determine and satisficing does not work well. Decision-makers monitor outcomes of each incremental change in a bid to avoid negative consequences because of each small change. Lindblom (cited in Tarter and Hoy, 1998:215) first described the incremental model where he argued decision-makers "spend more time muddling than in systematic means-ends analysis." Lindblom (cited in Tarter and Hoy, 1998) proposes the use of the incremental model when the problem is complex, uncertain, and conflict-laden.

The incremental model has a number of distinguishing features from both the rational and bounded rationality models. Firstly, the phases of setting objectives and generating alternatives are not separate as found in the rational and bounded rationality models. Predetermined objectives do not drive alternative analysis and the more complex the problem, the greater the possibility of objectives changing as decisions evolve (Tarter and Hoy, 1998:215). Secondly, the incremental model limits alternatives available to the decision-maker that only consider choices that will not significantly change the existing situation. The options that fall outside the decision-maker's narrow problem definition are ignored and this reduces the complexity in decision-making (Tarter and Hoy, 1998). The next distinguishing feature is that by focusing on those small deviations from the current situation, decision-makers make effective use of available time and knowledge to generate alternatives. The final feature is that unlike in the rational and bounded rationality models where theory can guide decision making, the incremental model's use of practical alternatives is more effective in decision-making (Tarter and Hoy, 1998).

5.2.4 The Mixed Scanning Model

Although the incremental model is a common decision-making strategy, it has drawbacks that include it being conservative and aimless. Etzioni (cited in Tarter and Hoy, 1998:216) suggests an approach to the complexities and uncertainties in decision-making that involves mixed scanning. Mixed scanning is driven by basic policy, incremental change, and limited information (Tarter and Hoy, 1998:216). This decision-making model is an adaptive strategy that combines satisficing and the flexibility the incremental model offers. The foundation for the mixed scanning model rests on strategic principles. These include, firstly, decision-makers need to use focused trial and error, secondly, decision-makers need to be tentative, and finally decision-makers need to monitor the effects of their initial decisions. The strengths of this model are it's ability to discourage full-scale commitment of limited resources and the model offers flexibility (Tarter and Hoy, 1998).

5.2.5 The Garbage-can Model

This model for decision-making can occur in organisations where uncertainty is prevalent. The characteristics of such organisations include firstly, problematic preferences, which are ambiguities in the sequential steps of the decision-making process. Secondly, unclear technology generates an inability to determine cause-and-effect relationships because of random activities. Finally, fluid participation refers to the constant turnover of participants in the decision-making (Tarter and Hoy, 1998:217).

In this model, decisions according to Tarter and Hoy (1998:217-218) "do not begin with a problem and end with a solution, but rather decisions are a product of independent streams of organisational events that fortuitously flow together." These streams include problems, solutions, participants, and choice opportunities and decision-making within these four streams produces randomness (Tarter and Hoy, 1998). Although the garbage can model aptly describes some decisions, it is not a general model used in decision-making (Tarter and Hoy, 1998).

5.2.6 Political Model for decision-making

Factors affecting political decision-making processes include the stakeholders, choice of goals, and the alternative solutions (Hellriegel and Slocum, 1996:258). The political model of decision-making has the following characteristics. Firstly, personal goals and not organisational goals are the driving force of decision-making. Secondly, personal means-ends analysis replaces organisational means-ends analysis such that personal needs are first determined and then organisational means are used to achieve them. Politics shapes decisions and even when a satisficing or mixed scanning process is used, it is used on a personal level. Finally, the political model relies on power to explain decision-making by managers (Tarter and Hoy, 1998:220).

5.2.7 The appropriate model

There is no one prescribed way to make decisions. The effectiveness of the approach to adopt is dependent of the situation. In terms of this study the situation is even more complex because of fast changes in technology (see chapter 4). Tarter and Hoy (1998:225) present a framework (see Table 5.1) where they identify which decision-making model is appropriate in a particular situation.

Table 5.1. Decision-making models

Circumstance	**Model**
Narrow, specific problems, complete information	Rational
Incomplete information; definable satisfactory outcomes	Bounded Rationality
Incomplete information; complex decisions; outcomes uncertain;	Incremental

guiding policy	
Incomplete information; complex decisions; outcomes uncertain; no guiding principles; short-term strategy until policy guidelines are established	Mixed Scanning
To understand fortuitous decisions	Garbage-can
When personal goals displace organisational ones	Political

Source: Adapted from Tarter and Hoy, 1998:225

From above the static nature of decision-making according to the described models can be deduced. That poses a problem to entrepreneurs in LFDP due to the largely unpredictable nature of technology changes.

5.3 TECHNOLOGICAL FORECASTING

Technological forecasting is a decision-making tool often used to make technology-based decisions. Although there is nothing new in attempting to forecast the future trends of technology, it is only recently that the range of techniques known collectively as technological forecasting has been developed. The following are attempts to define technological forecasting (TF):

Prehoda (1967:58) defines TF as “The description of prediction of a foreseeable technological innovation, specific scientific refinement, or likely scientific discovery, that promises to serve some useful function, with some indication of the most probable time of occurrence.”

Bright (1968:312) defines TF as “Forecasting means systems of logical analysis that lead to common quantitative conclusions (or a limited range of possibilities) about technological attributes and parameters, as well as technical economic attributes. Such forecasts differ from opinion in that they rest upon an explicit set of quantitative relationships and stated assumptions, and they are produced by a logic that yields relatively consistent results.”

Cetron (1969:197) adds to the above that TF is "A prediction, with a level of confidence, of a technological achievement in a given time frame with a specified level of support."

Synthesizing the definitions of technological forecasting one is able to define technological forecasting as the systematic and logical analysis of data that promises to serve a useful function within a formalised structure. The analysis is about technological attributes and boundaries as well as the associated economic facet to technical attributes.

For the purposes of this study TF is seen as impacting on the decision-making ability of the entrepreneur when faced with technology-related questions such as the LFDP industry.

5.3.1 Inputs to the Forecasting System

Arnfield (1969) argues that like any other procedure for systematic analysis, forecasting can only be as accurate as the information fed into it. The inadequacy of the input data cannot be compensated, though it might easily be hidden, by highly sophisticated quantitative analysis. In addition, what is to the disposal is limited to:

- Information from the past
- Knowledge of the present
- The ability of the human intellect - logical thought process insight, and judgement.

These are the resources to be marshalled and interpreted within a forecasting system. Discussion of TF inevitably focuses on the detail of the techniques themselves, but this must not be allowed to distract attention from the two factors that determine the usefulness of the results - the quality of the input data and the calibre of the minds applied to the task. Figure 5.1 indicates the various inputs and how they contribute to the decision-making process.

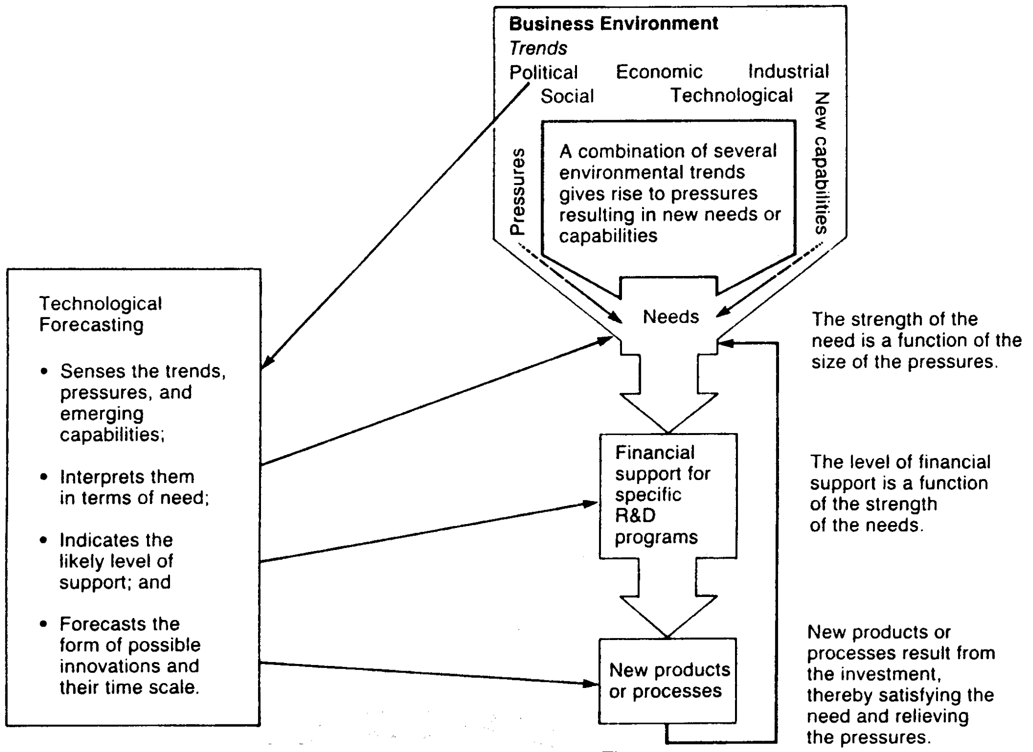


Figure 5.1. Technological forecasting and the Innovation chain

Source: Anfield (1969: 65)

5.3.2 Decision-Making with Technological Forecasting

Managers cannot afford to take decisions affecting the future of their organisations without examining any clues they can find to the best of their ability. Forecasts are important inputs to the process of strategy formulation and planning. While this approach may be satisfactory conceptually, it is of little value unless one can make sufficiently accurate forecasts to aid the practical manager in his decision-making. During recent years, numerous techniques for technological forecasting have been developed with the object of enabling the entrepreneur to obtain the maximum use from the information available to him or her.

The investment of time and resources can only be justified in terms of the benefit expected to derive from it. This criterion must be used to prevent excessive expenditure on forecasts, which do not aid decision-making, however interesting they may be in themselves. As Drucker (1970:217) comments "Decisions exist only in the present. The question that faces the long-range planner is not what we should do tomorrow, it is: What do we have to do today to be ready for an uncertain tomorrow? The question is not what will happen in the future. It is what futuristics do we have to factor into our present thinking and doing; what time spans do we have to consider, and how do we converge them to a simultaneous decision in the present."

In some industries, today's decisions cover a long time scale. Although the importance of the more distant dates loses significance because of financial discounting, it may still be necessary to make forecasts for a period of 20 or more years (Hall, 1988). By contrast, the planning horizons for some companies can be much shorter than 20 years. It is still important to forecast, for many significant changes can occur in a decade. Thus the only meaningful determinant of the time period for which forecasts are necessary would appear to be the planning horizon of the company. This is a function of the rate at which the company's activities can be made to respond to changes rather than the rate at which the environment itself is changing. In this regard Hall (1988:139) adds that "In the field of product development, however, close control is necessary to ensure commercial viability, control of costs, and particularly of time scales. In this area, we can in the computer field respond to outside stimuli within about five years for any normal project and seven years for the very largest. The practical range of technological forecasting required, therefore, and on which whole attention needs to be focused, is about five to seven years, this corresponding both to our response time and to the generation period of computer development."

Deduced from the above it is clear that forecasting can assist business decisions and technology in the following ways:

- Wide-ranging surveillance of the total environment to identify development, both within and outside the business's normal sphere of activity, which could influence the industry's future and, in particular, the company's own products of LFDPs.
- Estimating the time scale of important events in relation to the company's decision making and planning horizons. This gives an indication of the urgency for action.

- The provision of more refined information following a detailed forecast in cases where an initial analysis finds evidence of the possibility of a major threat or opportunity in the near future, but where this evidence is insufficient to justify action,

  OR

  continued monitoring of trends which, while not expected to lead to the necessity for immediate action, are, nevertheless, likely to become important at some time in the future and must consequently be kept under review.
- Major reorientation of company policy to avoid situations, which appear to pose a threat or to seek new opportunities by:
  - Redefinition of the industry or the company's business objectives in the light of new technological competition and inventions especially to LFDP’s.
  - Modification of the corporate strategy.
  - Modification of the R&D strategy.
- Improving operational decision making, particularly in relation to:
  - The R&D portfolio.
  - R&D project selection.
  - Resource allocation between technologies (various LFDP’s).
  - Investment in plant and equipment, including large format digital printing equipment.
  - Recruitment policy for operators in LFDP equipment.

5.4 THE CONTEXT FOR ENTREPRENEURIAL DECISION-MAKING

Among the various characterisations of the entrepreneur found in literature (also see paragraph 2.5), Batstone and Pheby (1996:36) present various entrepreneur definitions which include defining an entrepreneur as a decision maker; a risk taker; an innovator; an industrial leader; an organiser an co-ordinator of economic resources; a contractor; an arbitrator; an allocator of resources. On closer examination the entrepreneur as a decision-maker has been highlighted and without decision-making, none of the other activities can be undertaken (Batstone and Pheby, 1996).

Management theory according to Kirk (1998:89) “recognises entrepreneurial decision-making as the activity of managers pursuing equilibrium between dynamic external forces and factors internal to the organisation.” The priority for entrepreneurs is developing a core competency, which will provide the organisation with a sustainable competitive advantage. This perspective allows the freedom for managers to take the entrepreneurial initiative in their decision-making. The entrepreneurial decision-making process is facilitated by organisational factors of culture and power. Culture refers to the current ways of organisational thinking, which is a reflection of the external and internal experience as well as recent influences.

Stacey (cited in Kirk, 1998:89) has argued that the effect of shared paradigms is to “normalise ways of thinking and routines of decision-making which can inhibit entrepreneurial behaviour.” Stacey (cited in Kirk, 1998:90) recognises organisational situations where creativity and entrepreneurial action is required. This requires managers to tap into tacit, subjective insights, intuitions, and individual hunches to develop new knowledge. In this light, Child (cited in Kirk, 1998:90) highlighted the role organisational politics and stakeholders in shaping organisational decision-making. In summary, the context of entrepreneurial decision-making is defined by the interaction of economic, cultural, and political factors (Kirk, 1998:90).

Classical theory of decision-making is essentially static and in its simplest form, allows decisions to be made once a predefined point has been identified. However, if entrepreneurship is perceived as dynamic, it is difficult to associate entrepreneurship features such as risk taking and innovation for example, with such theoretical schema (Batstone and Pheby, 1996; Tarter and Hoy, 1998). Shackle’s (cited in Batstone and Pheby, 1996:39) theory “implies decision making in the face of irremediable uncertainty.” When developing the decision making model, Shackle (cited in Batstone and Pheby, 1996:40) argues “it is inappropriate to analyse uncertainty in a probabilistic manner.” As a result, Shackle suggests a decision making model under uncertainty based on two qualities of an expectation, firstly the desiredness of an imagined sequel to any possible action, and secondly, the possibility of the outcome occurring. Shackle's model proposes a process-based approach that firstly, specifies the options open to comparison and then examine the nature of these options. Although the procedure leans towards the formal and classical theory of decision-making, the emphasis is on innovation and creativity, which is closely aligned with the LFDP industry. Without that, an entrepreneur in the LFDP industry will experience difficulty in surviving.

5.5 A DECISION-MAKING MODEL FOR TECHNOLOGICAL BUSINESSES

High levels of market and technological uncertainty characterise decision-making in the technology business. Individuals in firms considering purchasing technology products need to develop several strategies that reduce uncertainty in order to make effective decisions (Dawes, Patterson and Midgley, 1997). In this regard Dawes et al., (1997:85) has developed a model that can help to overcome the problem of uncertainty (see Figure 5.2).

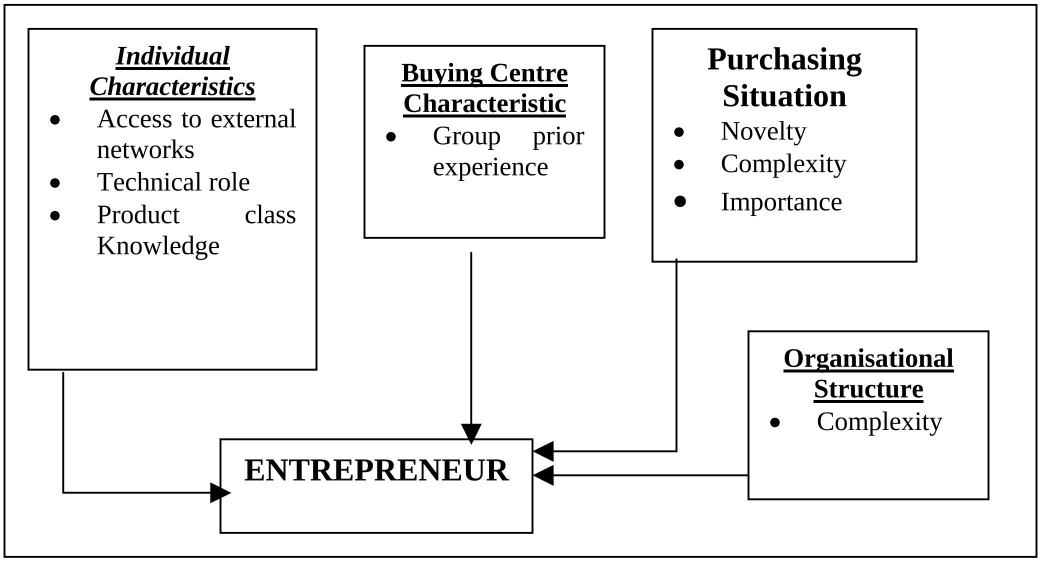


Figure 5.2. A model of consultant involvement in the purchase of high technology products

Adapted from Dawes et al., 1997:85

This model will be discussed in the following paragraphs.

5.5.1 Individual Characteristics

The three characteristics of the buyer are linked to the level of involvement or non-involvement of an external consultant. These characteristics listed by Dawes (1997) are discussed below.

Access to external networks: This variable relates to the extent to which the key buyer had access to external networks containing persons with the required knowledge of the type of technological product being purchased. Buyers with extensive external networks are likely to have more sources of information. This information becomes an input in the evaluation criteria process for supplier selection and their product offerings. Key buyers with well-developed networks are unlikely to turn to consultants in their purchasing process (Dawes et al., 1997).

Technical vs. administrative role: This variable refers to the tasks that the buyer has to perform when performing their job duties. Buyers with technical roles are likely to possess the necessary technical skills to evaluate competing products. However, buyers who have administrative skills and lack the relevant technical skill are more likely to involve an external technical consultant in the purchasing process (Dawes et al., 1997).

Product class knowledge: The third variable in the model represents the buyer's knowledge concerning the product in question. Class knowledge is likely to have greater impact on models characterised by non-programmed decision-making as opposed to programmed decision-making. The greater the product class knowledge, the more confident the buyer will be in the purchase decision process and as such, they do not seek help from an outside consultant (Dawes et al., 1997).

5.5.2 Buyer Centre Characteristic

The focus on the buyer centre characteristic is described by analysing prior experience.

Group prior experience: This variable indicates the buying centre's collective experience in making purchasing decisions for technological products. Although a key buyer may lack prior experience, several members in the organisation may possess the relevant knowledge to make an informed decision. The greater the buying centre's collective prior experience and knowledge, the less likely the involvement of external technical consultants (Dawes et al., 1997).

5.5.3 Purchase Situation variables

The purchase situation according to Dawes et al., (1997:87) is "one of the central concepts in the organisational buying and is defined by the interaction of the product (or service) and the buying organisation." Three constructs, novelty, complexity, and importance are part of the purchase situation and these are briefly described (Dawes et al., 1997).

Novelty: Empirical studies have indicated that the novelty of the purchase to the organisation plays an important role in explaining various aspects of organisational buying behaviour. When the buying situation presents greater novelty for the organisation, “information requirements are likely to be much greater for the organisation” as it is unlikely to have adequate relevant information and competencies to handle new information (Dawes et al., 1997:87). The result is that the greater the perceived novelty, the greater the chances of external involvement of consultants (Dawes et al., 1997).

Complexity: The complexity of the purchase situation can be because of the complexity of the product and/or the complexity of the buying decision. These two factors are distinct in that a product’s technical complexity does not necessarily influence the complexity of the buying decision. Empirical studies show that increased buying decision complexity lead to greater uncertainty for the buyer and to counter such uncertainty, the buyer will likely collect more external information. The major source of external information could then be the outside technical expert (Dawes et al., 1997).

Importance: The importance of the purchase decision according to Dawes et al. (1997:88) can be defined in terms of its impact on “the individual, a department, a buying centre, or an entire organisation.” Researchers have operationalised in two main ways, firstly, in terms of “the relative importance of the purchase to others of a similar type” and secondly, in terms of ‘its perceived impact on organisational profitability and productivity” (Dawes et al., 1997:88). For the purpose of the study, the focus will be on the second operationalisation, where purchase of new technology will likely have a great impact on organisational profitability and productivity. The result is that buyers will more than likely involve an external technical consultant in the purchase decision process (Dawes et al., 1997).

5.5.4 Organisational Structure

Although there are a number of dimensions of organisation structure namely complexity, formalisation, and centralisation, for the purpose of the study, the focus will be on organisational complexity (Dawes et al., 1997).

Organisational Complexity: This variable refers to the extent of differentiation prevalent in an organisation and its three components, namely horizontal, vertical, and spatial differentiation. Vertical differentiation is the depth of the organisation's hierarchical structure while spatial differentiation is the extent to which the location of an organisation's facilities and personnel are distributed. Horizontal differentiation is the degree of differentiation between "units based on the orientation of members, the nature of the tasks they perform, and their education and training" (Dawes et al., 1997:89). The more complex the firm, the more likelihood of in-house expertise and hence the less likely need to involve an external technical consultant (Dawes et al., 1997).

This model is useful to help explain the non-use of an external consultant with respect to the purchase decision; however, the model does not successfully explain the use of a consultant.

5.6 INTEGRATED MODEL

The model discussed in paragraph 5.5 (see also Figure 5.2) focused on the role a consultant can play in decision-making. However, an adapted Figure 5.2 can act as basis for this study because it provides a basis from which the main research problem can be addresses i.e. to establish a framework which can assist entrepreneurs to optimise their investment in large format digital printing (LFDP). This adapted basis is outline in Table 5.2 and will act as basis for research, which will be discussed in Chapter 6.

In Chapter 1 (see paragraph 1.1) it was outlined that one of the difficulties of this study is that the theoretical basis for this study is very limited because it is such a new field. Therefore, it is not always possible to use existing theories directly for testing. However, various theoretical principles have helped to adapt Figure 5.5 into Table 5.2. These theories are cross-referenced in Table 5.2.

Table 5.2. Integrated research model

Category	Details to be tested	Cross referencing
Individual characteristics	Characteristics of the entrepreneur, knowledge of critical success factors of the entrepreneur, and the interpersonal influence of the entrepreneur	Paragraphs 2.4, 2.5 Chapter 3
Buying centre characteristics	Who influences the buying decision	Chapter 5
Purchasing situation	The nature of the product is considered here	Chapter 2 and 4
Organisational structure	The structure of the organisation is considered	Paragraph 2.7

The above will be used as basis for research, which will be discussed in the following chapter.

5.7 SUMMARY

The chapter reviewed several decision-making models. The chapter described how the entrepreneur when making a purchase decision could use technological forecasting. The entrepreneur is faced with a choice of which model to use when making decisions, however, the chapter reviewed a model that entrepreneurs can use when making such a decision in the LFDP industry.

For the purposes of this study the following are critical issues deduced from this chapter:

- There is a need for the entrepreneur to constantly make decisions and as such the entrepreneur must evaluate each model and determine which will satisfy their needs;

- Decision-making in a technology firm requires extra components and as such the entrepreneur must know these and use them in order to make a better decision;
- Technological forecasting is useful for the entrepreneur as it forces them to scan the external environment before making a decision; and
- The decision-making model by Shackle allows us to integrate entrepreneurship with traditional decision-making models to understand how the entrepreneur makes their decisions.

CHAPTER 6

RESEARCH METHODOLOGY

6.1 INTRODUCTION

Chapter 1 presented the research problem: To establish a framework, which can assist entrepreneurs to optimise their investment in large format digital printing. The researcher decided that exploratory researcher would assist in the understanding of decision-making because of the relative newness of this field which results in a lack of information. The chapter will discuss the research design and its various elements.

6.2 RESEARCH DESIGN

The research design is defined by Welman and Kruger (1999:46) as the "plan to which we obtain research participants and collect information from them. In it we describe what we are going to accomplish with the participants with a view to reaching conclusions about the research problem." The various elements of the research design are discussed in the following sections of the chapter.

6.2.1 Purpose of research

The study was exploratory in nature. The aim of the research was to test an existing model used in technology decision-making and then try to formulate a framework that entrepreneurs could use to make technology-type decisions. Exploratory research facilitates this process as it allows the researcher to gain insight in an area that they have little knowledge and in this instance, it was used to gain understanding of what is the entrepreneur's decision-making process when purchasing LFDP. Exploratory research was chosen because of it allows the researcher to undertake a small-scale study as there are few companies in the LFDP industry. Exploratory research also allows the researcher to develop, refine and/or test measurement tools (Kumar, 1999). There are three ways to undertake exploratory research, a search of literature, talking to experts (in the LFDP industry), and conducting focus group interviews. In this study, the researcher spoke (interviewed) those in the LFDP industry to gain insight. The advantages of using exploratory research are the flexibility and adaptability it allows the researcher (Saunders, Lewis and Thornhill, 1997).

6.2.2 Research Population and Sampling

Kumar (1999:149) defines the population for a research study as a "group (usually people) about whom we want to be able to draw conclusions." In this study, the population consists of owners/managers of LFDP. For the purposes of the study, the study population consisted of thirty-one owners/managers from South Africa, United States of America, United Kingdom, Zimbabwe, Australia, Botswana, Canada and Namibia. This sample size was considered to be sufficient due to firstly, the few LFDP companies, the fact that many companies do not want to disclose information on their printing techniques as it is a source of competitive advantage. These owner-managers were also selected by means of the snowball sampling technique because a list of such owners were not attainable elsewhere.

A sample as defined by Kumar (1999: 149) is the small group "from whom you obtain the information" to make conclusions. For the purpose of this study, ten owners/managers from South Africa and the United States of America; four from the United Kingdom; Zimbabwe and Australia provided two each with Botswana, Canada and Namibia proving one each. It was decided to only select ten owners because of the interview method selected. It would be less practical of more than ten is selected from South Africa and the United States of America.

6.3.3 Research Methodology

The study made use of interviews and the questionnaire research method to collect the data. The researcher due to the geographical distribution of the study population administered the questionnaire telephonically. Table 11.1 presents main attributes of telephone interviews and is compared to postal interviews to justify the researcher's choice of data collection.

Table 6.1. Main attributes of telephone questionnaires and postal questionnaires

ATTRIBUTE	QUESTIONNAIRE TYPE	
	Telephone	**Postal**
Population's characteristics for which suitable	Individuals who can be phoned, selected by home or organisation	Individuals who can be contacted by post
Confidence that the right person responds	High	Low
Chance of contamination or distribution of responses	Occasionally distorted	May be contaminated by consultation with others
Size of sample	Dependant on number of interviewers	Large, can be geographically dispersed
Likely response rate	High, 50-70% reasonable	Variable, 30% reasonable
Length of questionnaire	Up to half an hour	6-8 A4 pages
Suitable type of questions	Open and closed questions, but simple questions	Closed questions, but not too complex, must be of interest to respondent
Time taken to complete data collection	Dependant on size of sample and number of interviewers	4-8 weeks from posting (depends on number of follow-ups)
Financial resource implications	Telephone calls, clerical support, photocopying and data entry if not using computer aided telephone interviewing	Outward and return postage, photocopying, data entry
Role of interviewer	Enhancing respondent participation, guiding the respondent through the questionnaire, answering respondent questions	None

(Adapted from Saunders et al., 1997: 247)

The advantage of administering the questionnaire telephonically is the anonymity factor and as a result, this could result in the researcher obtaining information that is more accurate. Potential disadvantages include restriction on the types of data that can be collected over the telephone, insufficient time to think about the question being asked and selection bias on the part of the researcher as they may contact respondents they know will assist them and this may not be a representative sample (Kumar, 1999).

The questionnaire (see Annexure B) was divided into distinct sections and the questions were designed to solicit information that would allow the researcher to test the existing model (see Chapter 5, Table 5.2). This question was tested with a statistician before implementation. From the responses, the researcher was able to present a potential model that could be used by entrepreneurs in making their decisions when purchasing LFDP. The sections of the questionnaire will be briefly discussed in the following paragraphs.

Section A: Biographical Data

This section provides some background in terms of the business and its owner/manager. The use of this data is not at all critical but merely informative.

Section B: Entrepreneurs/Owner/Manager's Profile

In order to gauge the type of person we are dealing with, it is necessary to look areas such as risk, new markets, embracing change (technology), economic freedom. These are some of the characteristics typical of an entrepreneur.

Section C: Critical Success Factors

It is also important to test/examine whether or not the entrepreneur is aware of what is required to be successful within the industry they are operating in. As a matter of course, for any firm to succeed in an industry they will have to comply with the critical success factors at the very least.

Section D: Measuring Interpersonal Influence

If an entrepreneur is risk averse, then one needs to examine/test who then plays a role in the making of decisions. One then looks at the immediate influences such as work colleagues and friends.

Section E: Buying Centre Characteristics

The questions were to determine who influences the buying decision process. In this case, the experienced staff will influence the decision. Both the owner/manager and employees are tested/examined.

Section F: Purchasing Situation

This section considers the nature of the product when decisions need to be made. The nature of the product might very well influence the entrepreneur in their purchase decisions.

Section G: Organisational Structure

The structure of the organisation will also affect the purchase decision. Large organisations generally have dedicated structures to decide. However, SMEs rely on the owner/manager to make decisions. When considering technology type decisions, the need for broader consultation may arise.

6.3 DATA ANALYSIS

The data collected for the research was quantitative. Quantitative data may be classified into two groups, categorical and quantifiable; the data for the study was categorical because it was impossible to measure the values. However, the data could be classified into sets according the characteristics that were identified as important for the research (i.e. the various sections of the questionnaire). The respondents were asked to rank their responses in sections of the questionnaire.

The data was coded using numerical codes to facilitate quick data entry and reduce the number of errors when entering data. Missing data was coded and Saunders et al., (1997) highlight possible reasons for missing data. These include firstly, the data were not required (due to filter questions), secondly, the respondent had no opinion thus left out the question and finally, the data were not available for some other reason. The data was cleaned before running tests.

Descriptive statistics were compiled using a statistical program. Descriptive statistics use a single number to describe data. Frequency distributions were used to summarise responses to specific questions. The researcher was then able to summarise basic relationships between variables.

6.4 LIMITATIONS

There are a number of limitations with the research design. Firstly, the small sample makes generalisation difficult. The small size of the sample is because there are few LFDP companies in the industry and companies may not want to share information. Secondly, the questionnaire may have measurement errors. Finally, the questionnaire was conducted telephonically and it may have been difficult to extract meaningful information.

6.5 SUMMARY

The research methodology was discussed together with the advantages and shortfalls of using the chosen methodology. For the purpose of the study, the main findings included

- Identifying the sample for the study
- Identifying the research method and justifying why it was adopted
- Acknowledging potential shortcomings when using a questionnaire

- Explaining the sections of the questionnaire and what data the questionnaire was soliciting

CHAPTER 7

RESULTS AND DISCUSSION

7. 1 INTRODUCTION

The questionnaire survey was designed to test the model presented in Chapter 5, section 5.5 (A decision-making model for technological business). The model suggests four areas the entrepreneur should address when making a purchase decision particularly the purchase of technological products. The results and inferences from the questionnaire will be discussed.

7.2 FINDINGS AND DICUSSION

7.2.1 Individual Characteristics

From Figure 7.1 below, the level of education of the owner revealed that twenty (64.5%) of the respondents have a degree and the other respondents have as a minimum matriculation (3.2%), certificate (3.2%), diploma (22.6%) and two respondents have a post graduate qualification. The level of education has bearings on the decision-making ability of the entrepreneur in the LFDP industry because it is a highly complex industry. Therefore education can be regarded as very important.

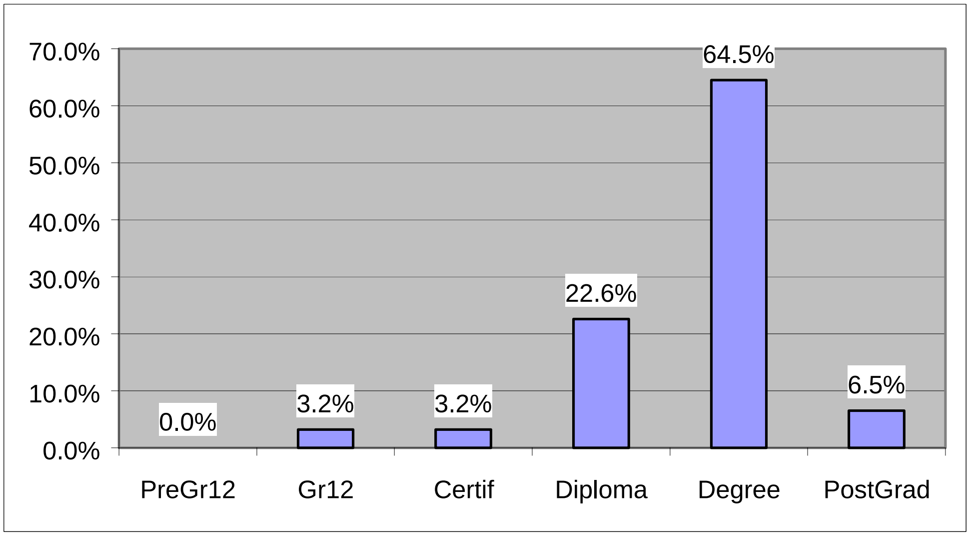


Figure 7.1: Qualifications of the Owner

From the survey, over 80% (Figure 7.2 - 67.7% and 12.9%) of the respondents indicated that they make decisions under conditions of risk and uncertainty. This finding supports the literature on characteristics of the entrepreneur, namely, the entrepreneur's ability to handle uncertainty and risk-taking (Maas and Fox, 1997).

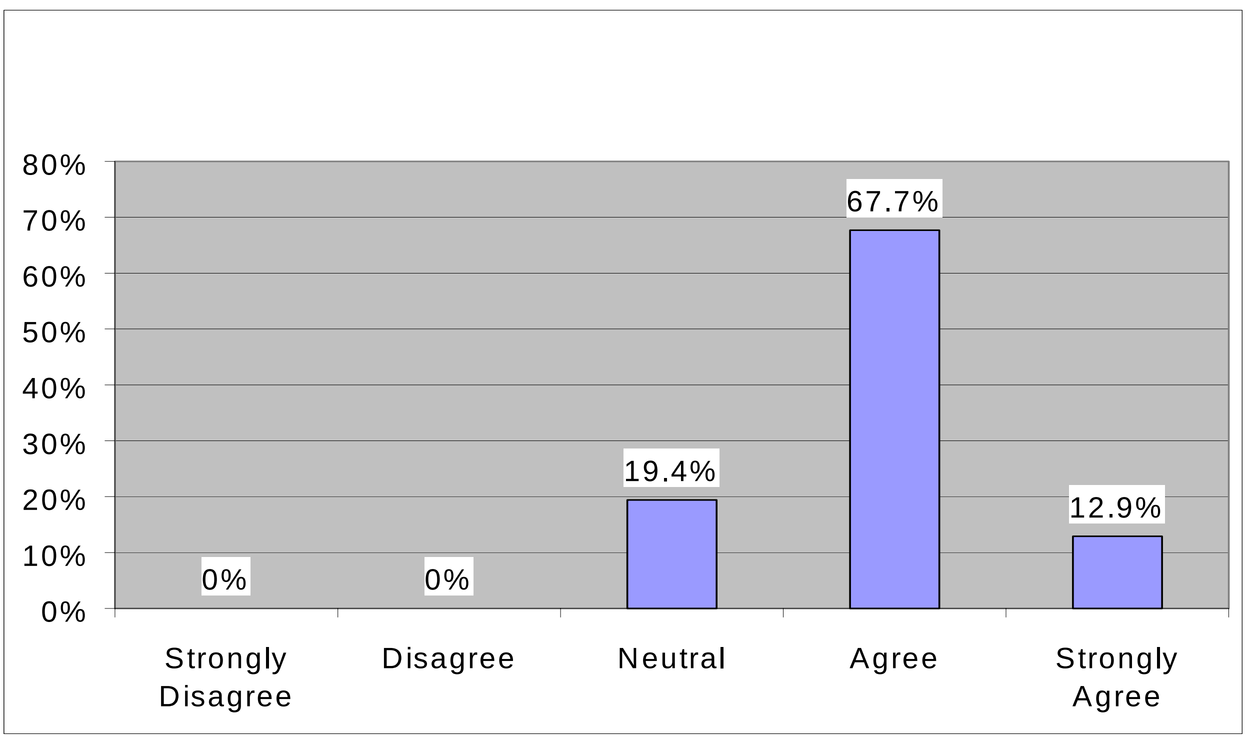


Figure 7.2: Decisions under Risk & Uncertainty

This finding is also supported by that firstly, twenty-five (80.6% - Figure 7.3) of the respondents overwhelmingly believed in embracing new technology and secondly, twenty-one (67.7%) respondents rated their technological performance as excellent when compared to other firms in the industry.

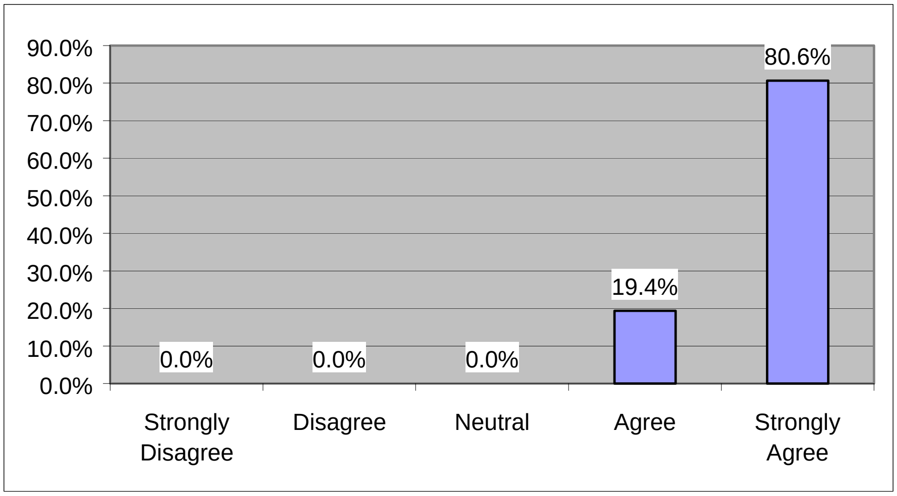


Figure 7.3: Embracing New Technology

Figure 7.4 indicates that twenty-five (80.6%) respondents strongly agree that future technological changes will influence their operations. This finding has implications on how the entrepreneur can prepare the enterprise to look for opportunities within the industry. It may be suggested that the entrepreneur should make use of technology forecasting techniques to better understand how the changes in the business environment can affect the business.

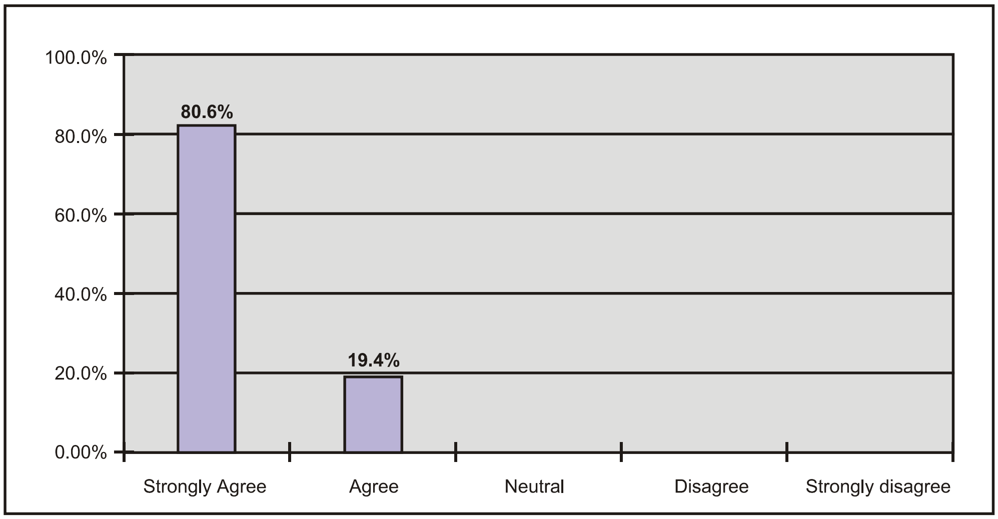


Figure 7.4: Future Technological Changes

To add to the above it seems to be more important as twenty-one (67.7%) of the respondents did not make use of any technology forecasting techniques. Technology forecasting techniques embrace some elements of Pettigrew's Model (Maas and Fox, 1997), namely, the entrepreneur, external environment, and the organisation. These elements are important and need to be considered when making a decision in a fast changing LFDP industry.

Access to external networks is imperative if the entrepreneur is to make an informed decision. From the survey, it is found that twenty-two (71.0%) of the entrepreneurs have major technical experience within their industry. This influences the decision-making in that entrepreneurs will reduce their reliance on external networks to gather information for decision-making. This may be because the entrepreneur has over the years developed a decision-making process that works for the enterprise. From Figure 7.5, the findings show that respondents are actively involved in the decision making process. For example, 64.5% of the respondents agree that: (1) they consult others in the organisation, (2) it is important colleagues accept the product they purchase, (3) they want to know what product class makes a good impression on peers and (4) they identify with other people who buy from the same product class.

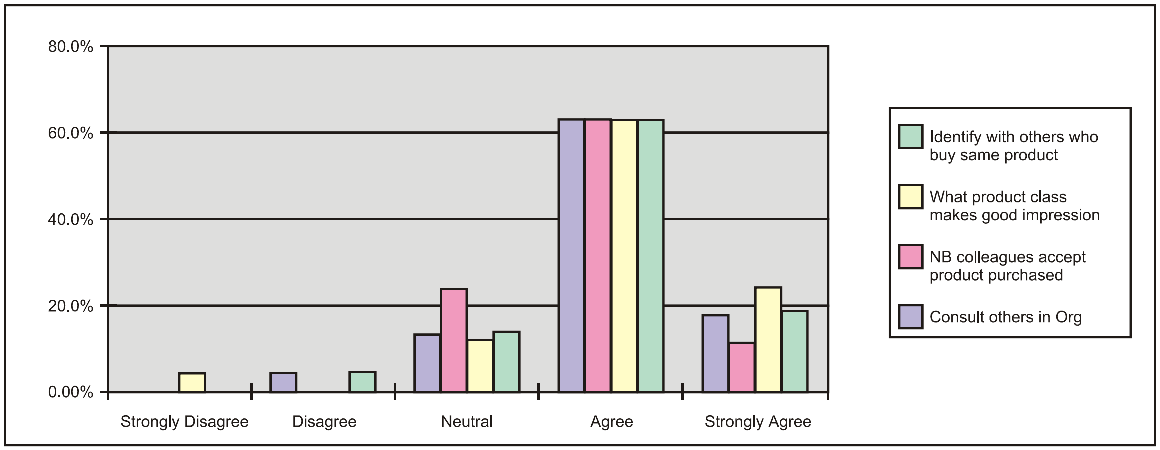


Figure 7.5: Measuring Interpersonal Influence

This trend is backed by the fact that twenty-two (71.0%) of the respondents prefer to consult suppliers and twenty-seven (87.1%) gather information in order to make informed decisions. This may reflect the need for high internal locus of control where the entrepreneur wants to be involved at every stage of the decision-making process.

Although the questionnaire did not ask the reasons why entrepreneurs want to grow their firms, it was still found that seventeen (54.8%) respondents agreed that their industry had growth potential. This is depicted in Figure 7.6 below.

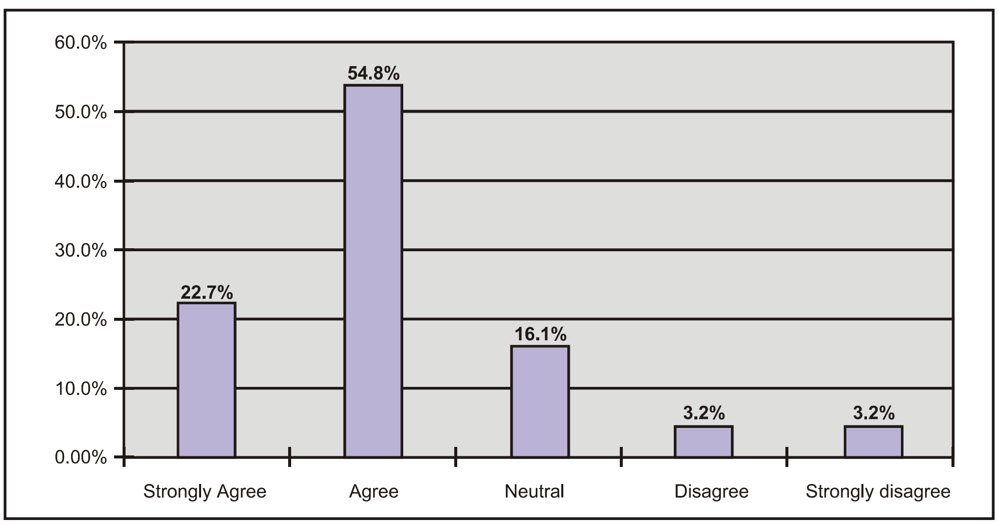


Figure 7.6: Industry Growth Potential

The survey also revealed, Figure 7.7, that twenty (64.5%) respondents felt that their growth potential in terms of finance, growth and human resources was good.

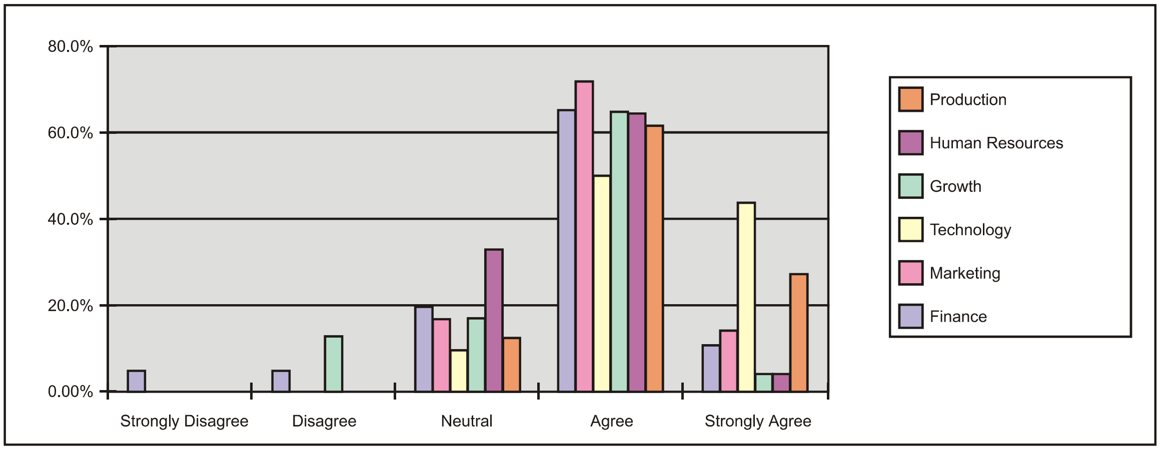


Figure 7.7: Growth Potential in certain areas

A further thirteen (41.9%) respondents thought their growth potential in terms of technology was excellent. This was backed by the finding, depicted in Figure 7.8, that twenty-one (67.7%) of the respondents planned to expand their business in the next five years.

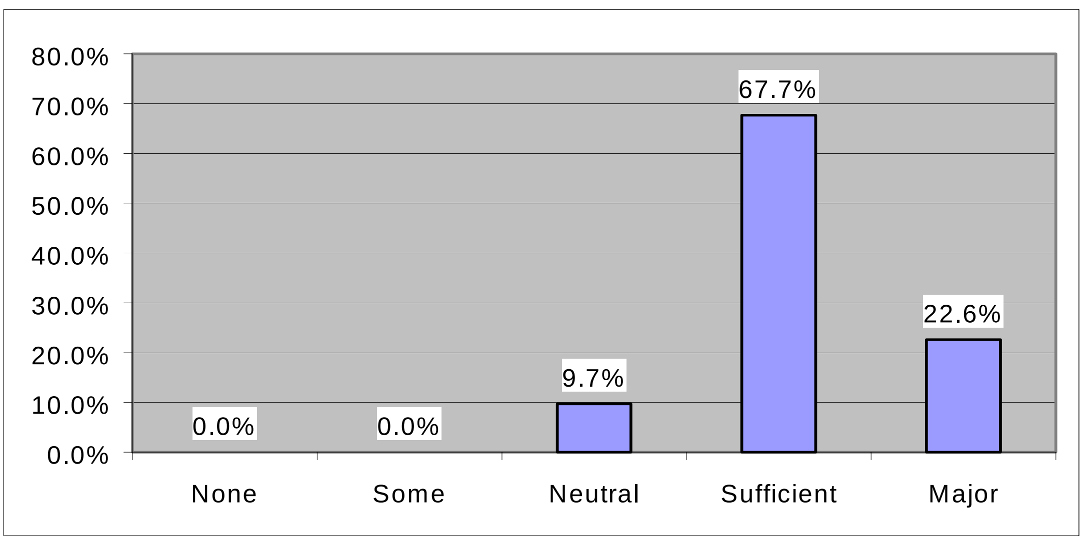


Figure 7.8: Planned Future Expansion

Once again, technological forecasting could be of great use to the entrepreneur when faced with the expansion decision. It is important to note that entrepreneurs felt that their human resources could grow, this is extremely important as this distinguishes entrepreneurs from small business owners, and the creation of employment is an indicator of entrepreneurship.

7.2.2 Buying Centre Characteristics

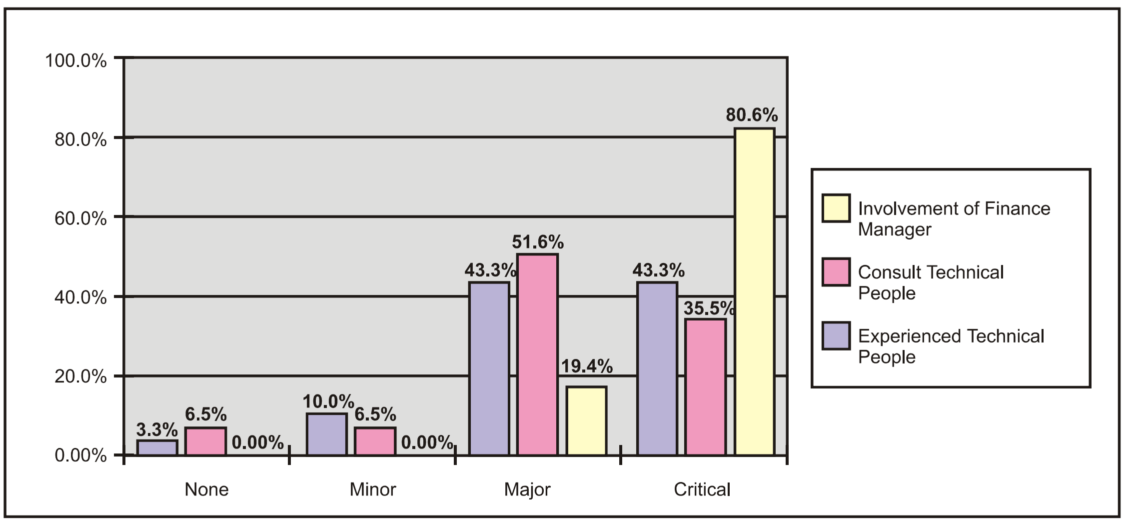


Figure 7.9: Buying Centre Characteristics

Figure 7.9 provides a graphical illustration of the buying centre characteristics where the majority (86.6%) of the enterprises have technical employees in the organisation, however, the technical division is not perceived to be critical in the purchase decision by at least sixteen (51.6%) of the entrepreneurs. The majority (twenty-five) of the entrepreneurs indicate that it is critical that the finance manager be involved in the purchase decision.

This also reflects the entrepreneur's desire to want to run a profitable firm. Adding to this is the fact that the majority of the entrepreneurs (twenty-two; 71.0%) invested between

41-100% with their own funds into the business and they would want to have a good return on their investment. Once again, this could be the reason why the technical division would not play a major role, as one would expect.

7.2.3 Purchasing Situation

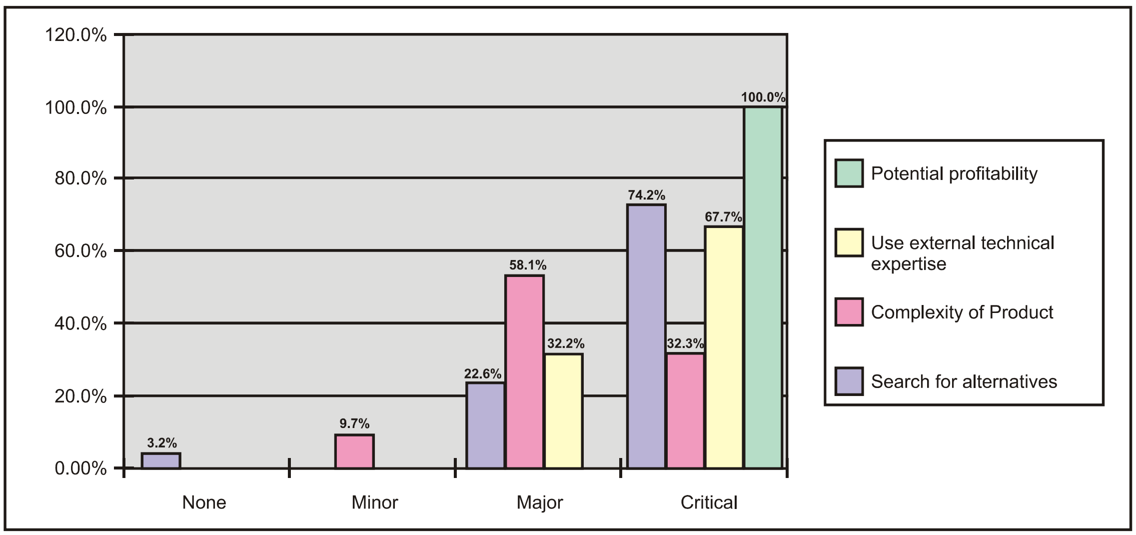


Figure 7.10: Purchasing Situation

The novelty aspect of the product is regarded by entrepreneurs (fifteen) as a minor purchasing factor. However, the aspects of the product features and price were perceived to be critical by twenty-four entrepreneurs and twenty-eight entrepreneurs respectively. It is critical to twenty-three (74.2%) (Figure 7.10) that they search for alternative products before they make their final decision and once again this supports the earlier observation that entrepreneurs will either consult their suppliers or gather information themselves before they make a decision and that they want to run a profitable organisation.

The complexity of the product is not recognised as a critical factor in the purchase decision and this could be because if the entrepreneur has difficulties he does make use of external networks (suppliers/technical expertise). All the respondents (100%) (Figure

7.10) in the survey indicated that a critical influence in the purchase decision is the importance attached to the product in terms of its capabilities to enhance productivity and profitability of the enterprise. This finding supports the definition of entrepreneurship (defined as an innovative economic organisation or network of organisations for the purpose of gain or growth under conditions of risk and uncertainty).

7.2.4 Organisational Structure

Figure 7.11 depicts the start-up periods for the respondents. From Figure 7.11, nineteen (61.3%) of the businesses were created between 1980 and 1989, which could suggest that the firms are in the maturity phase of the Churchill and Lewis (1983) business life-cycle. The needs of this stage include steady, profitable growth and once again this could be linked to the fact that the entrepreneur will only make a purchase if it has profitability and productivity potential for the organisation. However another plausible explanation for this trend can be that the cost of technology until recently was an entry barrier for other potential entrepreneurs. With the fast changes in technology this trend might change in the near future.

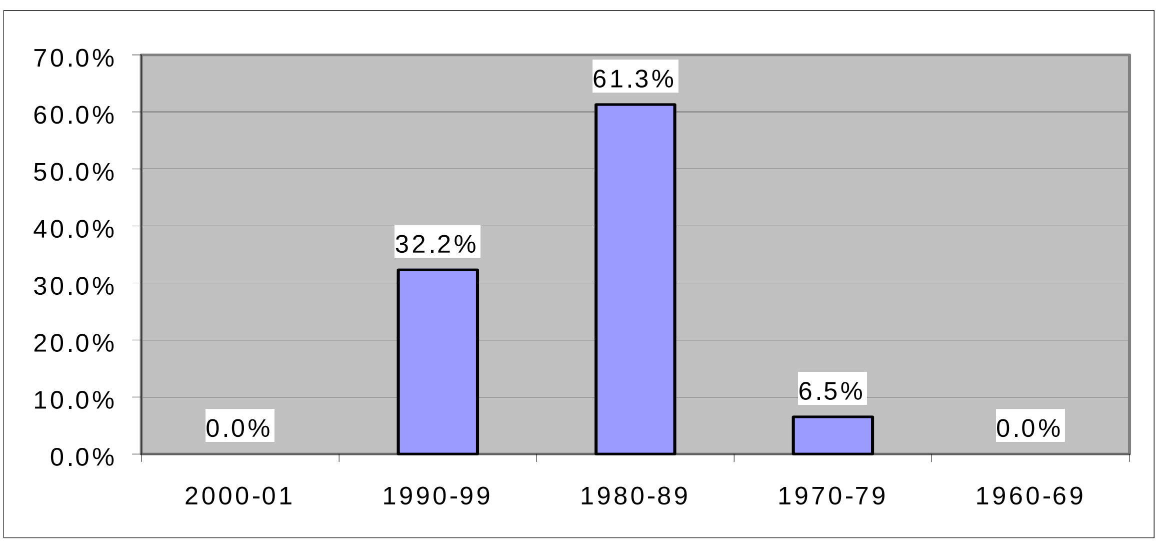


Figure 7.11: Creation of Enterprise

The dominant enterprise form was partnerships (54.8%) (Figure 7.12 below), followed by close corporations and sole proprietors (both 16.1%) and only four enterprises were private limited companies. The form of the business may have an effect on the decision-making process, for example, a sole proprietor may make decisions under conditions of risk, however, they may look to minimise the risk due to the fact that they are liable for all losses unlike the close corporation for example, which is not.

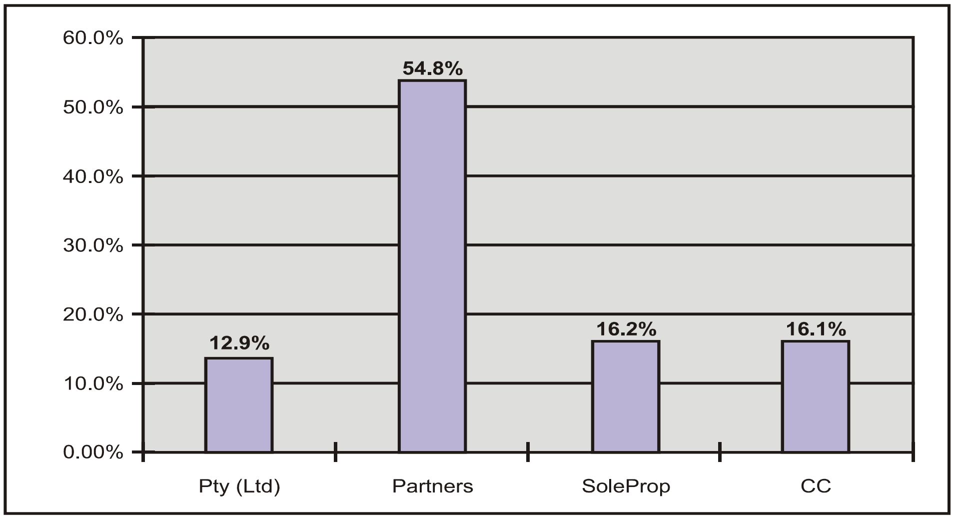


Figure 7.12: Business Forms

The finance division in the enterprise is said to be critical for the purchase decision by twenty-eight (90.3%) of the respondents. The technical division is regarded by sixteen (51.6%) of the respondents as critical to the purchase decision.

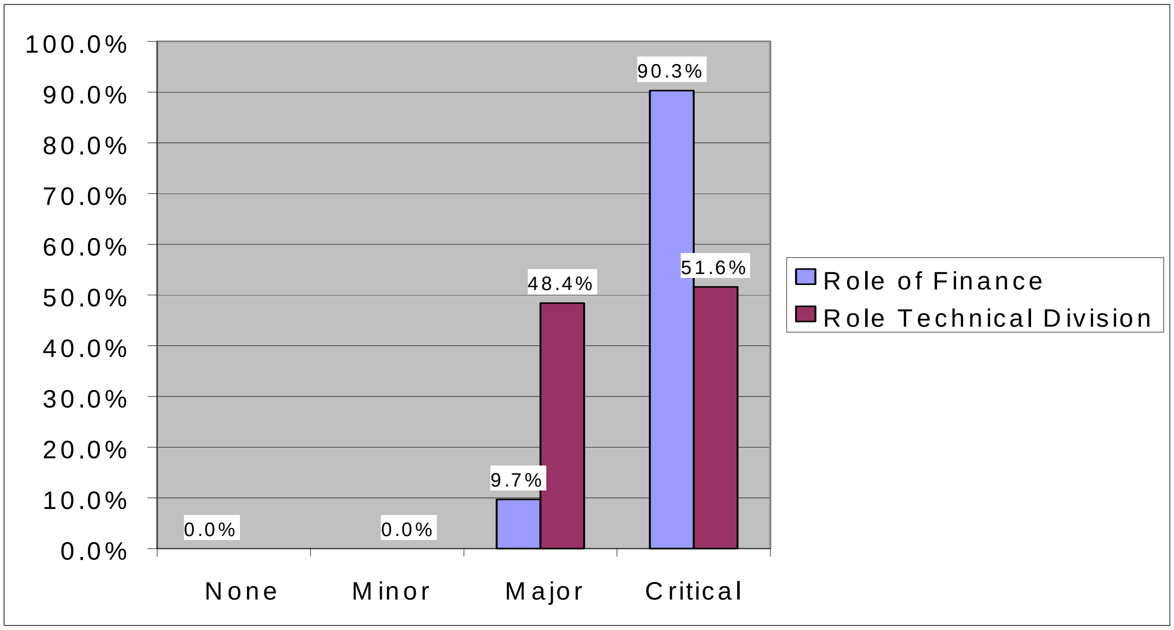


Figure 7.13: Critical Role Players in Purchase Decision

The same two divisions are regarded as critical to the final purchase decision. The technical division is important as the majority of the enterprises (fourteen) undertake in-house training and twenty-one of the respondents (67.7%) engage in training their employees during the usage of the new equipment.

7.3 SUMMARY

This chapter presented the findings of the questionnaire. The questionnaire was solicited information by testing an existing model that was used in technology decision-making. This new model is vindicated by the findings of the survey in terms of the various areas that were surveyed.

CHAPTER 8

CASE STUDY - ALFRESCO FULL COLOUR OUTDOOR GRAPHICS

This chapter deals with a case study that are devise to further test the framework (see Table 5.2), which can assist entrepreneurs to optimise their investment, in large format digital printing (LFDP). This test is necessary because one of the limitations of this study (see paragraph 6.4) is the small sample, which may influence the validity of this study. With the case study approach this issue can be addressed in a satisfactory way.

8.1 OBJECTIVE OF THIS CASE STUDY

The case study can assist entrepreneurs to optimise their investment, in LFDPs. This case reflects the integrated framework of entrepreneurial and technical decision-making processes of a LFDP company namely Alfresco Full Colour Outdoor Graphics (AFCOG) against the findings of the research. It further attempts to identify the entrepreneurial factors that inhibit performance (in terms of decision-making) at individual, group, and organisational levels relating to LFDP businesses as well as identifies the critical success factors in selecting the correct LFDP.

8.2 THE CASE STUDY AS RESEARCH INSTRUMENT

A case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident and it relies on multiple sources of evidence (Yin, 1994:13). Case study research investigates predefined phenomena but does not involve explicit control or manipulation of variables: the focus is on in-depth understanding of a phenomenon and its context (Cavaye, 1996). Case studies typically combine data collection techniques such as interviews, observation, questionnaires, and document and text analysis. Both qualitative data collection and analysis methods and quantitative may be used (Yin, 1994:14). Although similar to field studies, which also examine phenomena in their natural context, case studies differ in that the case researcher has less prior knowledge of constructs and variables (Benbasat et al., 1987; Cavaye, 1996). However, the difference between the two research methods is a matter of degree and is sometimes difficult to discern, as case study researchers may have clear a priori definitions of variables to be studied and the ways in which they can be measured (Benbasat et al., 1987; Yin. 1994, p. 34). Case study research also needs to be distinguished from the use of case studies as teaching devices, where the purpose is to illustrate particular situations and provide a framework for discussion amongst students (Yin, 1994, p. 10).

Case study research can be used to achieve various research aims: to provide descriptions of phenomena, develop theory, and test theory. In this case the author reflects the research findings against AFCOG's decision making model to test and verify the validity of the theory against the findings of this research. It is used to provide evidence for exploration of areas where existing knowledge is limited (Cavaye, 1996). The theory is either validated or else found to be inadequate in some way, and may then be further refined on the basis of the case study findings.

Case study research has been used within both the positivist and the interpretivist philosophical traditions (Cavaye, 1996; Doolin, 1996). The positivist perspective is founded on an ontology in which an objective physical and social world exists independently of humans' knowledge of it. Positivist research is concerned with the empirical testability of theories in order to discover the general principles or laws, which govern the natural and social world (Orlikowski & Baroudi, 1991). Inquiry is assumed to be value free, so that the researcher remains detached, neutral and objective. Case study research within this perspective is designed and evaluated according to the criteria of the natural science model of research: controlled observations, controlled deductions, replicability and generalisability (Lee, 1989a). Although manipulation of variables in the experimental sense is not possible in case study research, theoretical constructs can be defined and empirically evaluated and measured, and naturally occurring controls can be identified (Lee, 1989a; Cavaye, 1996). Literal and theoretical replication provides for generalisability of case study research findings (Lee, 1989a; Yin. 1994:46-51).

The interpretivist approach is based on an ontology in which reality is subjective, a social product constructed and interpreted by humans as social actors according to their beliefs and value systems. Interpretivist research attempts to understand phenomena through accessing the meanings that participants assign to them (Orlikowski & Baroudi, 1991:5) and focuses on their cultural and historical context. Interpretivist research rejects the notion of value-free research and is not concerned with the repeatability of an explanation.

This particular case is explorative in nature and aims to test the current theory on decision making within the constraints of one particular printing concern and then reflect that against the findings of the research in this paper. Because this particular research concerns itself with a human decision making model in a particular industry it cannot be considered purely positivistic in nature i.e. in need to generalise the findings across an objective physical and social world, independently of humans' knowledge of it. This case study is further to explore the generalisability of the research findings. This case further investigates whether theory and practice is aligned and whether the model and results are valid or should be adapted to accommodate the reality in practice from an interpretivist point of view. The reason for selecting AFCOG as the target for this case study is purely from an accessibility point of view. AFCOG is located in the geographical region were the researcher resides and is accessible for the purpose of gathering the qualitative data necessary for this particular case study.

8.3 BACKGROUND ON AFCOG

AFCOG is a South African Port Elizabeth-based company that contracts throughout Africa with a combined outdoor printing experience of more than 35 years and a professional staff force of seventeen people. They are preferred suppliers to SABCO and Coca-Cola as well as SA Breweries. Their core competence in the industry resides in:

- Graphic design and text layout
- Full colour outdoor graphics
- Outdoor advertising (production and design)
- Web page design
- Corporate identity
- Presentation design
- Large format digital printing

At AFCOG they are committed to ensure that AFCOG changes with the times. The fluid nature of their industry requires constant adaptation to prevent stagnation. No single technology can supply all their needs and as new and different technologies are presented to the marketplace, they broaden the variety of product options their customers can select from. The ability to manufacture a value-for-money printed product with great detail, high durability and predictable colour is their primary focus and passion.

AFCOG has proved themselves to be innovative when it comes to research and development of new and untried products. AFCOG are continuously extending the limits of performance of their media, inks and applied technology, to ensure that AFCOG manufacture products which are not only value for money, but are also able to perform according to predictable and measured durability criteria.

"One-stop" service to them means providing their customers with each and every element in the print process. Their passion is excellence as AFCOG strives to provide top quality "branding solutions". Their products have inherently unique performance attributes and are testimony to their commitment to quality and service excellence. AFCOG prefers not to wait for the industry and suppliers to evaluate product standards, but rather does so themselves.

As a fairly small concern in terms of staff complement (17) that are intimately involved in the LFDP industry and are ideal for the evaluation of the theory as presented in this paper.

8.4 BACKGROUND TO BUYING A LFDP

Deciding on the purchase of a LFDP from an entrepreneurial point of view is a seemingly insignificant task when considering that it would form part of an existing operation that focuses on large format printing. The research in this paper has undoubtedly questioned whether this is indeed an insignificant task. Any business manager will bear witness to the complexity of issues to be considered when purchasing technology in a particular industry. Not only is technology expensive but from and entrepreneurial point of view the entrepreneur will have to purchase it themselves or at the very least secure a loan. The risks involved are numerous and working though the variables are more than often a tedious and resource consuming task.

This case study is based on the decision-making processes that AFCOG will engage in before committing on a LFDP. The author addresses the following:

- How the research suggests such a process should take place and how AFCOG currently operates?
- How the developed model on the entrepreneurial decision making processes (See Figure 8.1) compares to AFCOG's employed processes (See Figure 8.2)?
- What does the evidence suggest regarding entrepreneurial decisions on LFDP's?

8.5 INDIVIDUAL CHARACTERISTICS

The level of education has bearing on the decision-making ability of the entrepreneur and the venture and in AFCOG's case the main decision-maker has a post graduate degree pertaining to the social sciences and not to the LFDP industry in particular. With the exception of the graphic designers the employees at AFCOG does not hold formal education but are fairly well experienced in this industry.

The AFCOG owner makes decisions under conditions of risk and uncertainty in particular when a new or existing client requests a different form of outdoor printing than what they used to request. The implications for the entrepreneur are the future prospects of the technology, the cost recovery of the equipment, the knowledge needed for optimised usage and various other risk elements in acquiring this new technology. In this case the entrepreneur is congruent to the findings of the research as well as in support of the literature on characteristics of the entrepreneur, namely, the entrepreneur's ability to handle uncertainty and risk-taking (see paragraph 2.2.3). New technology is embraced at AFCOG when the prospects for the generation of wealth is relatively well considered. The concerns for the AFCOG entrepreneur was more towards the limited economy of scale in the Eastern Cape than towards the primary risk factors in acquiring the new technology. This again is in support of the suggestion that "the entrepreneur should make use of technology forecasting techniques to better understand how the changes in the business environment can affect the business" (see paragraph 5.3). These elements are clearly important and need to be considered when making a decision.

Access to external networks is imperative to this entrepreneur in order to make an informed decision. Although, it is found that twenty-two (71.0%) of the entrepreneurs have major technical experience within their industry and that the entrepreneurs will reduce their reliance on external networks to gather information for decision-making. The AFCOG entrepreneur still networks outside his geographic region of operation in order to tap into applied experience. This however does not contradict the findings because the entrepreneur does still consult others in the organisation before investing in new technology and does regard their acceptance of this purchase to be important. He also consults with suppliers and gathers generic information on the technology before committing to a decision. This trend is backed by the fact that twenty-two (71.0%) of the respondents prefer to consult suppliers and twenty-seven (87.1%) gather information in order to make informed decisions. At every stage of the decision-making process this entrepreneur want a reasonable degree of control on the purchasing decision which is congruent to the significant findings relating to the individual characteristics of the entrepreneur in the decision making process (see paragraph 2.5).

AFCOG is clearly and entrepreneurial venture that wants to further employment in his region. The owner confirms the findings that technology in his industry is perceived to be a significant contributor to organisational growth. In the foreseeable future he wants to grow his venture and are optimistic that the return on equity will consistently outweigh their region's economic growth in general. This was backed by the finding that twenty-one (67.7%) of the respondents planned to expand their business in the next five years. Once again, technological forecasting could be of great use to the entrepreneur when faced with an expansion decision. The individual characteristics of AFCOG's entrepreneur show significant support for the findings in this particular part of the research.

8.6 BUYING CENTRE CHARACTERISTICS

AFCOG employs technical operators in his organisation, however, the technical division is not perceived to be critical in the purchase decision because the owner believes that the market need for a particular service is of primary importance and technical staff can be trained to perform the needed functions when required to do so. Again there are a consistency with the theory developed in this study where the majority of the respondents indicated that the technical department is not critical to the purchasing decision. However, AFCOG considers it critical to have the finance manager involved in this decision. This approach is also consistent with the research done earlier in this paper (see paragraph 7.2.2). AFCOG indicated that such a decision could not be made without a clear understanding of a couple of factors:

1. What are the debt/equity gearing, should they need to gain access to credit?
2. How will the cash flow of the organisation be influenced whether it is financed, purchased outright or even leased?
3. What type of return on investment can be expected from such a purchase?
4. What will the impact be on productivity and organisational capacity?
5. Will such an investment allow for sustainable growth? (Not too fast nor too slow growth)

8.7 PURCHASING SITUATION

The AFCOG entrepreneur is consistent with the research that he also regards the novelty aspect of the product as a minor purchasing factor because it is perceived that the novelty will wear off before the technology has generated sufficient return on the investment. AFCOG also supports the findings that the aspects of the product features and price are critical as found by twenty-four entrepreneurs and twenty-eight entrepreneurs respectively (see paragraph 7.2.3). Searching for alternatives is critical to AFCOG's ability to remain productive and refrain from being kept hostage by a specific supplier of technology. This holds true to twenty-three (74.2%) to search for alternative products before they make their final decision (see paragraph 7.2.3). Once again this supports the earlier observation that entrepreneurs will either consult their suppliers or gather information themselves before they make a decision and that they want to generate wealth by operating profitably (see paragraph 7.2.3).

The complexity of the product is not recognised as a critical factor in the purchase decision by the research (see paragraph 5.5.3) but AFCOG however does differ slightly by indicating that the level of complexity might require them to employ an individual that can operate the technology.

All the respondents (100%) in the survey indicated that a critical influence in the purchase decision is the importance attached to the product in terms of its capabilities to enhance productivity and profitability of the enterprise (see Figure 7.10). AFCOG, agrees with this finding. AFCOG can therefore also be seen as and entrepreneurial venture because it supports the definition of entrepreneurship (defined as an innovative economic organisation (or network of organisations) for the purpose of gain or growth under conditions of risk and uncertainty) (see paragraph 2.2).

8.8 ORGANISATIONAL STRUCTURE

In the research the dominant enterprise form was partnerships (54.8%), followed by close corporations (16.1%) and sole proprietors (16.2%) and only four enterprises were private limited companies (see Figure 7.12). AFCOG being both a closed corporation and with a shallow report and management structure is regarding themselves as fortunate because their decision making processes not being stifled by lengthy bureaucratic procedures. On the other hand AFCOG considers the risk factor to decrease the more people are involved in the decision process. This will imply that the more people that are involved the more considerations are taken into account before deciding on the acquisition. They are also uniform with the notion that the Finance Manager is critical in the purchase decision.

The finance division in the enterprise is said to be critical for the purchase decision by twenty-eight (90.3%) of the respondents (see Figure 7.13). This is also critical from AFCOG's perception because AFCOG's primary focus is on creating wealth and delivering a profit to the entrepreneur. The research indicates that the technical division is regarded as critical to the purchase decision (see Figure 7.13). AFCOG does not agree because AFCOG believes that the technical division can be trained to utilise the new technology and can be consulted but their input is not regarded as critical to the purchase decision. AFCOG's entrepreneur makes all the important decisions regarding his company – including the decisions of the people and skills employed. He is well aware of their views due to diligent communication exercises with his staff and an intimate understanding of AFCOG's production needs. Technical input is acquired through his personal need to understand the industry thoroughly. AFCOG's entrepreneur does however concede that if he did not posses this technological understanding, the input from the technical department would be critical. From an in-house training point of view AFCOG considers the technical department's input essential but that will be after the purchasing decision has been formulated.

8.9 LIMITATIONS OF MODEL

Deduced from discussions from the above paragraphs the limitations in real life to the decision making model (see Figure 8.1) is to determine the sequential events in which the decisions are taken.

8.10 SUMMARY AND CONCLUSION

The study questionnaire was soliciting information by testing an existing model that was used in technology decision-making and the case study was testing these findings in a particular case. Although the existing model focused on making decisions based on an individual's knowledge the research indicated that a multitude of information is required and that the individual's knowledge is more fallible that that of various of sources.

In AFCOG's case the final decision is still with the entrepreneur but with various processes preceding the final decision. These processes includes information seeking processes that can initiate the consideration of a LFDP such as:

Market trends and market demands

Political information

1. Environment information
2. Social information
3. Technology information
4. Economic information

Legal information

Once an LFDP is being considered by AFCOG the decision making evolves to another plane in as much as acquiring specific product information from:

1. The Financial Manager
2. The suppliers
3. Networked environment

Lastly, once satisfactory information from this level has been gathered the entrepreneur from AFCOG approaches his technical department to test their acceptance of the new technology. The decision is finally made only when acceptance has been noted. This whole process can be scrutinised (See Figure 8.2) and when compared to the decision making model as proposed by the research it becomes clear that the proposed model certainly holds true for AFCOG.

Although AFCOG's responses were congruent with the findings of the research it is clear (See figure 8.2) that the process that is followed during decision-making can differ from enterprise to enterprise and could be topics for future research.

8.11 FINDINGS ON THE PROPOSED DECISION MAKING MODEL

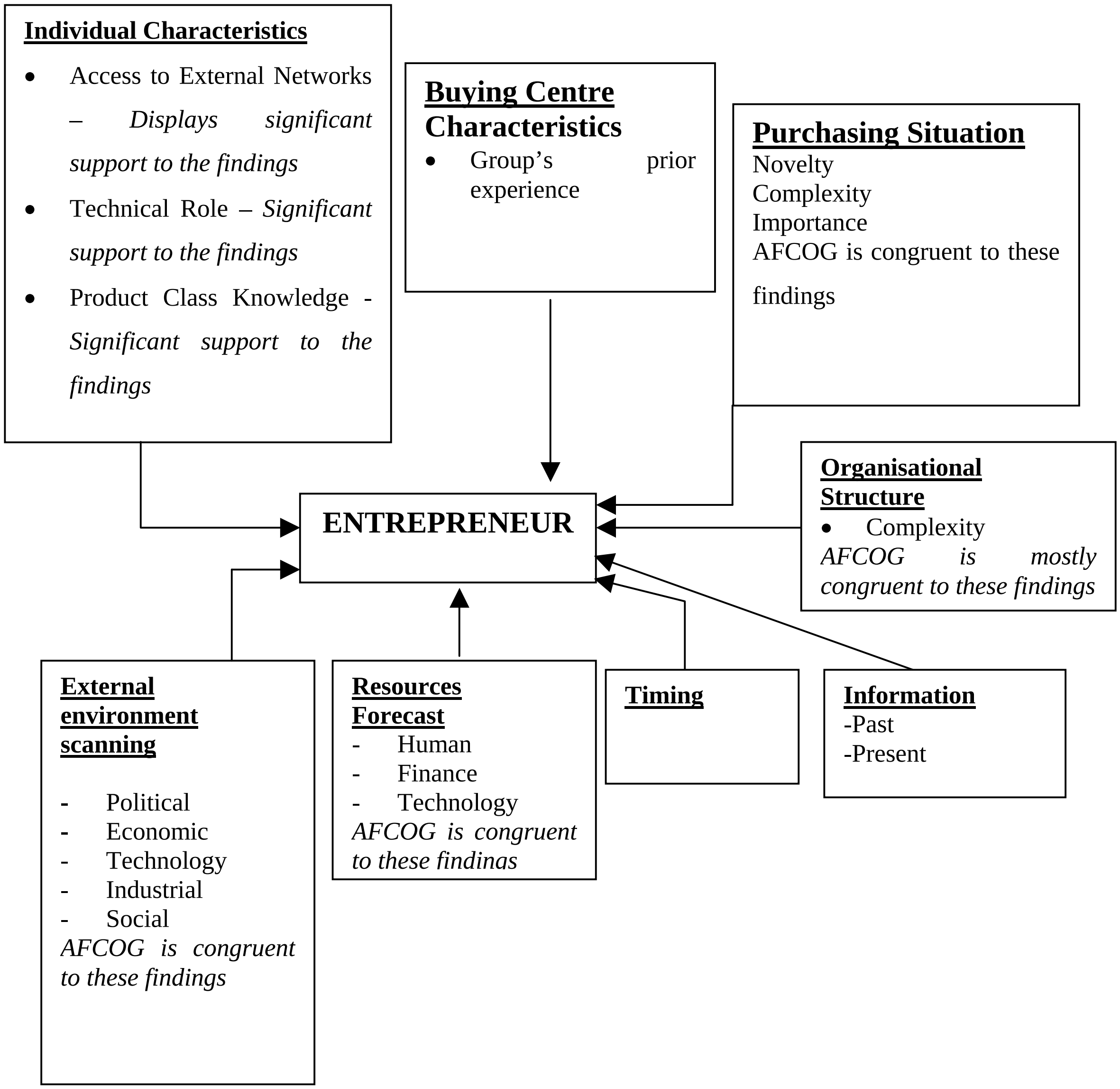


Figure 8.1. Proposed Decision making model

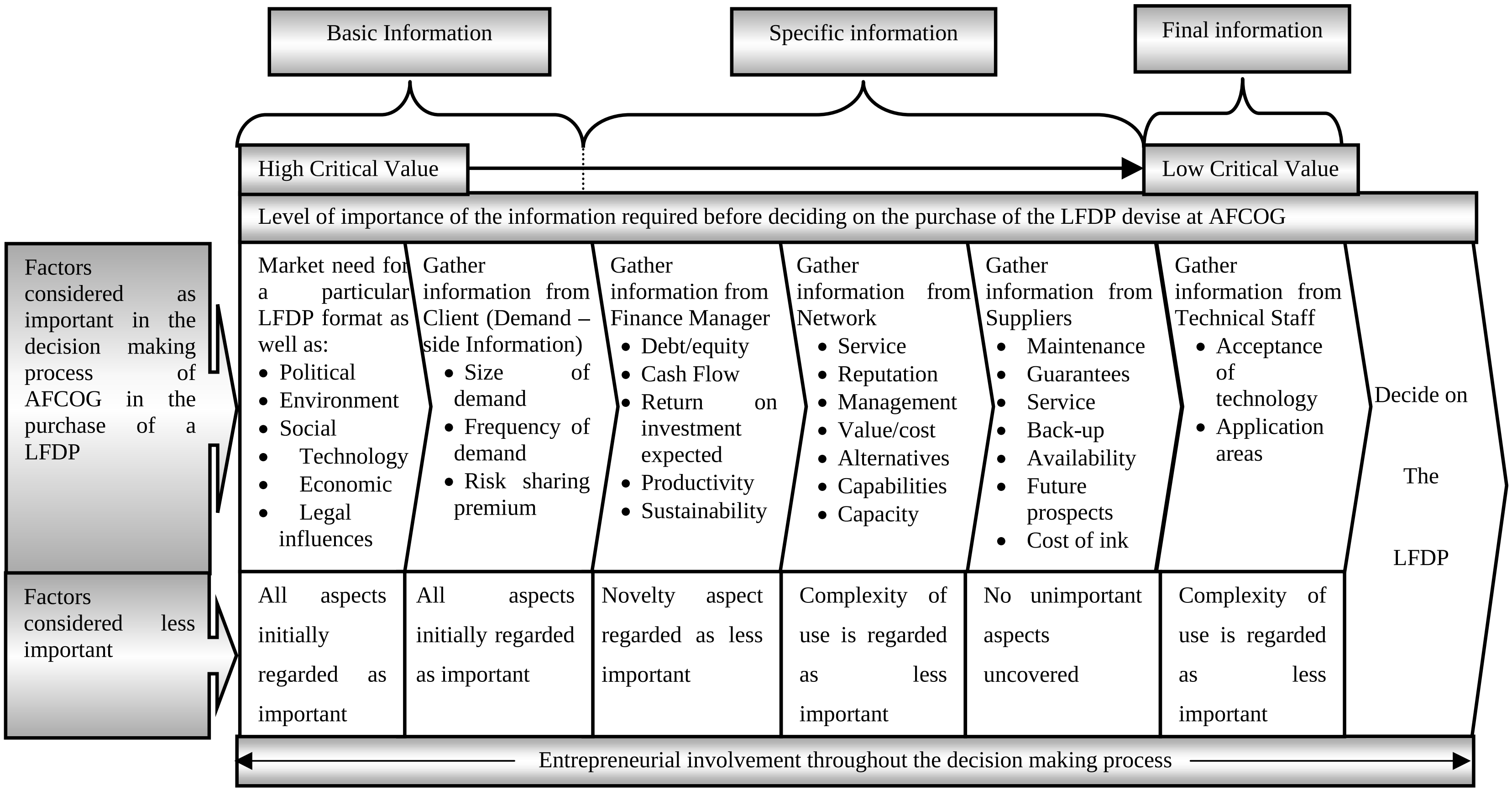


Figure 8.2. Decision making process of AFCOG in purchasing an LFDP

CHAPTER 9

RECOMMENDATIONS AND CONCLUSION

9.1 INTRODUCTION

It was stated in Chapter 1 that due to various reasons this study being explorative. Theory and practice were therefore explored to find a framework that can assist entrepreneurs optimising their investment in the LFDP domain. A theoretical decision model was firstly analysed after which it was tested in terms of a case study. Various limitations were identified during these processes. Subsequently, the following paragraph will outline an adapted model that can be used in practice by LFDP entrepreneurs. Due to its explorative nature this study has certain shortcomings. These shortcomings will follow the discussion of the adapted model. Finally, directions for future research will be provided in this chapter.

9.2 ADAPTED MODEL

From the literature and the findings of the study, the researcher recommends that the model presented in Chapter 5 (see Figure 5.2) integrate the key technological forecasting areas together with its main components. The reasoning is that technological forecasting is central to making key purchase decisions. The existing model's focus is on the individual's ability to make decisions based on their own knowledge. However, by integrating technology forecasting components, namely, scanning the business environment and resources (human, finance, capabilities) needed the decision-maker will be better equipped to make decisions that also takes into account the external environment and also allows them to plan and manage growth in a systematic way. The adapted model (see Figure 9.1) will be discussed in the following paragraphs in such a way that it will provide a framework to new LFDP entrepreneurs. This is also in line with the main research problem stating that the purpose of this study is to establish a framework which can assist entrepreneurs to optimise their investment in LFDP's (see paragraph 1.2)

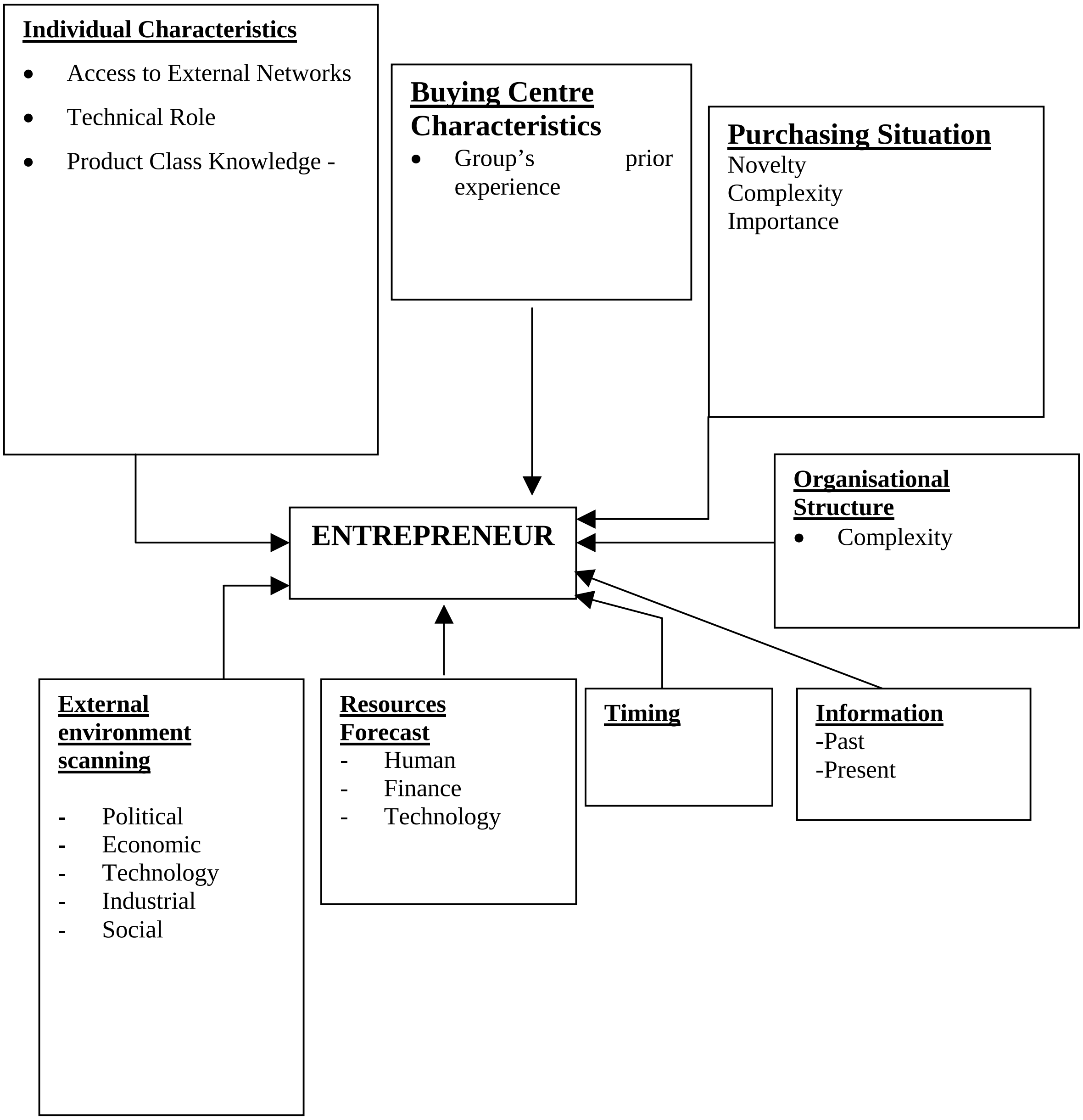


Figure 9.1 Adapted decision making model for technology based firms

9.2.1 Individual Characteristics

From the findings of the research, 71.0% of the respondents possess major industry experience and this is important as it allows them to make an informed decision before acquiring the printers. Access to external networks is also important because 64.5% of the individuals do liase with other people to get the necessary information. The technical role is more so important because of the high level of technicality that comes with LFDP. For example, the entrepreneur needs to understand what they actual want the printer to do for them i.e. print on billboards, vinyl. The type of information that the entrepreneur needs to know about LFDP was discussed in Chapters 4. On the other hand, an entrepreneur can be described as a risk-taker and as such, there may be times when he sees an opportunity to grow their business and for this to happen, their technical background and access to external networks may facilitate their action.

9.2.2 Buying centre characteristics

The findings indicate that the majority of respondents have technical staff in their organisations, however, these employees are not crucial to the decision-making process. However, for the proposed model, the technical employees are regarded as important in the decision-making process as they are often the operators of the equipment and are in a position to offer valid advise to the entrepreneur.

9.2.3 Purchasing situation

The novelty and complexity aspects of the equipment were not perceived to critical in the purchase decision. Nevertheless, this is not to say that they are not important. The entrepreneur may discover that the potential printer will allow them to offer and innovative product/service due to the novelty characteristics of the printer. The entrepreneur needs to look at this aspect as it may allow them to create a new competitive landscape. However, the issue of the importance of the machine for the success of the firm was critical. This aspect is important as it assists the entrepreneur in deciding if they need to purchase the machinery and what added value the machine will bring to the firm. The purchasing situation will be influenced by the resources, timing as well as information aspects, which form part of the technology forecasting components.

9.2.4 Organisational structure

The majority of the firms interviewed were partnerships and this may mean that there are few divisions that are found in the organisation. The organisational structure aspect is important because the majority of the decisions will be made between few people. This may mean that the entrepreneur(s) may have to rely on past information and their technical background to make the decision. The organisational structure is also important because as an entrepreneur, one needs to be in a position to take risks and acquire the necessary resources to take on an opportunity. As a result, if there are many divisions that need to be consulted to make a decision, the opportunity may be lost. It may be necessary for the entrepreneur to set up a system that will not lead to complexity in the organisation when purchase decisions need to be made.

9.2.5 External environmental scanning

Chapter 3 discusses entrepreneurship at length and the Pettigrew model in Maas and Fox (1996) highlights the importance of scanning the environment in order to find opportunities. The entrepreneur will be in a better position to make a purchase decision if they scan the environment to see if the printer will allow them to grow or enter a new market. The entrepreneur's individual characteristics will also become important, for example, the entrepreneur may make use of their external networks and technical roles to decide if they should purchase the printer.

9.2.6 Resources forecasting

Central to exploiting an opportunity is the entrepreneur's resources (human, financial and technology). In order to purchase a printer the entrepreneur needs to have such resources and try to establish if they will receive the return on investment that they want.

9.2.7 Timing

The entrepreneur needs to make decisions that will allow them to exploit an opportunity and timing is essential. Timing includes having information on hand that will facilitate the decision making and organisational structures that facilitate quick decisions.

9.2.8 Information

Information both past and present will facilitate the entrepreneur to make purchase decisions. The entrepreneur, for example, may make use of their external networks when it comes to the purchase decision, the employees who work with the printer to give them results and information from the environment scan that will provide trends of the LFDP industry.

The proposed model takes into account individual capabilities and technology forecasting components that can facilitate the decision-making process.

9.3 LIMITATIONS OF THIS STUDY

This study has three major limitations namely:

- The greatest limitation of this study is that there is limited theoretical basis regarding LFDP's to work from.
- The fast changing pace of (a) the technology and (b) printing as a discipline posed another limitation on this study and lastly
- This study is explorative and the results therefore are not tested in terms of reliability and validity. Generalisations is therefore not possible

9.4 FUTURE RESEARCH

While researching this topic, a number of aspects that have potential for future investigation were identified.

Firstly, how these printers can add to the creative process, or any aesthetic analysis of the test results, does not fall within the delimitations of this research. However the fact that the digital printer is becoming a more common tool in the creative process cannot be denied. The type of impact this will have on the creative process and the aesthetic qualities of the imagery could provide material for future investigations.

Within this research, the tests were conducted within specific parameters, for example, no particular brand of printer was tested. Printer types, irrespective of the manufacturer, were considered to be the same. There is certainly a need to do a comparative study of brands of printers that are suitable for images and applications. This study could be further refined into testing the smaller printers that clients could purchase, and those that bureaux purchase.

With the enormous range of substrates available and the potential of some printers (inkjet printers and laser printers) to print onto unconventional substrates, this too could provide an area to research both technical and aesthetic issues.

Another possible area of investigation is the effect of printing fine art images from different software programs. Testing how images print from a variety of applications, in different modes and with different forms of colour management, has potential for future research projects.

The above reflects mostly the technical domains of LFDP. In addition to that the following issues can be worthwhile investigating:

- The theoretical basis of entrepreneurship in LFDP
- Growth strategies in LFDP
- Internationalising capabilities of LFDP

9.5 CONCLUDING REMARKS

Manufacturers may phase out some printers such as the thermal wax printer, the aerosol inkjet and the large format electrostatic printer, in the future. Although many graphic artists are involved with producing work using the latest technology, there are also those that use old technology very creatively. Older digital printing processes may provide them with the opportunity to develop creative techniques, in the same way that modern photographers use processes such as gum bichromate and cyanotypes.

As most of the other printing processes are still being developed and improved on, it is reasonably safe to assume that they will be used commercially for many more years. Although digital printing processes will no doubt change in the future, this research, will certainly be relevant for some time to come.

Digital printing is a relatively new medium, some products have only been on the market for a few years. As is pointed out at the beginning of this document, new digital printing techniques are being introduced at a fast pace, as are new inks and substrates (Otsuki, 2000). This means that although printers were tested in the course of this research (1999/2000/2001), it is quite feasible that within a year or two, new untested printers will have appeared on the international market. Entrepreneurs wanting to use these new printing techniques could adapt the testing and evaluation methods described in this document to assess the new printers.

In this document it is also clearly stated that entrepreneurs are influenced by fast changes caused by, inter alia, research and development in technology. In this regard Handy (1990) has identified several of these fast changes that are already implemented or will be in the near future. These changes in technology influence the decision-making processes of the entrepreneur in purchasing a new LFDP and the case study that that was done in this study clearly indicates that the altered model for decision-making holds true for an entrepreneurial organisation such as AFCOG being a pillar of innovation and socio-economic growth.

Certain types of digital printers already offer the entrepreneurs excellent potential for printing their images. In order to use these printers effectively, the original image, the printer anomalies and the final applications of the print must be considered and matched. This document offers an approach to achieving this goal. As technology improves and new products are released, matching image to print will continue to challenge graphic artist, entrepreneurs and researchers alike. Therefore our adapted model on decision-making clearly delineates that the combination of entrepreneurial qualities and technology in the LFDP industry will ultimately challenge the entrepreneur on various levels in deciding on a new LFDP.

The following part of the conclusion is broken down into four sections, each section describes how the sub-problems posed in chapter one, are addressed by the research. Following this are some aspects that are essential for entrepreneurs and clientele to follow if they wish to have digital prints made of their work in South Africa. Finally, aspects that can quite possibly lead to future research topics are identified, these may have been indicated by the current research, or are aspects that do not fall within the delimitations of this document.

9.5.1 CURRENT PERFORMANCE MEASURES AND SYSTEMS OF VARIOUS LFDP'S

It was established that there are fifteen different types of digital printers available in South Africa (2000/2001). These printers offer a huge range of options in terms of quality, print sizes, print speeds, cost of prints, substrates, running costs, physical dimensions of the printers, longevity characteristics, cost of the printers themselves and manufacturers. This is illustrated in chapter 6. Although South Africa cannot match the quantity of printers available in for example the USA, all the basic processes are covered.

Although there are a number of Iris printers operating in South Africa, the machine dedicated to fine art print production, the IrisGPRINTER, is not available in South Africa (Solomon, 2000). The Iris continuous flow printing technology when used with the correct ink and substrate combinations has established itself as a very accurate method for producing limited edition prints and unique art works (Brown, 1998:2). These days manufacturers other than Iris, such as ColorSpan are marketing cheaper machines that work on the same continuous flow principle. As the number of this type of machine increases in South Africa, it becomes more likely that the bureaux will begin to offer the inks and papers that give better image permanence.

The initial assumption that machines that generally print commercial images can also be used to print fine art images was in principle accurate. In general, most bureaux will accept work from fine art clients (Maio, 2000). However in some cases, it seems that artists cannot compete with commercial clients. For instance the company, Visual Promotions, was not prepared to halt a production run on the only HK digital enlarger in South Africa, merely to output a single image for the researcher. This indicates that unless entrepreneurs have a substantial number of prints to make, certain processes will not be made available to them.

Another point to consider here, is that in the case of a company which houses a scarce resource (e.g. Visual Promotion's digital enlarger), the company might be under contract to produce images for one client only. For example the digital enlarger prints that combine both digital and photographic quality on backlit displays. These are ideal for use in the gambling industry, which needs backlit displays for their 'one armed bandits' or slot machines, and for companies such as MacDonald's, which needs backlit displays for their restaurants. The point is that, even if an client had the financial means to afford a large print run of a particular image, they still might not be accommodated, as the bureau might not need additional business when their livelihood is solely dependant on a major client's needs.

A technical explanation of how each printer lays down colour or tone was given in chapter 7. This explanation provides a better understanding of how certain results can be achieved with one printer but not with another. An example of this would be a comparison between a dye sublimation printer and a continuous flow inkjet printer. The dye sublimation process causes a slight diffusion of the dot, resulting in near-photographic quality. Continuous flow inkjet printers by comparison put down a very distinct fine overlapping dot, giving the image a very different quality. The different techniques and materials used by each printing system makes it unique and will always influence what the final image looks like.

From the research findings, it is evident that the entrepreneur should possess the required technical skills. If they do not, they should make use of external networks in order to assess the measures and systems of LFDP.

9.5.2 THE CRITICAL SUCCESS FACTORS IN SELECTING THE CORRECT LFDP BASED ON TECHNICAL TERMS

The identification of print anomalies proved to be a complex task and a number of different approaches were taken. Information gleaned from other sources on print anomalies proved to be rather vague, with general observations on colour accuracy and longevity (Cone, 2000). These did not fully describe each process and so a number of practical tests (see chapter 7), were conducted to provide more detailed information.

In order to deal only with the influence of the printer itself on print anomalies, the outside factors mentioned in chapter 7 were either eliminated or standardised. The initial test, which involved eleven different digital printing processes, revealed the following:

- The printer that had the least print anomalies was the piezo inkjet, followed by the Fuji Pictography, the colour laser, the continuous flow inkjet and the dye sublimation printers.

- All the other machines, the colour copier, the large format electrostatic, the phase-change inkjet, the thermal inkjet, the thermal wax and the aerosol airbrush inkjet had numerous print anomalies.

- Certain printing techniques are not suitable for fine art applications. The airbrush inkjet and the large format electrostatic printers produced poor results, this was confirmed by individuals in the industry (Franco, 2000).

As is described in chapter 7, there are numerous factors that influence the result of the digital printing process. Some of these factors are within the control of the graphic artist and others not. Certainly when working with a bureau, the graphic artist must assume those factors such as colour management, printer calibration and profiles are standardised and controlled. In retrospect, it was naïve to assume that all the printers are correctly calibrated and running at their optimum at all times. The instance of the dye sublimation printer printing a section out of register is an example of a machine not operating at its optimum.

Unfortunately not all operators are well trained or very knowledgeable about fine art digital printing. As was illustrated in chapter 7, print operators are sometimes unskilled and may need to make a number of prints before getting the colour balance right. In terms of profitability, they may not be allowed to print too many tests and so the client may be given a substandard print.

There is no significant difference between how commercial clients or graphic fine artists might use digital prints, in the sense that prints are generally used for promotion and display. They do from that point on, differ substantially in terms of what an artist is attempting to do with their prints. Some graphic artists are responsible for taking the printing processes much further than commercial users and printer manufacturers envisage. Commercial client's budgets will allow them to print enormous prints onto any substrate and allow them to cover the windows and floors of buildings.

One significant difference between the requirements of the graphic artists and the commercial client is how long they expect images to last. In general, artists expect prints to last for at least as long as colour photographs from negatives, approximately 12 – 15 years (Wilhelm & Meehan, 1999). The debate about image permanence is a difficult and heated one; fortunately many curators are more interested in the quality of the artwork, than the permanence of the print (Lippert, 2000). As is pointed out in chapter 8, very few up-to-date accredited tests exist for assessing the longevity of digital prints. Different organisations use varying criteria and many are unwilling to release their findings, as the tests are often initiated and paid for by printer, ink and substrate manufacturers. In spite of some criticism, the Wilhelm Imaging Research unit does at least make their updated results of their tests available on the Internet (Wilhelm, 1999).

From the information in this chapter the tests made, show how original artwork can be matched to its digital print facsimile. Here, one obviously accepts that in some cases the digital print is the original artwork, in the sense that the image was created on-screen and then printed. However, this research did not set out to look at the creative potential of the digital print but rather at the technical quality of the digital print and its relationship to an original artwork, be it an oil painting or an image created with computer software.

It should also be remembered that the success of the digital print from a graphic artist's point of view, must also take into consideration such influencing factors as the intended application of the final print (e.g. how does the graphic artist want to employ a particular digital print), its susceptibility to change over a particular period of time (i.e. longevity issues), and cost factors.

In terms of applications, with the correct ink and substrate combinations, most types of inkjet printers will deliver a print that will last for at least five years in normal viewing conditions (Wilhelm, 1999, 2000). The laser printer and colour copier prints last indefinitely and so they too can be used to print artwork for sale and exhibition. Any photographic material if processed correctly will last for a minimum of 12 years (Wilhelm, 1998) and so they too are well suited to this application.

When matching artwork to digital print, the following aspects were identified:

- The phase-change inkjet printer proved to be very good at mimicking the layered and textural qualities of the original painting, (see Figure C.6). It is also ideal for rendering bright, vibrant colours, printing fine text and as it can print onto both sides of the substrate, it is well suited to printing promotional material.

- Amongst the other inkjet printers, the piezo inkjet can print reasonable reproductions of oil paintings on paper. This process produces a good tonal range and very little visible dot pattern. The oil painting (see Figure 9.1) was printed in (see Figure C.3) on the piezo inkjet printer. This process can only be considered the best overall as indicated in Table C.1.

- From the test on the continuous flow inkjet it certainly proved itself to be one of the more accurate digital printing processes available to the graphic artist. It has the ability to reproduce a black and white image, (see Figure C.4) which is characterised by both fine line and areas of subtle tonality. The Iris continuous flow inkjets are well established as proofing devices, as they give a smooth tonal range, good colour accuracy and capture areas of very fine detail. This process also lends itself to the reproduction of printed artworks for sale and exhibition. Sizes are limited (55 x 76 cm), but with the wide range of substrates and the fact that good longevity characteristics can be achieved, it is one of the most successful fine art digital mediums. It seems ideal for reproducing computer-based images, photographic images (black and white and colour), lithographs, etchings, platinum and palladium prints, drawings, computer-based images, watercolours and oil paintings.

- Out of the other photographic processes, the Fuji Pictography's potential to print final artwork is slightly limited by the small sizes (31 x 46 cm) that can be printed but it reproduces photographic images very will. This is possibly not fully illustrated by the print made from Figure in that the print operator struggled to make colour corrections for this image. The Fuji Pictography prints can be used very effectively for promotional purposes.

Once again, the entrepreneur should use the proposed decision-making model (see Figure C.3) to identify critical success factors in selecting the LFDP. If the entrepreneur is uncertain, they should ask for assistance from their technical staff to see if the LFDP they wish to purchase will firstly, perform the job, secondly, allow them to attack an opportunity and finally, ensure that the firm will gain profitably from the machine. The model assists the entrepreneur to address issues such as importance, timing, for example, before making the purchase.

9.5.3 THE ENTREPRENEURIAL FACTORS THAT INHIBIT PERFORMANCE

(IN TERMS OF DECISION-MAKING) AT INDIVIDUAL, GROUP AND ORGANISATIONAL LEVELS RELATING TO LFDP BUSINESSES

The aim of Chapter 2 was to provide a framework on which to base the study of entrepreneurship in technology type enterprises. The chapter discussed the nature of entrepreneurship and a definition of entrepreneurship. For the purposes of the study, the definition of entrepreneurship suggested was that to view entrepreneurship as an innovative economic organisation (or network of organisations) for the purpose of gain or growth under conditions of risk and uncertainty. The important finding from the chapter was the recognition of entrepreneurship's dual role in economic development and job creation.

Entrepreneurship and growth was discussed in Chapter 3 in the study. The focus of the chapter was the identification of the entrepreneurial manager and how they manage growth. Various models of growth discussed in the chapter were namely Churchill and Lewis lifecycle growth model and Greiner's stage growth model. The main findings from the literature for the study were firstly, the use of growth models to discuss the progression of entrepreneurship. Secondly, the importance identifying entrepreneurial owners/managers is paramount to identifying those enterprises, which have growth potential from those who are in existence for substance reasons.

Chapter 4 discussed the role of entrepreneurship on an international level. Entrepreneurship and its features in terms of entrepreneurial activity in advanced economies such as the US and Japan for example, were discussed to offer a different perspective. A discussion of economies in transition such as Eastern Europe followed and features of such economies include for example, high levels of uncertainty, a lack of formal financial infrastructure an inadequate regulation. Kenya and India were used as examples of an emerging economy in which the small firm has always been a part of the economy although it lacked formality at the highest levels. The main contribution of the chapter was the fact that although levels of entrepreneurial activity or culture varied in the different economies, entrepreneurship is fundamental to the development of the economies.

Technological forecasting for decision-making was discussed in Chapter 5. Decision-making is central to managing any type of organisation and with respect to technology type organisation; technological forecasting is an important tool. The chapter presented a number of areas in which technological forecasting can assist the entrepreneur. The principles underlying technological forecasting and the main inputs into the system including past information, present knowledge and human intellect were discussed to provide further insight of technology forecasting as a decision-making aid. The proposed model could be used to ask the entrepreneur questions that will assist them to make decisions that do not hinder their growth potential.

9.5.4 HOW TO OVERCOME FACTORS AND TO FACILITATE BETTER PERFORMANCE

It is proposed that the entrepreneur makes use of the decision-making framework identified in Chapter 7 (see Figure 7.14) in order to overcome barriers in the purchase decision-making process. The framework address both entrepreneurial and technical aspects, which the entrepreneur should be in a position to find solutions to. The framework is discussed in Chapter 7 (see sections 11.3.1 - 11.3.8) as to how it can facilitate the entrepreneur’s decision-making process. What emanates from the study is that the entrepreneur should be in a position to make decisions that will allow him to grow his establishment.

9.5.5 FURTHER RESEARCH

While researching this topic, a number of aspects that have potential for future investigation were identified.

Firstly, how these printers can add to the creative process, or any aesthetic analysis of the test results, does not fall within the delimitations of this research. However the fact that the digital printer is becoming a more common tool in the creative process cannot be denied. The type of impact this will have on the creative process and the aesthetic qualities of the imagery could provide material for future investigations.

Within this research, the tests were conducted within specific parameters, for example, no particular brand of printer was tested. Printer types, irrespective of the manufacturer, were considered to be the same. There is certainly a need to do a comparative study of brands of printers that are suitable for images and applications. This study could be further refined into testing the smaller printers that clients could purchase, and those that bureaux purchase.

The tests conducted in this chapter were printed on commonly available substrates, in most cases onto paper. With the enormous range of substrates available and the potential of some printers (inkjet printers and laser printers) to print onto unconventional substrates, this too could provide an area to research both technical and aesthetic issues.

Another possible area of investigation is the effect of printing fine art images from different software programs. Testing how images print from a variety of applications, in different modes and with different forms of colour management, has potential for future research projects.

Empirically testing the proposed decision-making model presented in Chapter 7 (see Figure 7.3).

9.6 DISCUSSION

Manufacturers may phase out some printers such as the thermal wax printer, the aerosol inkjet and the large format electrostatic printer, in the future. Although many graphic artists are involved with producing work using the latest technology, there are also those that use old technology very creatively. Older digital printing processes may provide them with the opportunity to develop creative techniques, in the same way that modern photographers use processes such as gum bichromate and cyanotypes.

As most of the other printing processes are still being developed and improved on, it is reasonably safe to assume that they will be used commercially for many more years. Although digital printing processes will no doubt change in the future, this research, will certainly be relevant for some time to come.

Digital printing is a relatively new medium, some products have only been on the market for a few years. As is pointed out at the beginning of this document, new digital printing techniques are being introduced at a fast pace, as are new inks and substrates (Otsuki, 2000). This means that although printers were tested in the course of this research (1999/2000/2001), it is quite feasible that within a year or two, new untested printers will have appeared on the international market. Entrepreneurs wanting to use these new printing techniques could adapt the testing and evaluation methods described in this document to assess the new printers.

To sum up, certain types of digital printers already offer the entrepreneur excellent potential for printing their images. In order to use these printers effectively, the original image, the printer anomalies and the final applications of the print must be considered and matched. This document offers an approach to achieving this goal. As technology improves and new products are released, matching image to print will continue to challenge graphic artist, entrepreneurs and researchers alike.

GLOSSARY

Additive colour theory: White light is made up of equal parts of red, green and blue light. Additive primaries: These are red, green and blue.

Application: A software program that carries out a task, such as image manipulation or graphics programs.

Backlit: Any object that has the light shining from behind it towards the viewer. Bi-directional printing: A printer that prints from right to left, advances the substrate and the prints from left to right.

Bit: Binary Digit. The smallest unit of data a computer can process.

Bit map: An image or object that is broken up into individual pixels arranged in a grid pattern. Each pixel is represented by a number of bits of information dictating its position, colour etc.

Bit-mapped graphics: Graphic images that are made up of pixels. Also called raster graphics.

Brightness: The areas in a positive image that contain the least density.

Bureau (x- plural): Service centre where digital files can be played out. Calibration: A process of adjusting a piece of equipment to a known standard or to match another piece of equipment.

Capstan design: A system used in imagesetters to move the film through the machine during exposure.

Cathode-ray tube (CRT): The vacuum tube used in a TV or video terminal screen.

Charge-coupled devices (CCD): A micro-electronic light sensitive device, used in digital cameras, digital backs and some scanners.

CIE: (Commission Internationale de L'Eclairage) an international committee that creates standard colour models for representing colour.

CIELAB (or CIE L*a*b*, CIE Lab): Colour space in which values L*, a*, and b* are plotted at right angles to one another to form a three-dimensional co-ordinated system.

CMYK: Cyan, Magenta, Yellow and Black. The four subtractive colours and process colours used in four-colour printed reproduction.

Colorimeter: An optical measuring instrument that responds to the RGB quantities of light reflected by objects.

ColorSync: Colour management architecture for Apple Macintosh computers. Third-party vendors utilise the ColorSync framework to provide device calibration, device characterisation, and device profile-building methods.

Colour balance: The overall colour of a print, which depends on the relative strengths of the three primary or secondary colours.

Colour gamut: The range of colours that can be reproduced using a certain process.

Colour management system: A software system used to ensure colour consistency among the different input and output devices so that printed results match originals.

Colour model: A method of representing colour information as numeric data.

Colour space: A three-dimensional geometric representation that can be used to depict the colour gamut of a device, human visual perception, etc.

Compact disc (CD): A standard medium for storage of digital data in machine-readable form, accessible with a laser-based reader.

Compact disc read only memory (CD-ROM): A data storage system using CDs as the medium.

Compression: A software or hardware process that reduces the size of digital files so that they occupy less space.

Contact print: A photographic print made by placing the original in contact with the sensitive material and exposing it to light.

Continuous tone: An image that has not been screened and contains gradient tones from highlight to shadow.

Contrast: The tonal difference between the darkest and lightest part of an image.

Cromalin: A proofing process that uses the four half tone colour separations to create a full colour image. CMYK powders are used to create the image.

Cyanotype: A printing process that is often referred to as the blueprint, or Prussian blue process.

Dedicated device: A piece of hardware that is permanently assigned to one task. Dedicated system: A system that only does one task.

Densitometer: A photoelectric instrument that measures the density of photographic images or the density of printed inks. There are transmission and reflection densitometers.

Density: A measure of the relative difference between a white area and a toned or black area, or the ability of a material to absorb light.

Device profile: A file, used with a colour management system, that describes the colour characteristics of a properly calibrated input or output device.

Device: Any piece of equipment that is plugged into a computer, such as a scanner, printer or camera.

Device-dependant: Describes a colour space that can be defined only by using information on the colour-rendering capabilities of a specific device.

Device-independent: Describes a colour space that can be defined using the full gamut of human vision, as defined by a standard observer, independent of the colour-rendering capabilities of any: specific device.

Digital: The use of binary code to record information. Text would be recorded in a code like ASCII and scanned images in bitmapped form.

Digitise: To convert an image or signal into binary code.

Dithering: Converting tones to an arrangement of dots.

Dot gain: An increase in the size of halftone or stochastic dots that can be caused by a number of factors, such as the absorption of ink into the substrate.

Dot: The individual element of a halftone. They can be several shapes including round, square or elliptical.

Dpi: Dots Per Inch. A measurement of output device resolution and quality.

Drum scanner: A scanner in which the original wraps around an internal or external drum.

Dynamic range: A scanner or digital camera's ability to capture an image's brightness range from the highlights to the shadows.

Effective resolution: The resolution of a scan, which may be created by a combination of sampled points and pixels created by interpolation. In this way, the effective resolution of a scan may be greater than the optical resolution of the scanner that captured it.

Electron gun: The device in the CRT that produces the electron beam that activates the phosphors, causing them to emit red, green and blue light.

Electrophotographic printing: The technology used in copy machines, laser printers and large-scale electrostatic devices. Elements within the machine are charged which causes toner to either be attracted or repelled by a charged substrate.

Electrostatic printing: Printing process that uses a special paper that is charged by an electron beam, toner is applied which sticks to the charged areas. Encapsulated Postscript (EPS): An image description format. EPS files are generally used for graphics and text.

File format: The structure or arrangement of data stored in a file.

File: A document or application that has been given a name.

Flat bed: A flat bed optical input or output device (scanner or plotter) transfers images by means of a flat plane rather than a revolving cylinder.

Flexography: A relief printing process that makes use of halftone negatives.

Four-colour process: A method of printing colours by using tints of cyan, magenta, yellow and black (CMYK).

Gamma: The relationship between the tone values in an image file to the tone values produced by an output device.

Gamut compression: The colour space co-ordinates of a colour space with a larger gamut are reduced to accommodate the smaller gamut of a destination colour space.

Gamut mapping: Converting the co-ordinates of the two more colour spaces into a common colour space. Often results in tonal range compression.

Giclée: The term initially used to describe Iris fine art digital prints, from the French "gicler" - to spray. The term is now used to describe any fine art digital print using the continuous flow inkjet printing system.

Graphics: Graphics are basically pictures and drawings, either created by computer or entered into the computer by scanning or photographing.

Gravure: An intaglio printing process, mainly used in roll-fed web printing presses.

Grey scale: A range of tones of grey between pure white and solid black.

Halftone:When an image is broken up into a number of dots that represent the densities of the original. The dots give an illusion of continuous tone.

Hard copy: A printed copy of output in readable form.

HexaChrome: A [sic] colour printing process introduced by Pantone. Green and orange plates are added to the standard CMYK plates.

Hi-Fi colour printing: A colour printing method that uses more than the four colours to attain a wider colour gamut.

High resolution: Any image that is displayed in better quality by increasing the number of dots, or pixels, per inch than normal.

Highlight: The lightest or areas in an image. .

Hue: The name of a pure colour.

ICC: International Colour Consortium: The ICC consists of a group of companies, its purpose is to create, promote, and encourage an open, vendor-neutral, cross-platform, colour management system architecture and components.

Image processing: Digitised images can be manipulated using image-processing software.

Image processor: Device that takes input data and changes it into the proper formats for imaging devices such as for printing or display.

Image resolution: The fineness or coarseness of an image as it was digitised - measured as dots-per-inch (DPI).

Image: The computerised representation of a picture or graphic.

Input resolution: The number of samples that can be taken per unit of length when digitising an image.

Interactive: When the computer and the user can communicate, if this happens instantaneously, it is considered to take place in real time.

Internet: The name for a world-wide TCP/IP-based networked computing community with millions of users world-wide.

Interpolate: To estimate values between two known values; for example, to assign an intermediate colour to a pixel based on the colours of the pixels around it, thereby increasing effective resolution.

Ion deposition: A printing system that makes use of cold pressure fusing and so cannot be used for colour printing. It is used mostly for printing high volumes of small documents.

L*A*B*: A system for describing, measuring, and controlling colour, using hue, luminance, and brightness established by the CIE. (See CIELAB)

Laser: The acronym for light amplification by stimulated emission by radiation. The laser is an intense light beam with a very specific bandwidth.

LCD: Liquid crystal display. An electronic component containing a tiny quantity of liquid that crystallises (turns black) when a small electrical current passes through it and returns to a liquid state when the current is switched off.

Light emitting diode (LED): A solid state device that radiates light at a single frequency.

Lithographic: A planographic printing process that uses ink receptive and water receptive areas, to control what will and will not be printed.

Lpi: (lines per inch) A measure of the resolution of a halftone screen (usually between 55 and 200), referring to the frequency of the horizontal and vertical lines of dots.

Magnetographic: Printing process similar to electrophotographic except that it uses magnetic fields as opposed to electrical charges. It is not suitable for colour printing.

Maximum density: The measurement of the darkest area on film.

MHz: Megahertz

Minimum density: The measurement of the clearest area of an image on film

Monitor: Another term for a display screen.

Nanometer (nm): Unit of length equals to $10-^{9}$ meter, or one millionth of a millimetre, wavelengths are measured in nanometers.

Negative: In photography, film containing an image in which values of the original are reversed. In lithography, a film containing type or halftones, in which the values are reversed, whites are black and blacks.

Offset lithography: See lithography.

Optical scanner: Input device that translates images to bitmapped or raster machine-readable data.

Optical storage: The means of storing or archiving data on optical discs such as CDs or laser discs.

Output device: Any device by which computer-based information can be read by humans.

Output resolution: Stated in lines per inch or lines per millimetre, output resolution reflects the number of pixels per unit size the printer can put onto the film.

Output: Information that has been manipulated by the computer, and displayed either on the video monitor or rendered on paper or film as hard copy, or saved on disk in a digital format.

pH: Degree of acidity or alkalinity measured on a scale from 0-14, with 7 being the neutral point.

Phosphor:Substance that glows when struck by electrons.

Photomultiplier (PM): A photo cathode having extremely high stability and capable of reading low level light measurements in the entire part of the visible spectrum.

PICT: A common format for bitmapped or object-oriented images.

Pigment: An insoluble colorant, as opposed to a dye, which soluble.

Pixel: An acronym for picture element. The smallest element that can be recorded edited and output by a digital imaging system.

Positive: In photography and lithography, a film or print containing an image in which the light and dark values are the same as the original.

Postscript: A page definition language (PDL) developed by Adobe Systems. When a page of text and/or graphics is saved as a PostScript file, the page is stored as a set of instructions specifying the measurements, typefaces, and graphic shapes that make up the page.

Ppi: (pixels per inch) A measure of the resolution of scanned images.

Ppm: Pages per minute.

Prepress: The preparation work required to turn artwork into the printing plates needed for mass production.

Primary colours: Additive primaries are red, blue and green. The subtractive primaries are cyan, magenta and yellow.

Print on-demand (POD): A process of printing documents electronically when (and where) needed, rather than: printing stock ahead and storing it in advance of need.

Process colours: In printing, the subtractive primary process ink colours are cyan, magenta, yellow plus black.

Raster image (RIP): A device that translates the processor instructions for a page in a page-description or graphic output language to the actual pattern of dots supplied to a printing or display system.

Rasterization: Translation of a vector-based image to a pixel-based image. RC paper: Resin-coated photographic paper.

Register: In printing and image assembly, the fitting of two or more images on the same exact spot.

Resolution: The measure of fineness and detail in an electronic image.

Retouching: The correction or deliberate manipulation of colour, tone or detail in an original or the scan of an original.

RGB colour model: A colour model used for devices, such as scanners and computer monitors, using the additive primary colours red, green and blue.

RGB: Red, Green, and Blue. The primary colours called 'additive' colours.

Sample: In scanning, to measure a single point on the original to create a value for a pixel in a larger bitmap. A sampled file is created from thousands of individual samples.

Saturation: A measure of the purity of a colour, determined by the amount of grey it contains.

Scan: To convert human-readable images into bit-mapped or ASCII machine-readable code.

Scanner: A device used to digitise images to be manipulated, output, or stored in a computer system.

Screen printing: Printing process which makes use of an image placed onto a fine screen, inks can either print through the screen or are blocked by the image.

Screen ruling: The number of lines or dots per inch in both directions on a contact screen to make halftones or separations. Screen rulings are available from 55 lines per inch to 200 lines per inch.

Shadows: The darkest (black and near black) colours or levels of grey in an image.

Sharpen: The process of increasing the contrast at specific points in a photographic image, where lighter and darker areas touch.

Soft proof: A proof that is seen on a colour monitor.

Spectrophotometer: An instrument that measures the characteristics of light reflected from or transmitted through an object.

Spi: Samples per inch. A measure of the optical resolution of a scan or scanner.

Substrate: The material on which a pigment or ink is laid down.

TIFF: Tag image file format. A document format developed by Aldus, Microsoft and leading scanner vendors as a standard for bitmapped graphics, including scanned images.

Toner: A dry ink powder that has been electrically charged.

Transparency: A film-based positive image that is viewed and reproduced through transmitted light.

Unsharp mask: A sharpening filter that first blurs the image around the edges of the component shapes and then subtracts the blurred values from the image. The net effect is to sharpen the definition of the image's components.

Value: A measure of the lightness or darkness of a hue. The less white in a colour, the greater its value.

Vector: A line segment of a specified length and direction.

Vector: Images defined by sets of straight lines, defined by the locations of the end points.

Vectorization: Translation of a pixel-based image to a vector-based image.

World Wide Web (WWW): The graphical portion of the Internet.

ZIP Drive: A disk drive designed and marketed by Iomega that stores 100MB of information

REFERENCES

ADOBE SYSTEMS INCORPORATED. 1998. **Adobe Photostat 5.0 User Guide.** Edinburgh: Adobe Systems Incorporated

AGFA-GEVAERT. 1994. **An introduction to digital scanning**. Morstel: Agfa-Gevaert N.V.

AGFA-GEVAERT. 1995. **A guide to color separation. (3rd ed.)** Los Angeles: Miles Inc. and Agfa-Gevaert N.V.

AGFA-GEVAERT. (1996). **A guide to digital photography**. NDXM5 GB00 199606. Morstel, Belgium: Agfa-Gevaert N.V.

ALLIE, F. and HIMAN, L. 1998. 'Entrepreneurship in South Africa." In Morrison, A, (ed.) **Entrepreneurship: An International Perspective.** Woburn: Butterworth-Heinemann.

ANDERSON, D. 1998. **Inkjet printers:The PC Technology Guide** [Online]. Available: http://www.pctechguide/13inkjets.htm. [accessed 19/03/1999]

AXELROD, R. 1981. 'The emergence of cooperation among egoists,' **American Review of Political Science, 75**: 306-18.

BABBIE, E. 1992. **The practice of social research** (6th ed). Carlifonia: Wadsworth Publishing Co.

BARBER, J., METCALFE, S AND PORTEOUS, M. 1998. "Barriers to growth: the ACARD study", in Barber, J., Metcalfe, s. and Porteous, M. (eds) **Barriers to Growth in Small Firms.** London: Routledge.

BARKHAM, R., GUNGIN, G., HANVEY, E and HART, M. 1996. **The Determinants of Small Firms Growth**. London: Jessica Kingsley.

BATE, C. (Ed). 1999. **1999 Digital imaging and publishing creative resource directory.** Johannesburg: Digital Imaging and Publishing Graphix Publications (PTY) Ltd.

BATSTONE, S. 1998. **SME Policy in Slovkia: The Role of Bi-Lateral and Multi-Lateral Aid** paper presented to a Conference on Enterprise in the Transition Economies, Wolverhampton, September.

BATSTONE, S. and PHEBY, J. 1996. "Entrepreneurship and decision making: the contribution of G.L.S. Shackle" **International Journal of Entrepreneurial Behaviour & Research, 2**(2): 34-51.

BATY, G.B. 1974. **Entrepreneurship: Playing to Win.** Reston: Reston Publishing.

BAUMOL, W. 1968. "Entrepreneurship in economic theory," **American Economic Review, Papers and Proceedings, 58**(2): 64 – 71.

BERG, R. 1997. "Colour quick printing: a new opportunity for photo labs," **Photolabs Management,** 38-39

BIRCH, J.G. 1986. **Entrepreneurship.** New York: Wiley.

BOULTER, S. and INGRAHAM, J. 1999. **Understanding digital prints: Dye vs. pigment inks.** [Online]. Available: http://www.digitalfineart.com/articles/summer1999/dyesvspigment.pdf [accessed 02/10/2001]

BRIGHT, J.R (ed). 1968. **Technological Forecasting for Industry and Government: Methods and applications.** Englewood Cliffs: Prentice-Hall.

BROWN, M. 1998. **The giclee revolution.** [On-line]. Available: http://www.digitalfineart.com/articles/summer1999/ [accessed 02/10/1999]

BROWN, R. 1997. "The business of colour," **Photolab Management,** 38-39.

BROWNING, B.L. 1997. **Analysis of paper (2nd ed.)**. New York: Marcel Dekker, INC.

BRUNO, M. 1993. “Digital Printing” in Zakia, R. and Stroebel, L. (eds) **Focal Encyclopedia of Photography**. Great Britain: Butterworth-Heineman.

BRUNO, A.V., LEIDECKER, J. K. and HARDER, J.W. 1987. “Practice of Business / Why Firms Fail,” **Business Horizon March - April 1987**: 50-58.

BURCHELL B. AND WILKINSON F. 1997. “Trust, business relationships and the contract environment” **Cambridge Journal of Economics, 21**(2): 217-237.

BURKHOLDER, D. 1999. **Making digital negatives for contact printing [2nd ed.].** Carrolton: Bladed Iris Press.

BURNS, P. and HARRISON, J. 1996. “Growth” in Burns, P. and Dewhurst, J. (eds) **Small Business and Entrepreneurship**. London: Macmillan.

CANNON-BROOKES. 1983. “Impermanence: A curator’s viewpoint.” **Leonardo, 16**(1): 34 – 35.

CARLISLE, B. and GOTLIEB, A. 1995. **Problems, Training and Consultancy Needs in SMEs in Russia –An Exploratory Study** paper presented to the 18th ISBA Small Firms National Conference, Paisley, November.

CARTON et. al. 1998. **“The entrepreneur and entrepreneurship: Operational definitions of their role in Society”** The University of Georgia Terry College of Business Paper presented to the ICSB, Singapore Conference.

CASSON, M. 1990. **Enterprise and Competitiveness.** Oxford: Clarendon Press.

CETRON, M. J. 1969. **Technological Forecasting: A practical Approach**. London: Gordon and Breach

CHMELEWSKI, K, GOGGIN, N. and SQUIRE, J. 1995. “Art as signal: Inside the loop.” **Leonardo, 28**(2), 85 – 92.

COLORSPAN. 1999. **Display Maker Series XII**. Eden Prairie: Colorspan.

CONE, J. 2000. Personal Communication, 26 April

COSTELLO, N. 1996. "Learning and routines in High-Tech SMEs: Analysing Rich Case Study Material" **Journal of Economic Issues, 30**(2): 591-597.

CRESSY, R. 1996. "Are Business and Start-ups Debt Rationed?" **The economic Journal, 106**(438): 1253-1270.

CRESSY, R. 1996. **Small Business Failure: Failure to Fund Or Failure to Learn** paper presented to the ESRC Network of Industrial Economists, meeting on Entrepreneurship and Small Business, University of Durham, December.

CULKIN, N. and SMITH, D. 2000. "An emotional business: a guide to understanding the motivations of small business decision takers" **Qualitatitive Market Research: An International Journal, 3**(3): 145-157.

CURRAN, J. and BLACKBURN, R. 1993. **Local Economic Networks: The death of the Local Economy.** London: Routledge.

DAS, K. 1998. "Collective Dynamism and Firm strategy: a study of an Indian industrial cluster" **Entrepreneurship and regional, 10**(1): 33-50.

DAVIDSON, T. (Ed.) 1999. "Downtown where the lights are much brighter…" **Outdoor Graphics**, **1 – 2**. Johannesburg, South Africa: Outdoor Advertising Association of S.A.

DAVIES, S.E. 1993. "Large-scale photo output: a new contender" **Step-by-step graphics, 9**(5): 45-46.

DAWES, P.L., PATTERSON, P.G. and MIDGLEY, D.F. 1997. "Involvement of technical consultants in high technology business markets" **Journal of Business & Industrial Marketing, 12**(2): 83-102.

DEAKINS, D and HUSSAIN, G. 1994. "Financial Information, the Banker and Small Business: A Comment" **British Accounting Review, 26**: 24-31.

DEAKINS, D., MILEHAM, P. and O'NEILL, E. 1999. **Insiders v Outsiders: Director Relationship in Small Companies.** Paper presented at 22nd ISBA Conference, Leeds November. 395 – 413.

DEWHURST, J. 1996. "The Entrepreneur", in Burns, P. and Dewhurst, J. (eds). **Small Business and Entrepreneurship.** London: Macmillan.

DICOSOLA, M. 1998. An approach to color management. **The Big Picture, 3**(6):70 – 76.

DONDO, A. and NGUMO, M. 1998). "Entrepreneurship in Kenya" in Morrision, A. (ed). **Entrepreneurship: An International Perspective.** Woburn: Butterworth-Heinemann.

DRUCKER, P. F. 1970. **Technology, Management, and Society.** London: Heinemann

EASTMAN KODAK 1997. **Kodak Digital Science™8650 printers [Brochure].** United Kingdom: Eastman Kodak Company.

EASTMAN KODAK. 1998. **Kodak Professional 8670 PS thermal printers No. CLO7151, 7/98 [Brochure].** United Kingdom: Eastman Kodak Company.

EASTMAN KODAK. 1999. Inkjet printers [On-line]. Available: http://www.kodak.com/us/en/digital/dic/book2/chapter2/inkjet.shtml [accessed 02/03/1999]

EASTMAN KODAK. 1999. **Solid ink printers** [On-line]. Available: http://www.kodak.com/us/en/digital/dic/book2/chapter2/solidink.shtml [accessed 02/03/1999]

EASTMAN KODAK. 1999. **Thermal wax printers** [On-line]. Available: http://www.kodak.com/us/en/digital/dic/book2/chapter2/thermalwax.shtml [accessed 02/03/1999]

EASTMAN KODAK. 1999. **Dye-sublimation printers** [On-line]. Available: http://www.kodak.com/us/en/digital/dic/book2/chapter2/dyesub.shtml [accessed 02/03/1999]

EDLUND, P. 1996. Mounting and laminating: Part 2: On your mark. **Photo Lab Management.** March: 50 – 52

EDLUND, P. 1996. Mounting and laminating: Part 1: Keep it simple; keep it profitable. **Photo Lab Management.** February: 82 – 85

EGGERS, R. 1996. Wide format trend. **Photo Lab Management.** March: 35 – 42.

ENCAD, 2000. [On-line]. Available: http://www.encad.com/

FOX, W. and MAAS, G.J.P. 1997. **Entrepreneurship and public management**. Kenwyn: Juta

FRANCO, R. 2000. Personal Communication, 9 May

FREEL, M. 1998. "Evolution, innovation and learning: evidence from case studies" **Entrepreneurship and Regional Development, 10**(2): 137-149.

FUJIFILM. 1996. **Digital color printer Pictrography 4000 No. EB-613ER** (SK.97.05.TZ.MW) [Brochure). Japan: Fuji Photo Film.

GALLAGHER, C. and MILLER, P. 1991. "New Fast Growing Companies Create Jobs" **Long Range Planning, 24**(1): 96 – 101.

GALLAGHER, C. and ROBSON, G. 1996. **The Identification of high Growth SMEs** paper presented to the 19th National Small Firms Policy and Research Conference Birmingham.

GALLAGHER, C. and STEWART, H. 1985. "Business Death and Firms Size in the UK" **International Small Business Journal, 4**(1): 42 – 57.

GERBER SCIENTIFIC PRODUCTS. 2000. **Homepage.** [On-line]. Available: http://www.gerberscientific.com/

GERBER SCIENTIFIC PRODUCTS. 2000. **Wide-Format Inkjet Printers – Simple answer to basic questions.** [On-line]. Available: http://www.signweb.com.digital/cont/inkjetques.html

GIERCZYCKI, L. 1998 **"Power and Entrepreneurial Management: c** " Graduate School of Business, Curtin University of Technology Paper presented to the ICSB, Singapore Conference.

GLAS, M. 1998. “Entrepreneurship in Slovenia” in Morrison, A. (ed.) **Entrepreneurship: An International Perspective.** Woburn: Butterworth-Heinemann.

GORDON-GRAHAM, R. 2000. Personal Communication, 1 February

GREEN, P. 1997. “Rolling your own,” **British Journal of Photography,** 12-13

GROTH, D. 1998 **Printing Terms Dictionary.** Universal Printing and Publishing, Inc. [online]. Available: http://www.uniprint.com/terms.htm [Cited October 25, 1999]

HALL, R.H. 1987. **Organizations: Structures, Processes, and Outcomes,** 4th edition, Englewood Cliffs: Prentice-Hall.

HALL, G. 1995. **Surviving and Prospering in the Small Firm Sector.** London: Routledge.

HELLRIEGEL, D. and SLOCUM, J.W. 1996. **Management.** Cincinnati: South-Western College Publishing

HERACLEOUS, L.T. 1994. “Rational Decision Making: Myth or Reality?” **Management Development Review, 7**(4): 16-23.

HEWLETT PACKARD. 2000. Hewlett Packard Home page. [On-line]. Available: http://www.hp.com/designjet/

HILLS, G.E. 1985. “Marketing Analysis in the Business Plan: Venture Capitalist’s Perception’s,” **Journal of Small Business Management**: 38 – 46.

IRGA (International Reprographics Association). 1998. **The digital color graphics certification program. Training and reference guide.** Chicago: IRGA

IT STRATEGIES. 1999. “Is the future of large format huge?: **Digital Output, 5**(7): 16 – 19.

JENSEN, J.B. and McGUCKIN, R.H. 1997. “Firm Performance and Evolution: Empirical Regularities in the US Micodata” **Industrial and Corporate Change, 6**(1): 25-47.

Johannesburg South Africa: Digital Imaging and Publishing Graphix Publications (PTY) Ltd.

JONES, G. 1999. “Digital Imaging – It is the clean alternative.” 1999 DIMA annual conference, Las Vegas, NV. Jackson, MI: DIMA.

JORDAAN, T. 1997. **Dye sublimation**. Johannesburg: X.E.S.S.A.

JORDAAN, T. 1997. **Colorgrapx customer business guideline Xerox**. Johannesburg: X.E.S.S.A.

JORDAAN, T. 2000. Personal Communication, 19 April

JOVANOVIC, B. 1982. “Selection and the Evolution of Industry’s” **Econometrica, 50**(3): 649-670.

KARNEY, J. and STONE, M.D. 1998. Network Printers. **PC Magazine SA, 6**(5):46 – 47.

KASHYAP, S.P. 1988. “Growth of small-scale enterprises in India: its nature and content” **World Development, 16:** 667-681.

KIRK, D. 1998. “Entrepreneurial context and behaviour in SMEs: An investigation of two contrasting manufacturing firms” **International Journal of Entrepreneurial Behaviour & Research, 4**(2): 88-100.

KRAUSE, D.S. 1999. **Exploring lenticular prints.** [On-line]. Available: http://www.digitalfineart.com/articles/fall1999/lenticular.pdf [accessed 12/09/1999]

KUMAR, R. 1999. **Research Methodology: A Step-by-Step guide for Beginners.** London: Sage Publications.

LE, H.P. 1998. Progress and trends in ink-jet printing, Part 1. **Technology Journal of Imaging Science and Technology, 42**(1)

LESLIE, R. 1998. **An online interview with Therese Mulligan.** [On-line]. Available: http://www.asci.org/Digital98/interview.html [accessed 05/03/1999]

LEVITT, T. 1960. "Marketing Myopia," **Harvard Business Review (July – August 1960):** 45 – 56.

LOWE, A. 1996. **Hard copy. Exolart** [On-line]. Available: http://www.imaginet.fr/exolart/exolanglaise /presservices/specialities/journal/avril/adam-lowe.html [accessed 19/03/1999]

MACAULAY, S. 1963. "Non-contractual relations in business: a preliminary study" **American Sociological Review, 45**: 55-69.

MAIO, T. 2000. Personal Communication, 9 February

MALEK, M. 1999. **Explorations. Building the digital image.** [On-line]. Available: http://www.digitalfineart.com/articles/fall1999/newsfall.pdf [accessed 01/10/1999]

MALEK, M. 1999. **Understanding digital prints. Making the move to Digital Fine Art,** [On-line]. Available: http://www.digitalfineart.com/articles/fall1999/understanding.pdf [accessed 27/09/1999]

MOORE, L. 1999. **Spotlight: A second renaissance?** [On-line]. Available: http://www.digitalfineart,com/articles/fall1999/spotlight,pdf [accessed 02/10/1999]

MORTIMER, A. 1991. **Colour reproduction in the printing industry. Pira guide series.** Chippenham: Pira International.

MURRAY, G. 1994. "The Second 'Equity Gap': Exit Problems for seed and Early Stage Venture Capitalist and their Investee Companies**" International Small Business Journal, 12**(4): 58-76

MULLER, N. 2000. Personal Communication, 7 May

NICHOLSON, B. 1998. **Aston Reinvestment Trust** Paper presented to the ESRC Seminar Series, The Finance of Small Firms, University of Mibblesex, October.

NUR Hopepage. 2001. [On-line]. Available: http://www.nur.com [accessed 2000]

OAKEY, R. 1995. **High-Technology Small Firms: Variable Barriers to Growth.** London: Paul Chapman.

O'LEARY, S. 1998. "Color management systems in print-for-pay shops." **Big Picture, 3**(6): 77 – 83.

OSTUKI, J. 1996. **Large format inkjet printing. Presentation for Xerox South Africa.** Santa Clara: Capitol Color.

OSTUKI, J. 1996. **Operation of large format digital imaging center. Presentation for Xerox South Africa.** Santa Clara: Capitol Color.

OSTUKI, J. 1998. **Large format digital imaging. Presentation for Xerox South Africa.** Santa Clara: Capitol Color

OSTUKI, J. 2000. Personal Communication, 17 February

OZCAN, G. B. 1995. "Small Business Networks and Local Ties in Turkey" **Entrepreneurship and Regional Development, 7**(3): 265-82.

PIEKARA, J. 1999. **The status of standards for outdoor graphics.** Presented at, The Big Picture Conference, Orlando, FL.

PENROSE, E. 1959. **The Theory of the Growth of the Firm**. London: Blackwell.

PHASE ONE. 1996. **Phase One Photophase user guide (3rd ed.).** Denmark: Phase One A/S.

PREHODA, R. W. 1967. **Designing the Future: The Role of Technological Forecasting.** London: Chilton Books.

RAY, S. F. (1994). **Photographic imaging and electronic photography.** Oxford, Great Britain: Butterworth Heineman LTD.

REDGRAVE, L. 2000. **Your Money – Saving Guide To Large Format Digital Printing**. [On-line]. Available: http://www.Rolanddga.com/

REILLY, J.M and FREY, F.S. 1996. **Recommendations for the evaluation of digital images produced from photographic, microphotographic, and various paper formats.** Report

ROBERTS, K. and THOLEN, J. 1997. **Young Entrepreneurs in the York Market Economies**, paper presented to a conference on Enterprise in the Transition Economies, Wolverhampton, September.

ROLAND. 1998. **Hi-fi jet. Model FJ-50/FJ-40 RDG-519 '98 SEP. A-4 G-S [Brochure].** Japan: Roland

RONSTADT, R.C. 1984. **Entrepreneurship.** Dover: Lord Publishing.

SAKO, M. 1992. **Prices Quality and Trust: Inter – Firm Relations in Britain and Japan**, Cambridge: CUP.

SAUNDERS, M.N.K, LEWIS, P. and THORNHILL, A.1997. **Research Methods for Business Students.** London: Pitman Publishing

SCHMITZ, H. 1990. "Small Firms and Flexible Specialisation in Developing Countries" **Labour and Society, 15**: 257-85.

SCITEX, 1999. **Scitex on-line.** [On-line]. Available: http://www.scitex.com.htm [accessed 06/10/1999]

SCHOLLHAMMER, H. and KURILOFF, A.H. 1979. **Entrepreneurship and small Business Management.** New York: Wiley.

SCOTT, M. and BRUCE, R. 1987. " Five Stages of Growth in Small Business" **Long Range Planning, 20**(3): 45 – 52.

SCOTTISH ENTERPRISE. 1993. **The Business Birth Rate Enquiry**. Glasgow: Scottish Enterprise.

SCOTTISH ENTERPRISE. 1998. **The Cluster Approach.** Glasgow: Scottish Enterprise.

SMALLBONE, D. and NORTH, D. 1995. "Targeting Established SMEs: Does Their Age matter?" **International Small Business Journal, 13**(3): 47-64.

SMALLBONE, D., LEIGH, R. AND NORTH, D. 1995. "The Characteristics and Strategies of High Growth SMEs" **International Journal of Entrepreneurial Behaviour and Research, 1**(3): 44-62.

SOLOMON, K. 2000. Personal Communication, 11 February

SMOLEN, M. 1999. **The print making partnership. How artists and printmakers work together to turn artistic visions into reality**. [On-line]. Available: http://www.digitalfineart.com/articles/summer1999/partnerships.pdf [accessed 27/09/1999]

SOMERVILLE, H.1999. **Stochastic screening** [On-line]. Available: http://www.herzig.com/stochastic.htm [accessed 22/11/1999]

STEWART, B. 1984. **Signwork: a craftman's manual**. London: Granada

STREAK, R. 1999. Personal Communication, 11 November

STOREY, D. 1994. **Understanding the Small Business Sector.** London: Routledge

STOREY, D. AND JOHNSON, S. 1987. **Are Small Firms the Answer to Unemployment?** London: Employment Institute.

STOREY, D. AND SYKES, N. (1996) "Uncertainty, Innovation and Management", in Burns, P. and Dewhurst, J. (eds) **Small Business and Entrepreneurship**, London: Macmillan.

SUMMAINC Homepage. [On-line]. Available: http://www.summainc.com [accessed 2000]

TARTER, C.J. and HOY, W.K. 1998. "Toward a contingency theory of decision making" **Journal of Educational Administration, 36**(3): 212-228.

TEKTRONIX. The big 60. (1999, June). Digital Output, 5, (7), 22 – 33.

TEKTRONIX. 1998. **Phase 780 A3 color laser printer** No. 780DS-01EA [Brochure].
The man who new too much. (1998, June, July). Artbyte, 11, (2), 51 – 56

TEKTRONIX. 1997. **Phaser® 480 x color printer main features and specification** [On-line]. Available: http://www.tek.com/color_printers/products/msds/msdsp/480sp.htm [accessed 06/11/1998]

TEKTRONIX. 1997. **Phaser® 600 color printer main features and specifications** [On-line]. Available: http://www.tek.com/color_printers/products/msds/msdsp/600sp.htm [accessed 06/11/1998]

TEKTRONIX. 1997. **Materials safety data sheet** [On-line]. Available: http://www.tek.com/color_printers/products/msds/msdsp/300sp.htm [accessed 06/11/1998]

TEKTRONIX. 1997. **The Tektronix Phaser® 300 x color printer** [On-line]. Available: http://www.tek.com/color_printers/products/msds/msdsp/300fe.htm [accessed 06/11/1998]

TEKTRONIX. 1997. **Products.** [On-line]. Available: http://www.tek.com/home/products.html [accessed 06/11/1998]

THOMPSON, G. 1993. "Network Coordination" in Maidment, R. and Thompson, G. (eds) **Managing the United Kingdom**. London: Stage.

TIMMONS, J. 1994. **New Venture Creation, 4th ed**. New York: Irwin.

TIMMONS, J. 1999. **New venture creation: entrepreneurship in the 21st century.** London: McGraw-Hill

TURNER, S. 1990. **Which paper? A review of fine papers for artist, craft people and designers.** England: BAS Printers Limited.

VESPER, K. H. 1990. **New Venture Strategies**

VUTEK. 2000. Homepage [On-line]. Available: http://www.vutek.com/

VYAKARNAMS, S., JACOUBS, R. and HANDELBERG, J. 1996. **"Building amend Managing Relationships: The core competence of rapid growth business"** paper presented to the 19th National Small Firms Policy and Research Conference, Birmingham (unpublished, amended version).

WEINER, P., GROTTA. S. and GRATTA, D. 1994. **Digital imaging for visual artist**. London: McGraw-Hill

WELMAN, J.C. and KRUGER, S.J. 1999. **Research Methodology for the Business and Administration Sciences.** Johannesburg: International Thomson Publishing

WESTHEAD, P. 1995. "New Owner- Managed Business in Rural And Urban Areas in Great Britain: A Matched Pairs Comparison" **Regional Studies, 29**(4): 367 380.

WESTHEAD, P. and BIRLEY, S. 1995. "Employment Growth in New Independent Owner-management Firms in GB" **International Small Business Journal, 13**(3): 11-34.

WFDIC. 1998. **Above the ordinary** [On-line]. Available: http://www.wfidc.org/a/casel.htm [accessed 05/09/1999]

WHITE, I. 1998. **Lecture6. From screen to paper: calibrating and outputting the image.** [On-line]. Available: http://www.jcu.edu.au/adt/art_and_design/project/lecture6.htm [accessed 09/09/1998]

WILHELM, H. 1998. **Years of print display before noticeable fading occurs. IAFADP Technical Notes.** [On-line]. Available: http://www.iafadp.org/technical/index/html [accessed 05/03/1999]

WILHELM, H. 1999. **Indoor image permanence: Archival dye-based inks.** Presented at, The Big Picture Conference, Orlando, FL.

XEROX. 1998. **Xerox Xpress large format piezo inkjet printers.** United Kingdom: Xerox Corporation.

XEROX. 1998. **Xerox Colorgrax systems electrostatic color printing: Xerox 8900 series colour printers.** United Kingdom: Xerox Corporation.

XEROX. 1999. **Xerox the document company**. [On-line]. Available: http://www.xerox.com.html [accessed 04/11/1999]

X-RITE. 1996. **The color guide and glossary. Communication, measurement, and control for digital imaging and graphics arts.** Sunnyvale: Visual Edge Technology.

ZAKIA, R. and STROEBEL, L.(eds.). 1993 **The Focal Encyclopaedia of Photography** (3rd ed.). Oxford, Great Britain: Butterworth - Heineman.

ANNEXURE A

LARGE FORMAT DIGITAL PRINTERS

A.1 BACKGROUND TO COMPANIES

A.1.1 VUTEk Inc

Founded in 1988, American manufacturer VUTEk Inc. supplies large format digital printers to the graphic arts market. VUTEk uses an innovative piezo-electric printing process. VUTEk’s product range includes the UltraVu super-wide format ink-jet printers in 2 metre, 3 metre and 5 metre sizes, available with or without RIP. Based in Meredith, New Hampshire, VUTEk Inc. distributes its products in 55 countries worldwide (Vutek, 2000).

A.1.2 Encad

ENCAD introduced their first large-format colour inkjet printer, the NovaJet, back in 1991.
Encad offers a package deal, of printers, inks, media, software, and training. Encad are based in San Diego, in the Sorrento Valley area. Encad are operating in 70 countries worldwide (Encad, 2000).

A.1.3 Summa Inc

SummaChrome are a subsidiary of Summa Inc., and Summa Inc (based in U.S.A.) has a policy of their international customers dealing with their local distributors. This is due to language barriers and international law (SummaChrome, 2000).

A.1.4 Gerber Scientific

Founded in 1945 by the late H. Joseph Gerber, Gerber Scientific, Inc. has many products available: sign making, screen printing, commercial printing, graphic arts, electronics, optical, apparel and soft goods, automotive, and aerospace. Gerber boasts more than 1200 global and domestic patents, due to the three divisions: Gerber Scientific Products, Inc., Gerber Technology, Inc., and Gerber Coburn, Inc. Gerber Scientific, Inc. holds a place of honour at the Smithsonian Institution development of automation technology worldwide (Gerber, 2000).

A.1.5 Xerox

Xerox is a global company. Xerox offers products and services that turn paper information into digital information. Xerox's growing portfolio of global, industry-based document solutions combines services software and hardware are Xerox's main selling point (Xerox, 2000).

A.1.6 NUR Macroprinters Ltd.

Manufactures the market leading NUR Blueboard HiQ™ super wide piezo continuous inkjet printing system as well as the NUR Fresco screen less wide format press for production printing (NUR, 2000).

A.1.7 Scitex

For the past 30 years, Scitex has compiled a list of industry firsts. Scitex continues to challenge the printing industry by trying to develop cheaper printers, printers that are on the cutting edge of technology (Scitex, 2000).

A.1.8 Roland

Roland DGA Corporation is a wholly-owned subsidiary of Roland DG Corporation, a manufacturer of computer-aided input and output devices used in sign making, graphic arts, engraving, 3D modelling, engineering and architecture. Roland's technology developed around the time of the CAD/CAM revolution. Roland DG is still one of the few manufacturers of pen plotters (Roland, 2000).

A.1.9 Hewlett – Packard

Founded in 1939 Hewlett – Packard's headquarters are based in Palo Alto, California. Hewlett – Packard employees worldwide 83,200, has 600 sales offices and distributors worldwide in more than 120 countries (Hewlett – Packard, 2000).

A.2 LIST OF PRINTERS INVESTIGATED

The following list provides the printers investigated and a brief discussion of each printer follows.

- Vutek 2360 SC
- Vutek UltraVu 3300
- Vutek UltraVu 5300
- Vutek 3200i & 1660
- Encad 1500 TX
- Encad Novajet 700
- Encad Novajet 630
- Summachrome Durachrome
- Gerber MaXX
- Gerber Edge
- Hewlett – Packard's 3500 CP & 3800 CP
- Xerox ColourgrafX 54e
- NUR Blueboard
- NUR Fresco
- Scitex GrandJet V2, V3 & V5.
- Roland Hi-Fi Jet

A.2.1Vutek 2360 SC

Key characteristics:

- The printer costs $385 000
- Width of material used is 2m
- Printer is a 6 colour drop-on-demand inkjet
- Capable for paper, vinyl and pressure – sensitive materials
- 360 dots per inch (dpi) resolution
- 80 inch output image width
- Inks are solvent based and employ pigments selected for long outdoor life (2 – year warranty) (Vutek, 2000).

A.2.2 Vutek UltraVu 3300

The enhanced version of the 3000 series

Key Characteristics:

- The printer costs $485 000
- Width of material is 3.2 metres wide
- Printer is a drop-on-demand inkjet
- Has a 300 dot per inch native print resolution
- Has three modes of printing
- Accepts major data formats
- Gives photo realistic prints
- Prints on a variety of substrates including reinforced vinyl, self-adhesive film, cloth, paper, and mesh (Vutek, 2000).

A.2.3 Vutek UltraVu 5300

The enhanced version of the 5000 series

Key Characteristics:

- The printer costs $585 000
- Printer is a drop-on-demand inkjet

- The UltraVu 5300 differs only from the 3300 in that the UltraVu 5300 has a width of material of five metres (Vutek, 2000).

A.2.4 Vutek 3200i & 1660

Key Characteristics:

- The printer costs not available
- Width of material used is 5 metres
- Digital airbrush printers
- Produces over 16 million colours on any single spot for photo realistic image quality
- Produces a 14 x 28 foot billboard, printed on both sides in 55 minutes
- Uses U.V. resistant outdoor inks based on the same pigments used in automotive paint
- Prints on a variety of substrates including standard outdoor materials (Vutek, 2000).

A.2.5 Encad 1500 TX

Key Characteristics:

- The printer costs $34 995
- Is a Thermal Inkjet printer
- Process colour inks combine to produce a large spectrum of colours
- Print Resolution of 300 dpi
- Prints on cottons, rayons and silks
- Width of material can come between 24 to 60 inches (Encad, 2000).

A.2.6 Encad NovaJet 700

Key Characteristics:

- The printer costs $19 995
- On – demand thermal inkjet
- Using Microburst technology, the Novajet 700 prints 600 dpi

- The Novajet 700 is available in 42 or 60 inch widths
- Accepts 600 x 600 dpi or 300 x 300 dpi files (Encad, 2000).

A.2.7 Encad NovaJet 630

Key Characteristics:

- The printer costs $14 995
- On-demand thermal inkjet
- Has a 600 dpi resolution, supplied by 500ml ink system
- Comes in 42 or 60-inch models (Encad, 2000).

A.2.8 SummaChrome DuraChrome

Key Characteristics:

- Printer costs $44 995
- Prints on high- quality coated paper, synthetic paper and polyester films
- Thermal transfer method with resin or wax ribbons in 4 – pass CMYK mode
- 304 dpi resolution
- Can produce 12 to 52 inch media sizes (Summa, 2000).

A.2.9 Gerber MaXX

Key Characteristics:

- Price of printer unavailable
- Is a 36 inch wide thermal transfer printer
- Prints onto materials up to 36 inches wide
- Offers unattended operation
- Is durable outdoors
- Prints onto a growing selection of MaXX READY materials
- Is clean, quick and easy, with no liquids to dispose of
- Up to six colours can be loaded into the MaXX (Gerber Scientific, 2000).

A.2.10 Gerber Edge

Key Characteristics:

- Price of printer unavailable
- Prints on materials up to 0.38m
- 300 Dpi resolution
- Output is outdoor durable for three to five years without lamination and is ready to apply
- You can print onto a wide variety of EDGE READY materials
- Continuous length printing and automatic panelling of large images (Gerber Scientific, 2000).

A.2.11 Hewlett – Packard

The two printers chosen from HP's range were:

- HP DesignJet 3500 CP &
- HP DesignJet 3800 CP

Both printers are very similar:

- The 3500CP costs $14 561 and the 3800CP costs $16 275
- Colour thermal Inkjet
- 600 dpi resolution at best, 300 dpi at normal & 300 dpi at economy
- One year warranty on – site
- The 3500CP prints on coated papers, glossy photo papers, vinyl and the 3800CP on paper, PVC, mesh PVC
- The 3500 CP gives 1.37 metres print width & the 3800 CP gives 16.4 feet print width (Hewlett – Packard, 2000).

A.2.12 Xerox ColourgrafX 54e

XEROX manufactures many printers of all sizes and their large format printer is the ColourgrafX 54e

Key Characteristics:

- Price of printer is $89 900
- Xerox rates this printer as the price/performance leader for LFDP's
- It produces high volumes and short turnarounds for a variety of applications including transfer to vinyl and outdoor graphics
- Due to the full – screen display the operator can quickly check printer conditions and supplies levels
- Diagnostics indicate when maintenance is needed
- Electrostatic printer
- Print width is 53.32 inches
- Print length is 400 feet
- 300 x 300 dpi resolution
- Has an accuracy of ± five millimetres
- Is fifty percent more faster than previous models
- All supplies are available from Xerox (Xerox, 2000).

A.2.13 NUR Blueboard HiQ

Key Characteristics:

- Price of printer is $515 000
- The NUR Blueboard HiQ is a piezo continuous inkjet printing system for producing full-colour super wide format prints
- It can use a variety of media up to 16.4 ft. (5 meters) wide.
- The NUR Blueboard HiQ is particularly effective in producing excellent quality indoor display graphics as well as super wide outdoor applications.
- Produces full-colour images and sharp text on virtually any rolled substrate up to 16.4 ft. (5 meters) wide.
- 150 dpi
- Guaranteed colour repeatability
- Superior outdoor durability without special coatings or laminations
- Optimal throughput: Print one job and process other jobs simultaneously
- Accepts industry-standard digital image files

- Easy loading and unloading of materials (NUR, 2000).

A.2.14 NUR Fresco

Key Characteristics:

- Price of printer is $395 000
- The NUR Fresco is the ideal for the short and medium-run needs of screen printers.
- The NUR Fresco prints standard wide format jobs including point-of-purchase displays, banners, bus shelter displays, fleet graphics, posters, bus wraps, transit station posters, shopping mall displays, airport terminal displays and more.
- The NUR Fresco can print at any length needed or can cut to sheets. The machine prints at widths up to 72 inch (1.8 m) and accepts a wide range of standard substrates, including paper, self-adhesive vinyl and other flexible media.

Key characteristics:

- Piezo continuous drop-on-demand inkjet.
- 360 dpi resolution
- Automatic cleaning cycle with minimal operator intervention.
- Standard paper, self-adhesive vinyl, blue back paper, banner vinyl, flex-face, etc.
- Four pigment-based process colour inks (NUR 2000).

A.2.15 Scitex GrandJet V2, V3 & V5.

Scitex manufacture a GrandJet range: GrandJet V2, V3 & V5. The GrandJet range is highly versatile.

Key characteristics

- A 370 dpi resolution
- The V5 prints up to 5 metres wide, the V3 prints up to 3.2 metres wide and the V2 prints up to 2.2 metres wide

- Can print out images on canvas, mesh, PVC, paper, Panaflex, vinyl etc.
- The range is drop – on – demand Piezo Electric, that provides colours in 18 million shades
- The inks are pigment, solvent – based and the pigments are UV resistant for 2 – 4 years (Scitex, 2000; Holland, 2000).

A.2.16 Roland Hi-Fi Jet

Key Characteristics:

- The first to offer a 1440 dpi resolution in a wide format device.
- Has a licensing agreement with Pantone INC, giving a good partnership between manufacturer of printers and suppliers of inks.
- Three interchangeable six-colour inkjet options (Roland, 2000).

A.3 TRAINING, SUPPORT AND WARRANTY

The training, support and warranties provided by the various companies are briefly discussed in this paragraph.

A.3.1 VUTEK

A.3.1.1 Training

Vutex offers a five day installation and free first training session course. A follow–up training session is conducted 3 – 4 weeks later. There is a 24 hour help line available in the United States and in addition there are field engineers based in UK and Europe (Vutek, 2000).

A.3.1.2 Customer Support

Apart from a Vutek Area Manager, an Account Manager is assigned to the customers, who will liase over shipment, training, installation, for example.

There are engineers available to help and advise on any requirements. In addition, the European Demo centre is available in Heathrow and is used for the distribution of parts and inks (Vutek, 2000).

A.3.1.3 Warranty Issues

One year, beginning after the start date (installation), Vutek will visit the premises of the customer for the servicing of the equipment. The warranty can be extended for a further year at four percent of the original purchase price (Vutek, 2000).

A.3.2 ENCAD

A.3.2.1 Support

ENCAD Technical support provides end users with help for their printers. Technical support documents are provided with products and include step – by – step instructions. You can also submit an online – help form, e- mail ENCAD or fax ENCAD (ENCAD, 2000).

A.3.2.2 Training

ENCAD's Customer Briefing Centre (CBC), lets customers see and use ENCAD products and a customer can exchange ideas with executives and product managers. Seminars on current printing technologies and tours of ENCAD's manufacturing facility and labs are provided (ENCAD, 2000).

A.3.2.3 Warranty

ENCAD offers a 180-day on – site warranty. There are extended plans available, but ENCAD were not willing to tell us these plans, as we were not purchasing a printer (ENCAD, 2000).

A.3.3 SUMMACHROME

Of the eight companies contacted about Large Format Digital Printers, SummaChrome were not forthcoming with any information about their printer specifications, training, support or warranty (SummaChrome, 2000).

A.3.4 GERBER SCIENTIFIC

A.3.4.1 Service & Support

Gerber offer a Service plan, which the customer must purchase, and there are some advantages:

Minimise equipment downtime so you can meet customer deadlines

- Plans are less expensive than flat rate repair charges

The plan gives you access to:

- Unlimited technical and application assistance by a senior technical systems support specialist
- Members only assistance phone number
- Free shipment of support disks and media
- Special pre – release information on new software
- Purchase incentives and purchase discounts (Gerber Scientific, 2000).

A.3.5 SCITEX

Scitex did not provide any information other than the specifications for their printers.

A.3.6 XEROX

A.3.6.1 Back – up Service

- Specially trained Xerox field service representatives provide Service and maintenance services.
- Additional support is provided by technical staff, located at the company's engineering and manufacturing headquarters for large format products in San Jose, California.

- Xerox ColourgrafX has a 3 –year warranty. If a customer is dissatisfied with a covered product, Xerox will replace it without charge with an identical model (Xerox, 2000).

A.3.7 HEWLETT – PACKARD

A3.7.1 Support, Training & Warranty

- Part of your HP purchase,
- Your most common service and support needs are covered.
- HP Customer Care Basic Warranty Service, Customer Care Online, Online Diagnostics and Users' Forums (Hewlett – Packard, 2000).

A.3.8 NUR

A.3.8.1 Technical Support

Technical support is available through NUR centres and NUR distributors around the world. The company provides a variety of service programs to best suit individual customer needs (NUR, 2000).

- **Premium Service**

A Full Maintenance program for one fixed price. Telephone support, daytime on-site service with all parts and labour, equipment and software updates, and related training seminars are all included in this program (NUR, 2000).

- **Basic Service**

A Shared Maintenance Program for customers relying on their own skilled technical staff to undertake their own maintenance work while being supported NUR professional services at the same time. Under this program, NUR will train the customer's technical staff, provide unlimited telephone support, supply replacement parts at lower rates, and provide software updates and related training (NUR, 2000

ANNEXURE B

RESEARCH INSTRUMENT

SECTION A: BIOGRAPHICAL DATA

1. Name of the Enterprise: ____

2. Age of enterprise: __________________

3. Business form:

    - ☐ Close Corporation
    - ☐ Sole Proprietorship
    - ☐ Partnership
    - ☐ Pty Ltd

4. Highest Qualification of Owner/Manager: _______________________________

5. Is the founder of the enterprise still in control?

    - ☐ Yes
    - ☐ No

SECTION B: ENTREPRENEURS/OWNER/MANAGER'S PROFILE

1. Do you make decisions under conditions of risk and uncertainty?

    - ☐ Yes
    - ☐ No

2. Do you believe in creating a market opportunity for the product or service?

    - ☐ Yes
    - ☐ No

3. Do you believe in embracing a new technology?

    - ☐ Yes
    - ☐ No

4. Do you believe in embracing new business processes?

    - ☐ Yes
    - ☐ No

5. Do you have economic freedom in your enterprise?

    - ☐ Yes
    - ☐ No

6. Do you have the freedom to be creative and innovative with your enterprise?

    - ☐ Yes
    - ☐ No

SECTION C: CRITICAL SUCCESS FACTORS

1. How would you rate your organization's performance relative to your industry in terms of:

    - ☐ Finance
    - ☐ Marketing
    - ☐ Technology
    - ☐ Growth
    - ☐ Human Resources
    - ☐ Production

2. Do you foresee technological changes that will impact upon your product offering?

    - ☐ Yes
    - ☐ No

3. Do you foresee any changes within your industry?

    - ☐ Yes
    - ☐ No

4. Indicate what difficulties your enterprise experienced prior to 2001:

    - ☐ Access to Finance:
    - ☐ Access to Customer:
    - ☐ Recruiting Staff:
    - ☐ Access to Suppliers:
    - ☐ Other____

5. Indicate what difficulties your enterprise CURRENTLY faces:

- ☐ Access to Finance:
- ☐ Access to Customer:
- ☐ Recruiting Staff:
- ☐ Access to Suppliers:
- ☐ Other____

6. Indicate the area(s) of Management that you have difficulty with:

- ☐ Finance
- ☐ Marketing
- ☐ Strategy
- ☐ Production
- ☐ Human Resources
- ☐ Other____

7. Is timing (i.e. when you actually embrace the technology) an important aspect when acquiring new technology?

- ☐ Yes
- ☐ No

8. Do you have an efficient distribution strategy in place?

- ☐ Yes
- ☐ No

9. Do you rely on key customers?

- ☐ Yes
- ☐ No

10. How dependent are you on your key customers?

- ☐ Very dependent
- ☐ Moderately
- ☐ Not at all

11. Please provide a percentage to indicate how the business was financed:

Equity ______________

Debt ______________

12. Does your company believe in a team approach?

- ☐ Yes
- ☐ No

13. Do you have technical experience?

- ☐ Yes
- ☐ No

14. Will the acquisition of new technology improve sales growth?

- ☐ Yes
- ☐ No

15. Is your enterprise operating in an industry with growth potential?

- ☐ Yes
- ☐ No

16. How would you characterise the growth potential of your enterprise?

- ☐ High
- ☐ Moderate
- ☐ Low

17. Is the enterprise currently involved in exporting?

- ☐ Yes
- ☐ No

18. Do you plan to expand the business operations?

- ☐ Yes
- ☐ No

19. Does your enterprise make use of any technological forecasting techniques?

- ☐ Yes
- ☐ No

If yes, please specify: ____

SECTION D: MEASURING INTERPERSONAL INFLUENCE

1. I always consult others within the organisation before purchasing a product

    □ Always □ Sometimes □ Never

2. It is important that colleagues accept the product I purchase

    □ Always □ Sometimes □ Never

3. When buying the product, I generally purchase from a product class colleagues expect me to buy from

    □ Always □ Sometimes □ Never

4. I like to know what product class makes good impressions on others

    □ Always □ Sometimes □ Never

5. I often identify with other people by purchasing the same products and from the same product class that they from

    □ Always □ Sometimes □ Never

6. To make sure I buy the right product or from the right product class, I often:

    □ Observe what others purchase
    □ Consult colleagues
    □ Consult friends
    □ Consult suppliers

- ☐ Gather information
- ☐ Other

SECTION E: BUYING CENTRE CHARACTERISTICS

1. There are experienced technical employees in the organisation:

   ☐ Many ☐ Some ☐ None

2. Employees from the technical division are always consulted before the purchase is made

   ☐ Always ☐ Sometimes ☐ Never

3. Financial manager is involved in the purchase decision process

   ☐ Always ☐ Sometimes ☐ Never

4. I have experience in the technical field

   ☐ Always ☐ Sometimes ☐ Never

SECTION F: PURCHASING SITUATION

1. Which product factors influence the purchase decision?

   - ☐ Novelty
   - ☐ Features

- ☐ Price
- ☐ Attributes
- ☐ Prior Experience

2. I first search for alternatives before making my purchase decision

   ☐ Always ☐ Sometimes ☐ Never

3. The complexity of the product is a barrier to my decision making

   ☐ Always ☐ Sometimes ☐ Never

4. I make use of external technical expertise when the product has complex features

   ☐ Always ☐ Sometimes ☐ Never

5. The importance of the new product is based on potential profitability and productivity

   ☐ Always ☐ Sometimes ☐ Never

SECTION G: ORGANIZATIONAL STRUCTURE

1. Which functional areas are involved in the Purchase decision?

- ☐ Financial
- ☐ Marketing
- ☐ Operations
- ☐ Technical

- Human Resource division
- Other, please specify

2. Which departments are responsible for the Final decision?

- Financial
- Marketing
- Operations
- Technical
- Human Resource division
- Owner/Manager
- Other, please specify

3. Does your firm have in-house technical expertise?

- Yes
- No

4. Are employees trained in-house to use the product?

- Yes
- No

5. Once the new equipment is purchased, employees are trained

- Before using
- After using
- During usage

ANNEXURE C

IDENTIFYING DIGITAL PRINT ANOMALIES

C.1 INTRODUCTION

This chapter presents the results from various firms that evaluated the print quality of certain images.

C.2 PREVIOUS RESEARCH AND LITERATURE

Van Eck (1996) conducted a range of tests on digital printing processes from l997 to 2000. His tests covered a broad range of printing techniques, including traditional processes (intaglio, relief, planographic, and screen-print), some digital printing (inkjet, thermal transfer, and electrostatic). Other techniques are difficult to categorise and these include a selection of 19th-century processes (collotype, pigment transfer, photogravure), several associated with photography (dye transfer, C-type, and Cibachrome), genuine hybrid processes (indigo electrophotographic), and the odd maverick like the Cromalin (introduced in the late 60s as a one-off [sic] proofing system)(Van Eck, 1996:3).

Although there is no description of how the prints were evaluated, the tests revealed many print anomalies. The resulting portfolio is a demonstration of how radically some of these processes transform from the original print. On one level this demonstration surveys the qualities of different print technologies and processes. On another level, it raises important philosophical questions, which can be seen in terms of the varying material results produced by the mediation of each process (Muller, 2000).

Various authors, Weiner, Grotta and Grotta, (1994) have commented on digital print anomalies. However, their findings are of a general nature such as “the colours are more vibrant, the image usually more realistic”(Weiner, Grotta and Grotta, 1994:216). Burkholder (1999) is only concerned with the print anomalies encountered when creating digital negatives or positives, to be printed on a variety of materials. Burkholder gives the following criteria for successful negatives: they should retain the tonal range and detail of the original and they should not be too dense (as they are used for light transmission). The archival qualities and sturdiness of the materials are not seen as critical issues (Burkholder, 1999:114-115).

Some computer magazines publish the results of comparative tests on printers. Unfortunately these are generally performance tests and are more concerned with office type printers than large format models. The article "Network Printers" that appears in PC Magazine SA June 1998, does have a section on colour printers which includes tests done on laser and phase-change inkjet printers (Karney and Stone, 1998:70-71). The conclusions regarding print anomalies are minimal.

C.3 BUREAU MANAGERS

The following digital print managers are well known in digital bureaus in South Africa were interviewed, Van Eck from Hirt & Carter, Port Elizabeth and Muller of Alfresco Full colour outdoor graphics, Port Elizabeth. These two companies are amongst the most prominent in South Africa, Hirt & Carter not only provides digital printing facilities, but also offers a professional laboratory service, scanning, proofing, traditional printing and finishing facilities. Alfresco Graphics concentrates on large-scale inkjet output, up to billboard size, screen-printing, vinyl cutting and scanning. Two print managers in America were asked a number of questions via e-mail regarding print anomalies. Otsuki of Capitol Color Santa Clara CA and Jon Cone of Cone Editions are both recognised as knowledgeable individuals in the digital printing industry. Otsuki has presented a number of courses and seminars on large format digital printing (Jordaan, 2000). Cone Editions have gained a reputation for providing fine artists with an excellent digital printing service and are involved with research into manufacturing and testing inks for the fine art market. Only Jon Cone answered the e-mail questions.

C.4 THE INITIAL PRACTICAL TEST

This test was devised to identify print anomalies in a variety of digital print techniques. In order to create the test image a number of variables, some of which are mentioned in chapter one and in chapter seven, were eliminated. A Phase one PhotoPhase digital camera system on a Sinar P large format camera was used to record the image, this meant that any colour variations caused by film and processing could be avoided. Obviously the Phase One back has its own inherent characteristics, but manufacturers claim that it offers a number of advantages over film, 'namely that the image is "cleaner, does not contain film grain, has more exact colours, and has a better dynamic range" (Phase One, 1999). This technique is also recommended by Hunter Editions a company in Maine USA that prints fine art images (Malek, 1999:60).

C.4.1 Procedure for Capturing and Setting up the Digital Image

A still life was set up containing an Egyptian lady. The still life contained sections with gold patches, a dense black, a pure white, broken white, problematic colours, natural objects, metallic objects, text and a skin tone, this is illustrated in Figure 10.1: This approach extends the test done by PC Magazine SA (Karney and Stone, 1998:70 - 71).
Standard lighting was applied and the recommended filter used, the lens was set on F11 and an exposure of 1/40th of a second given. The exposure marker fell well within the green area, just above the one setting, as recommended in the Phase One User Guide (Phase One, 1996:24). This indicates that the image is correctly exposed. A gamut warning check was made, only the extremely strong highlights on the gold in the image

Figure C.1. Test sample for print samples (Alfresco, 2000)

were out of gamut. The image produced was 21 x 30cm at 300 ppi and a resulting file size of 25.8Mb. A grey balance was done, in accordance with the instructions in the Phase One User Guide (Phase One, 1996:24). The colour management software (ColorSync) was applied, RGB capture mode set and camera matched to monitor, all other settings were default settings.

The resulting file was opened in Adobe Photoshop 5.0 and measured using the 3 by 3 average eyedropper. The original image was assessed using this method and seen to have a contrast that was too low. Using the system recommended in the Adobe Photoshop 5.0 User Guide the white and black target values were adjusted to white R 244, G 244, B 244 and black R 10, G 10, B 10 (Adobe, 1998:114-116). The black and white areas were chosen off the chart, rather than off the solid black and white objects. This was done so that the black and white areas would print as very dense blacks and clear whites. The image was saved as high medium and low-resolution images of 100, 200 and 300 ppi tiff files onto an optical disc and then written onto compact discs (CD). Either the high or medium resolution image was used, depending on the printer's requirements. No finishing techniques were applied to the prints.

C.4.2 Range of Prints

The following tests were performed by the following companies, thermal inkjet (Alfresco, Port Elizabeth), piezo inkjet (Xerox, Johannesburg), continuous flow inkjet (Digital Distributors, Cape Town), airbrush inkjet (Second Glance, Cape Town), phase-change inkjet (Square One, Johannesburg), thermal wax on paper (Alfresco, Port Elizabeth) and on transparency material (Walker Hing, Port Elizabeth), dye sublimation (Walker A.A. Hing, Port Elizabeth), Fuji Pictography (Teltron, Johannesburg), colour laser (Xerox, Johannesburg), large format electrostatic (Xerox, Johannesburg).Tests were not made on a digital enlarger, extended gamut inkjet or imagesetters. The reason being that there was a need to maintain a consistent print to get results, if a digital enlarger, for example had been used by one of the companies and not the others, their evaluation may have been otherwise influenced.

C.4.3 Assessment of Test Prints

A group of eight graphic designers, sign specialists and bureau managers from Port Elizabeth were asked to individually assess the prints. These eight designeres were selected from the bureaus found in Port Elizabeth (Alfresco and Hirt and Carter). The prints were placed on a neutral background in an exhibition area and lit by diffused daylight. The panel was given additional information on size limitations, substrates and longevity, based on the information in Table 10.1. In order to focus their attention on critical aspects of each print, the evaluation was broken down as follows: 1. colour accuracy, 2. tonal range, 3. ability to render highlight and shadow detail, 4. sharpness (ability to render fine detail), 5. visibility of dot/ line/ screen pattern, 6. surface texture, 7. size limitations and 8. variety of substrates.

This breakdown is based in part on Lowe’s perceptual qualities (Lowe, 1996:5-6), the criteria used in the PC Magazine SA article (Karney & Stone, 1998:70-71), and the criteria described by Reilly and Frey (1996:19). The form used for the evaluations appears as Annexure B together with a statistical analysis of each factor.

In addition to the evaluation, the individuals were asked to comment on possible graphic applications for the various print media. Some evaluators saw potential for the more acceptable media to be used for making copies of original art works or for proofing. The majority of the evaluators thought that all the media offered creative potential in terms of exploiting the particular characteristics of the prints for fine art and craft applications. Other evaluators suggested applications such as large-scale outdoor installations, printmaking, painting, digital illustration and photography. Asked to comment on the limitations of the media, some evaluators expressed concerns regarding sharpness, longevity and size limitations.

C.5 IDENTIFIED PRINT ANOMALIES

The identified print anomalies are discussed under headings for each printer. The evaluation figures (between 0 and 5) referred to in these sections relate to those in Table C.1 and the statistical analysis in Annexure G.

Table C.1. Ranked Evaluations of Printers in Terms of the Identified Characteristics

	1	2	3	4	5	6	7	8	Ave
Piezo-electric Inkjet	4	4	3.8	4.4	3.4	4	4.5	4.6	4.1
Thermal Wax	3.8	4.4	4.4	4.4	4.1	3.8	2.5	3.7	3.9
Fuji Pictography	4.2	4	3.7	4.3	4.2	4	2.2	2.2	3.6
Continuous Flow	3.2	3.5	3.5	3.8	3.9	3.5	3.5	4.5	3.4
Electrostatic	2.2	2.5	2	1.7	1.4	2.5	3.2	4	2.4
Phase-Change Inkjet	2.2	2.5	2.2	2.5	2.5	2.7	2.2	2.5	2.3
Thermal Inkjet	2	2	1.5	1.5	1.7	2.4	3.3	3.2	2.2
Spray-jet / Aerosol Inkjet	1.2	1.6	1.2	1.4	1.2	1.5	3.8	2.2	1.7

Note: The characteristics used to evaluate the printer types are:
1.Colour accuracy, 2. Tonal range, 3. Ability to render highlight and shadow detail, 4.

Sharpness (ability to render fine detail), 5. Visibility of dot/ line/ screen patterns, 6. Surface texture, 7. Size limitations, 8. Variety of substrates, Ave is the average evaluation achieved by that particular printer. The maximum evaluation possible is 5.

C.5.1 Thermal Inkjets

Thermal inkjets offer large media sizes and a variety of substrates, UV resistant inks and indoor inks are available, though inks must be matched to the appropriate media or problems can arise, such as rapid fading and uneven drying (Muller, 2000). These machines produce saturated colour with high colour density, going for "maximum visual impact" (White, 1998:6), but lack subtlety of tone and in some machines the rather large dot pattern can be quite disturbing.

The initial print seen in Figure C.2, made on the thermal inkjet, gave a disappointing results with an average assessment of 2.2 out of a maximum of 5. In Annexure A the thermal inkjet is the second worst printer in terms of colour accuracy, tonal range, retaining highlight and shadow detail, sharpness and surface texture.

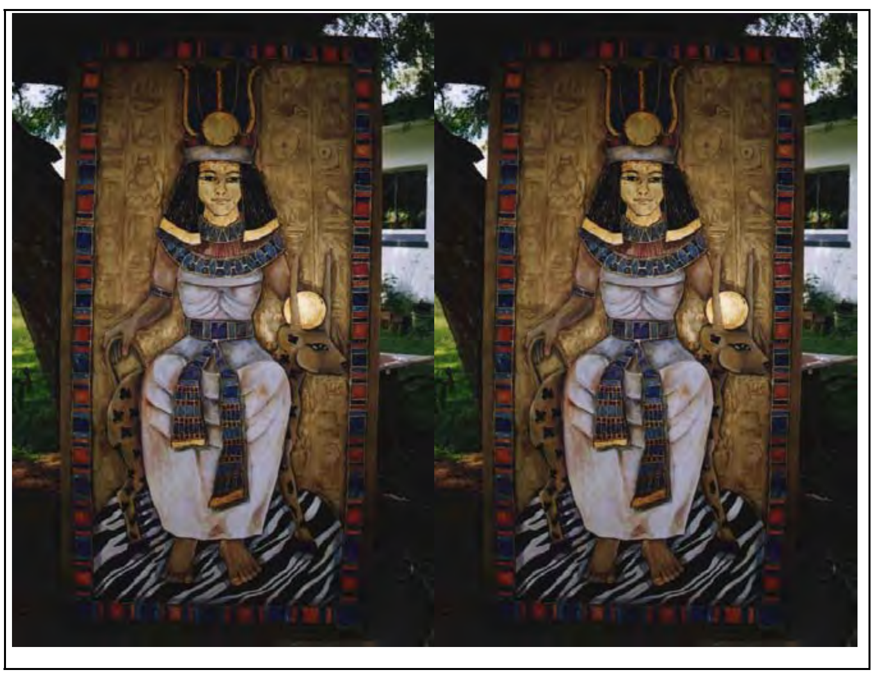


Figure C.2. Thermal inkjet print samples

C.5.2. Piezo Inkjet

In general the piezo inkjet was assessed as producing the best overall output, on average rated at 4.1 out of a possible perfect score of 5. In Annexure A, the printer was rated at number one in the following properties- tonal range, sharpness, size limitations and substrates. The printer was ranked number two in the following properties- two colour accuracy and texture. From a bureau manager's point of view these inkjet printers are low maintenance, user-friendly machines that are easy to calibrate. Definite advantages are that they offer very large print sizes and they can print onto almost any material (Jordaan, 2000). The fineness of the dot achieved by this machine is a positive factor, giving a good tonal range and sharper images (see Figure C.3) (Muller, 1999).

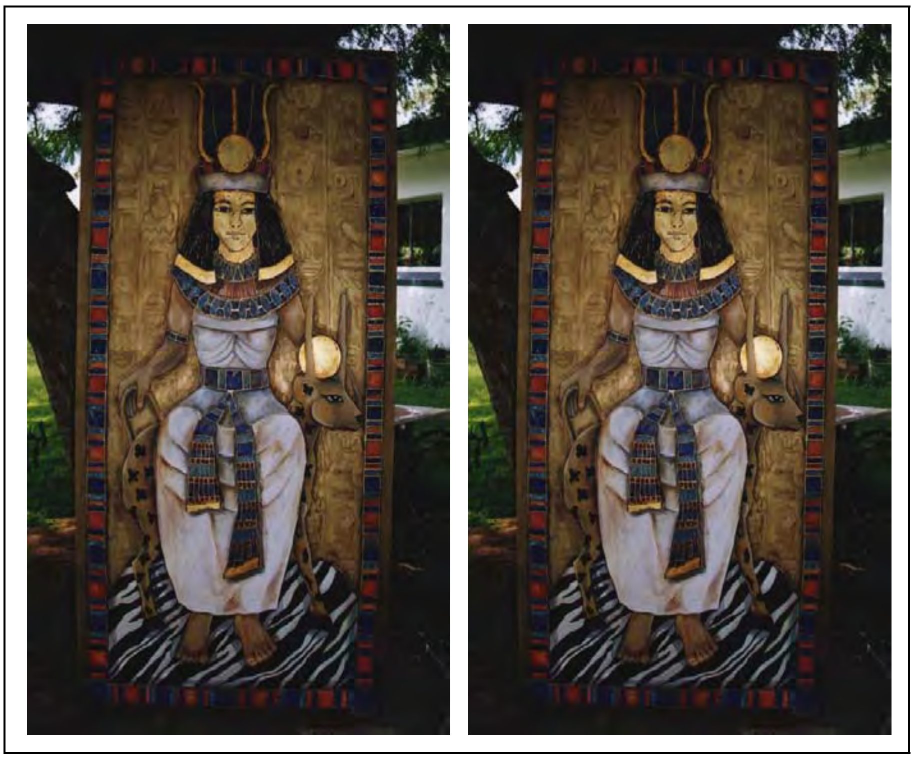


Figure C.3. Piezo inkjet print samples

C.5.3 Extended Gamut Inkjet

No initial test was made on this machine, as there are a very limited number of them available in South Africa. These machines are expected to give excellent colour and tonal rendition. However there are queries regarding longevity, especially with the Super

CMYK models (Wilhelm, 1999).

C.5.4 Continuous Flow Inkjet

The continuous flow inkjet prints give accurate colour, a good tonal range, high resolution and the ability to render fine detail. The inks are not waterproof and the printer is slow, it can only print an A0 full colour print in 95 minutes and costs per print are high. Cone Editions only produce continuous flow inkjet prints (Iris Giclée prints). Cone feels that they offer great colour accuracy and longevity (Cone, 2000). This does depend very much on the type of inks and substrates used.

The initial test print made on the continuous flow inkjet (not a Giclée system) was seen to be successful in all properties, with an average of 3.4. The print, seen in Figure C.4, was evaluated as one of the best in terms of sharpness and lack of a dot, line or screen pattern. Although limited in terms of print sizes, the potential to print on a wide range of substrates was seen as a definite advantage. The printer offers some obvious advantages to the sign specialist in terms of longevity, though not all bureaux offer the inks and substrates designed to achieve this.

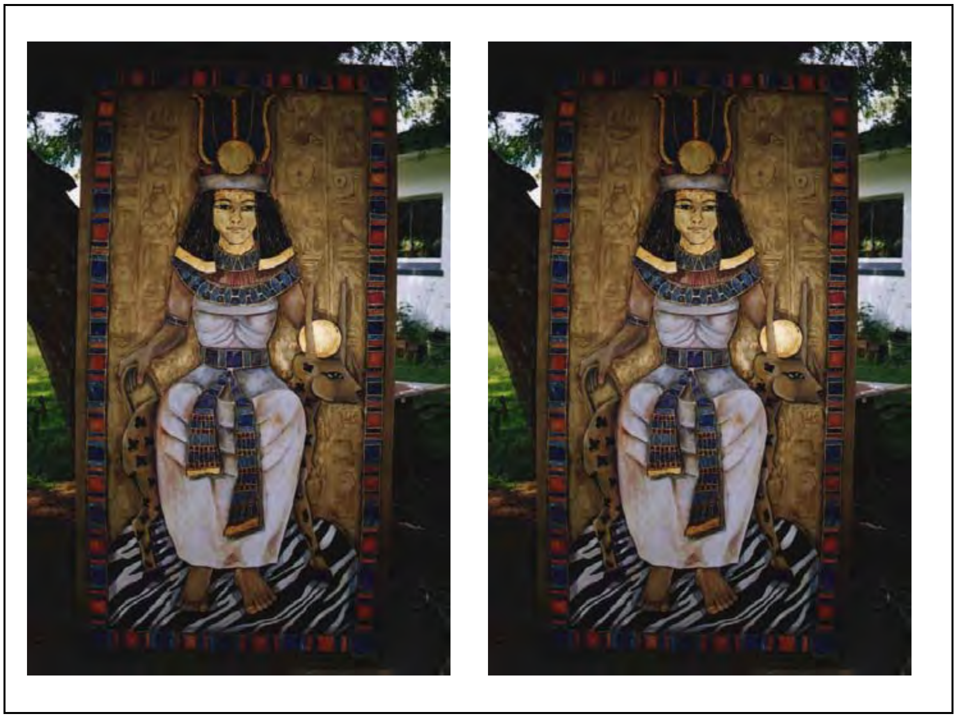


Figure C.4. Continuous flow inkjet print samples

C.5.5 Spray-jet / Aerosol Inkjet

The process is designed to print images on a very large scale and so the assessment of a 30 x 40 cm sized image, is not ideal. In general the appearance of the print is poor, the dot pattern is very large and noticeable, to the extent that it breaks up the reading of the image. This printer was rated in Annexure A to be the worst at achieving colour accuracy, a good tonal range, highlight and shadow detail, sharpness and surface texture. Because of its low quality appearance, illustrated in Figure C.5, and the low assessment of 1.7, this medium is not seen as a fine art print option and no further tests were made using this process.

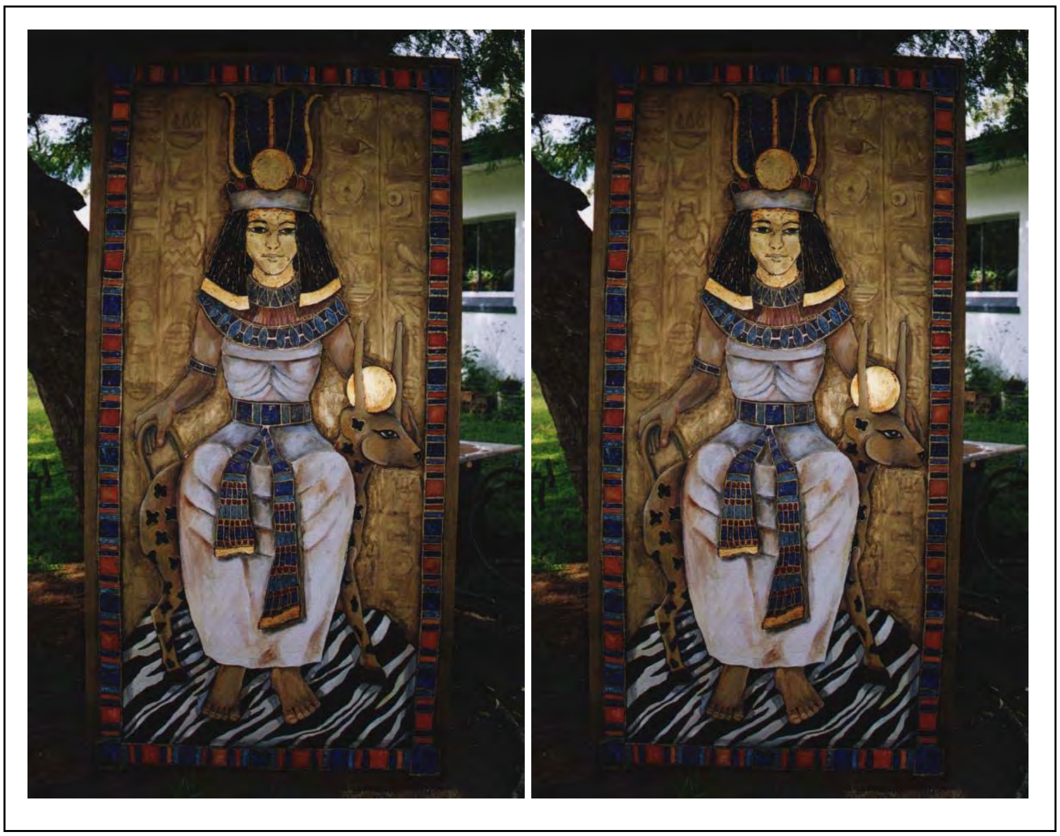


Figure C.5. Spray-jet/Aerosol inkjet print samples

C.5.6. Phase-change Inkjet

As the inks in this process are not absorbed by the substrate, this process can be used to print onto paper, vinyl, film or card stock. Another advantage is that the inks cannot spread out and be absorbed into adjacent areas; this results in increased image sharpness, and crisp lines. However because the wax sits on top of the substrate surface, prints can be easily damaged and may crack when folded. Printers can print onto both sides of the substrates. The printers are slow and expensive, but produce vivid colour (Franco, 2000).

The evaluation of the test print for this process was not very positive with its average evaluation being 2.3. It was particularly poor in terms of achieving colour accuracy, highlight and shadow detail and a good tonal range with its best characteristic the rendering of surface texture. The print is seen in Figure C.6.

Figure C.6. Phase-change inkjet print samples

The dye sublimation print was given an above average rating of 3.2 in the initial test, with only the size limitations and limited range substrates seen as disadvantages. The other properties as illustrated in Annexure A, are consistently well above average.

C.5.7 Thermal Wax

Although the thermal wax process is rather limited in terms of scale and substrate selection, it can be used for display and promotional purposes. Colours are saturated; image quality is good though the costs are high. The limited life span of prints means that its applications are limited (Gordon-Graham, 2000). The initial test was rated in most aspects, especially in terms of ability to render tonal range, maintain highlight and shadow detail, sharpness and the lack of a visible dot, screen or line pattern. See Figure C.7. where on average the thermal wax print was rated at 3.9.

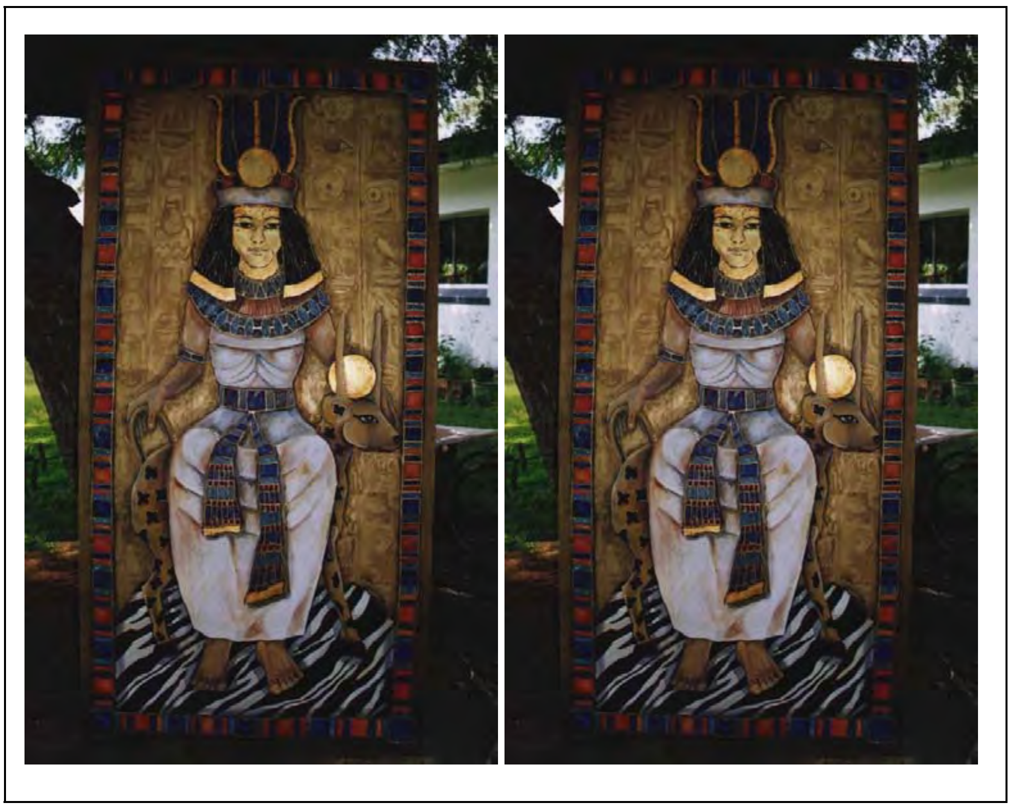


Figure C.7. Thermal wax print samples

C.5.8 Digital Enlargers

Photographic prints made on digital enlargers have certain intrinsic qualities. The technique of exposing materials with laser beams produces very high quality prints. This is enhanced by the resolving power of photographic materials. Excellent colour saturation can be achieved, but the ability to render some specific colours is not good. The rendition of text is not always sharp and there can be some fall off towards the edges of prints and dimensional changes of the image. "One of the disadvantages of ultra-wide laser printers is that the laser spot varies from being circular at the centre of the print to being increasingly elliptical towards the corners, resulting in distortion and reduced image quality" (Franco, 2000)

It proved impossible to access one of these printers in South Africa. Although a file was taken to a company in Pretoria, which runs one of these machines, they were unwilling to interrupt their commercial output to make a test print or the fine art print.

C.5.9 Film Recorders

With photographic material, the longevity and quality of the digital images is enhanced. From the initial slide, enlargements can be made, a large format transparency (10.2 x 12.7 cm) will enable the graphic artists to print up to approximately 1.5 meters square without losing image quality (White, 1998:8). "The spatial and colour resolution of many of today's film writers is good enough to produce transparencies that are difficult to distinguish from a photographically derived original" (Aaland and Burger, 1992:96). Ilfochrome print materials in particular, offer vibrant colours partially created by the highly reflective base and the glossy surface. The two-step process however has obvious drawbacks as the final print is a second-generation product, dust and the usual problems associated with enlargement of photographic images can degrade the image. The process is relatively expensive.

No initial test was made using this technique.

C.5.10 Imagesetter

There are a number of aspects that can be problematic when creating digital negatives or positives on an imagesetter, Burkholder (1999:176) names two problem areas, grain and streaks that are often caused by software problems or incorrect resolution settings. If multiple negatives are to be used for contact printing, registration problems can also be encountered. Achieving accurate contrast and an appropriate tonal range for a particular process can also be problematic; this aspect has more to do with setting up files than printing. Once again the negative or positive is used as an in-between step and so dust and scratches on the film can be problematic.

No initial test was made using this process.

C.5.11 Fuji Pictography

The Fuji Pictography printer gives an almost photographic quality print. Annexure A illustrates that this printer achieves excellent colour accuracy, good tonal range, and the image generally has little or no dot, line or screen pattern. This process received a good overall evaluation of 3.6. Figure C.8 shows the Fuji Pictography print

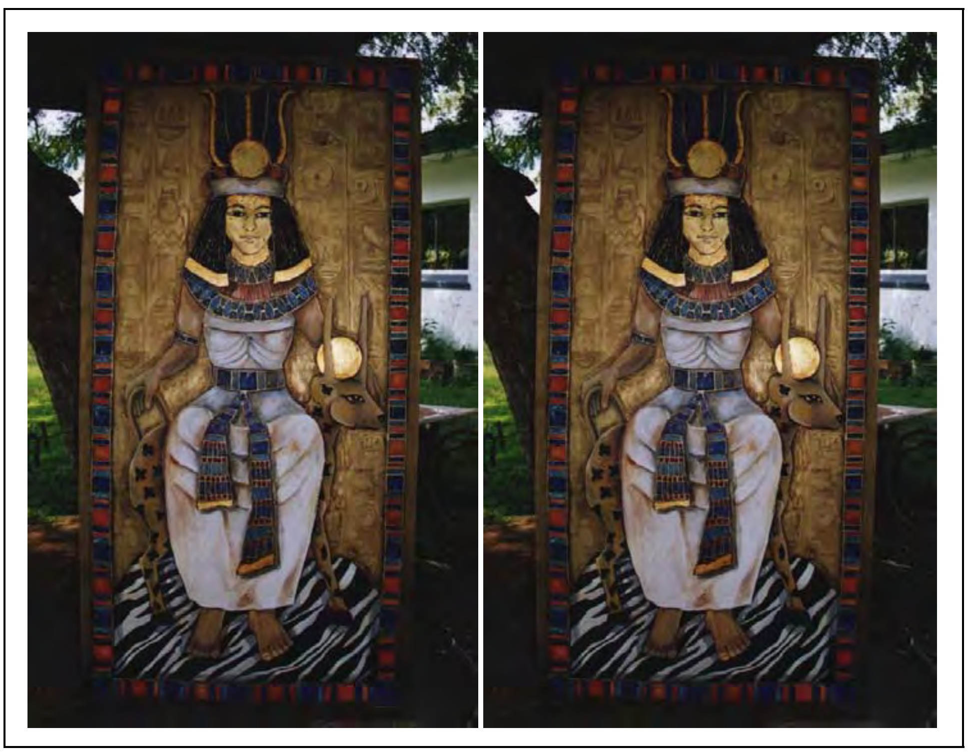


Figure C.8. Fuji Pictography print samples

C.5.12 Large Scale Electrostatic

Electrostatic prints are often not of very high quality and sometimes suffer from poor coverage, flare spots and streaks. The electrostatic process does however offer a stable outdoor image. In terms of operation, toners must be replaced monthly or inconsistent colours will result, printers are known to be temperamental and complicated to operate (Otzuki, 2000).

The toner problems make it impossible for the printer to print precisely the same every time.

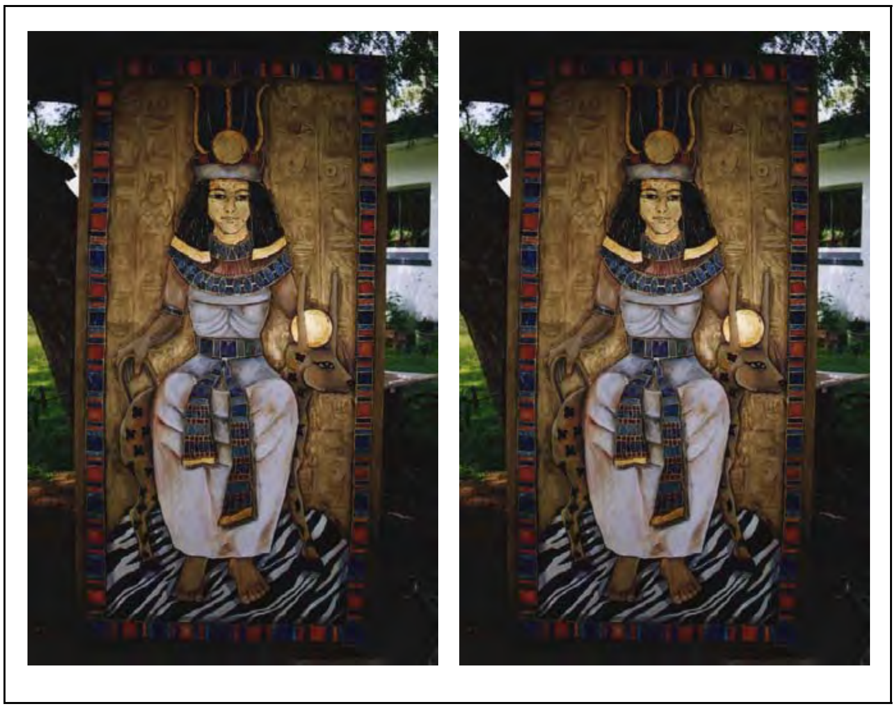


Figure C.9. Large Scale electrostatic print samples

The initial test image (Figure C.9) received one of the lowest assessments, with an average of 2.4 on a scale of zero to five. The poor tonal range, lack of sharpness, very visible dot pattern and poor surface texture were assessed as serious drawbacks. A number of companies that previously offered electrostatic prints have put their machines into storage and replaced them with piezo inkjet machines (Franco, 2000).

C.6 SUMMARY

This chapter provided print samples performed on a number of printers. This information is useful for the entrepreneur as they will be able to determine if the printer will perform the necessary tasks in order for the entrepreneur to offer their service. Eight graphic designers who have the technical skill to assess the various qualities that an entrepreneur needs to be aware of before purchasing a LFDP undertook the evaluation.

The contribution of this chapter for the study include

- Identification of printing properties of a number of LFDP
- The information is important as it can facilitate decision-making by the entrepreneur

ANNEXURE D

IDENTIFYING THE COMMERCIAL APPLICATIONS OF LARGE FORMAT DIGITAL PRINTS

D.1 INTRODUCTION

For entrepreneurs to make informed choices when choosing a digital print medium, an existing range of applications need to be identified. As both commercial and fine art applications offer potentially useful information, both these areas will be investigated in this chapter. Commercial applications of digital prints will be identified and specific examples of applications will be provided. Specific examples of applications will be given to illustrate how different print products have been used.

D.2 COMMERCIAL APPLICATIONS OF LARGE FORMAT DIGITAL PRINTING

The commercial application of large format digital prints is a constantly evolving market. As new processes, substrates and inks enter the arena, new applications are found for them. Up to this stage a number of commercial uses for digital prints have evolved. Jordaan (1999:2) lists them as follows:
"Uses: retail merchandising, trade show exhibits, service firms/utilities, public spaces/event promotion, corporate spaces/exhibits, point-of-purchase advertising, recreation and entertainment, automotive, architecture/construction, convention displays, presentations/seminars, grocery, restaurants/fast food, shopping mall/centres, [sic], medical/scientific/engineering, museums/galleries."
Other uses include photographic prints and enlargements, business-, greeting- and post cards, proofing, publishing, printing onto fabric, and film positives for traditional printing processes. Prints serve a wide range of applications, from prints used to decorate snowboards, to prints on mesh, which can be used to cover buildings or construction sites (see Figure D.1).

Figure D.1 Vinyl mesh panes used to cover a building (Alfresco, 1999)

Because of the wide range of applications and printing processes, most digital print bureaux accept work from a broad range of clients. These can include advertising agencies, architects, trade show designers, corporate and retail graphic design departments, photographers and publishing print shops. These clients design posters, displays, billboards, murals, stage sets, vehicle markings, and signage, postcards, brochures and many other images. Their designs generally include text, renderings or illustrations and photographs. In terms of computer software a huge range of design products can be used. This range of input formats, images and display criteria constantly challenge the bureau to offer unique solutions for each designer's needs.

D.2.1 Commercial Applications examples

Commercial applications of hybrid photographic processes such as image setters to print, film recorder to print and digital enlargers are vast. Photographers for instance can make use of these facilities for retouching and the restoration of photographic images. However this type of retouching is, for the bureau, labour intensive, and not a very profitable area, as print quantities are generally small. It is far more profitable for both bureau and client to use the large format digital negative or positive to print quantities of between 10 to 1000. These images are then used as postcards, business cards, posters or catalogue sheets. This route is cheaper than traditional printing methods especially if print quantities are low (Berg, 1997:28 – 32). Film recorders writing to transparency film are used extensively to produce slides for large format printing presentation. Once again clients often combine graphics, text and photographic images and these designs are sometimes printed to colour copy machines for handouts, as well as being used to generate the slides. Some companies such as RB Images of Hollywood print 1,700 – 2,500 sliders per month, with a turnaround time of three hours (Brown, 1997:39).

Digital enlargers offer the option of printing onto any type of photographic material, from backlit transparency film to black and white resin coated photogloss paper. Material such as Ilford's Ilfochrome, colour reversal, translucent material or a RA-4 translucent material is ideal for the display of photographic-type images. It is being used quite extensively by fast food area franchises such as McDonalds to display current products. Medium sized (101 x 127 cm) prints, in quantities of between 15 and 120 can be printed more economically than on regular offset presses. The prints are displayed in light boxes and require longevity qualities in the photographic materials used. The images are used to promote special offers on certain ranges of food and drink. Digital enlargers render the bright colours, fine text and photographic images of these pieces exceptionally well.

Dole was one of the first photographers to make use of digital printing for self-promotion. In 1996 Dole produced a number of large-scale images on the Xerox Versatec electrostatic printer. His aim was to show a prospective client a series of impressive posters that would illustrate his photographic skills. His decision to use digital printing to make the images was dictated by two aspects, firstly, that the computer offered very accurate adjustment controls and secondly the particularly attractive print characteristics of the Versatec. Davis (1993:46) points out that Dole chose the electrostatic machine because of its ability to "quickly turn out a large, museum-quality, four-colour print – all without entering a darkroom."

The different types of large format inkjets have a wide range of commercial applications. For instance, aerosol inkjet prints have been used on promotional billboards to advertise popular TV shows. Eggers (1996:38) describes how "during promotional periods in some major markets, billboards for Oprah Winfrey were being changed very day. Each afternoon, the topic for the next day went up. Only the actual topic panel was changed, but it was being done on a daily basis. Making frequent changes like that before the days of digital printing, would have made such output impractical, if not impossible."

In Pretoria (South Africa) inkjet prints on billboards were used to cover three sides of a fire gutted building. The two 21 m long by 17 m high images and one 42 m long image were used to promote local TV stations (Davidson, 1999:1 – 2). Inkjet prints on the appropriate outdoor substrates are also used on bus shelters, taxis, trucks, delivery vehicles and busses.

Why commercial clients use large format digital prints can be narrowed down to the following reasons.

- Images can be changed in the middle of a print run. For instance three posters with the same image can be printed, text changes made and further prints made at very little additional cost.
- Turnaround times are very short, in some cases a poster can be delivered to the client within a few hours.
- Scale is not a limiting factor and billboards of enormous sizes can be printed.
- Colours are vibrant and text is sharply defined.
- Images can be transferred on to almost any surface.

Jordaan (1997:7) lists the customer's requirements as "large format, Post Script, [sic] photographic quality, colour range, ease of use, fast production (quick turnaround), low cost, volume, media range, various substrates…"

D.3 FINE ART APPLICATIONS OF DIGITAL PRINTING

In 1995 the magazine Leonardo published examples of digital images that were part of an exhibition "Art as Signal: Inside the Loop," curated for the Krannert Art Museum, University of Illinois at Urbana-Champaign. The examples depict two-dimensional computer artwork and include examples of dye sublimation, Cibachrome (Ilfochrome), from film recorder transparency, colour laser and inkjet prints (Chmelewski, Goggin, Squire, 1995:85 – 92). When looking at what artists use digital printing for, it must be noted that some artists in America have been involved with digital printing for at least the past fifteen years (Moore, 1999:20). This has not been the case in South Africa, where many artists have only started to use digital media quite recently. However, these artists have already exhibited work and made use of a variety of media.

D.4 A COMPARISON OF COMMERCIAL AND FINE ART APPLICATIONS

An installation of images for promotion in a fast food restaurant does not differ vastly from an installation of a backlit fine art image. Many artists are still quite conservative in terms of how they see the application of digital prints. This is possible linked more to cost and access than lack of ideas. Some artists push the boundaries of the digital print media then mix them with traditional fine art techniques. As Lowe (1995:8) points out, "artists are always pushing the parameters of what a print engine can technically achieve and are mixing aspects of different processes together to exploit the potential offered by this diversity." They do not however have the budgets that commercial clients have and this could limit the type of applications that they would like to achieve, and the amount of experimentation that they could do.

One major factor when it comes to the application of commercial work is the fact that images are most often required to last only a few months at the most, while most fine artists would like their images to last for as long a possible. This has a limited effect on the choices that a fine artist can make when selecting printing processes, inks and substrates.

D.5 PERMANENCE ISSUES

As issues of image permanence are of major importance to artist and curator, this section is dedicated to outlining opinions on this issue, as well as explaining how longevity is assessed.

Entrepreneurs, using the first large format digital prints, were dismayed at how rapidly the inks faded. This resulted in the medium acquiring a poor reputation. Recent industry efforts to improve the longevity of large format digital prints have substantially changed the attitudes of operators and entrepreneurs. The George Eastman House started collecting small-scale digital prints in 1993. Therese Mulligan, the curator at George Eastman House, explains that “due to the rapidly changing nature of the digital medium, entities like galleries and auction houses are moving towards a greater acceptance of the medium” (Leslie, 1998).

For the operator there are a number of routes that they can take when printing for permanence, most importantly, the medium chosen should be suitable for the application. A dye sublimation print’s longevity characteristic is vastly different to a platinum print made from a digital negative. There is also the option of offering to provide the file of an image on a relatively indestructible medium, such as a good quality CD or magneto optical Disc. This means that the image could be printed again if any noticeable fading occurs, or if new and improved materials become available. There are certain drawbacks to this process. Some mediums, such as thermal wax prints, may be phased out in the future and the printers and materials will no longer be available. It might take a skilled operator to duplicate the original print when new materials; technology and software may cause subtle changes. Another issue mentioned by Henry Wilhelm is that the hardware and software for certain storage media may not be available in the future (Wilhelm, 1999).

From a curator's point of view, digital prints do not differ vastly from other art media in terms of conservation; especially with current art trends where graphic and signage specialist artists incorporate natural products into their work. Cannon-Brookes (1983:34) refers to "the total freedom now enjoyed by the artist presents formidable problems for the museum curator and his conservator, problems which are often little understood by either the graphic artist or the curator".

Leslie (1998) adds to by highlighting that if you are for a digital print like you do any other work on paper, thinking in terms of preservation when storing or displaying work, understanding all of its physical attributes, then you can be pretty certain of its longevity (Leslie, 1998).

As more products come onto the market, it is exceptionally difficult for operators or graphic artists to keep up with how long the images printed on the new materials will last. Fortunately, a number of organisations are testing digital printing products for permanence and frequently publish these results.

Considering that most digital printers were designed as proofing devices, permanence was not always considered a crucial factor when it came to creating substrates and inks. Wilhelm (1999) points out that "Iris never conceived of their printer being used to produce a work of art that might hang on a wall. It was designed for digital pre-press work and industrial-designing work, where permanence was not an issue." The situation that exists today is that some prints such as dye sublimation, thermal wax and some inkjet printers offer quick output, but are not always designed for permanence. Other machines such as the Giclée machines do not have the same print speed, but can offer high quality, long lasting images.

Fortunately, most manufacturers have attempted to improve the permanence of prints, largely because of demands made by their commercial clients. The permanence of inkjet inks and substrates has improved vastly over the past three years and photographic materials continue to improve in terms of longevity.

D.5.1 Factors Influencing the Permanence of Large Format Digital Prints

A number of factors appear to influence the permanence of digital prints. Generally, concerns are about inks fading, though realistically the influence of substrates cannot be ignored. Browning (1977:316) points out how important the permanence of paper is when intended for use in legal records, documents, art works, and library books of permanent value. He goes on to say that because of paper's complex make up, the factors influencing permanence have not yet been fully established (Browning, 1977:317). Not only will the paper on its own influence how long an image lasts, but the reaction of ink to substrate will also be a deciding factor. Many manufacturers will only guarantee their products when the appropriate ink is used with a specified substrate.

Other factors influencing image permanence are the finishing and presentation of images. Often images are laminated or mounted onto different surfaces and in some cases these surfaces can adversely affect the images. Otsuki (2000) claims that:

"Most colour changes are due to oxidation of the dyes or pigments. This oxidation can occur due to ultra violet (U/V) radiation, a natural reaction with the paper, laminate, glue, etc., exposure to acid in the air (pollution), or just about any other cause."

Exposure to visible and UV wavelengths, the pH balance of substrates, exposure to water, after treatment, such as lamination and mounting will all influence how quickly prints fade. A number of individuals at large format digital print bureaux, claim that testing done in America and Europe, has little bearing on South African or Australian outdoor conditions, where fading appears to occur at a more rapid rate (Franco, 2000).

D.6 TESTING THE LONGEVITY QUALITIES OF DIGITAL PRINTS

Although most manufactures give statistics as to how long prints will last indoors or outdoors, these statistics are generally considered to be inaccurate. Concerns are often voiced regarding how tests are conducted and how they are evaluated. There is at least

one independent organisation conducting tests for longevity on large format digital prints. The Rochester Institute of Technology (RIT) has an image permanence section that will run tests for industry clients. The Wilhelm Imaging Research Inc. in Grinnell Iowa has conducted testing on certain processes. Wilhelm is recognised as an expert in this field and was a founding member of the ANSI subcommittee on developing standards for testing the stability of colour photographs (Postcards, 1999: 65).
The Grinnell testing is done under lighting conditions that mimic standard indoor display illumination with a relative humidity of 60% (Wilhelm, 1999); this factor has received some criticism. Otsuki (2000) points out that it is often impossible to duplicate the conditions in which the commercial print will be exhibited and that at present there is no impartial organisation doing comprehensive outdoor testing. This was confirmed in a presentation on the status of standards for outdoor graphics at the Big Picture Conference (Piekara, 1999).

Another aggravating factor is that new media or ink is released every few weeks; a good testing programme is just not possible (Otsuki, 2000). Otsuki's (2000) assessment of longevity, based on his experience in the commercial printing market is far more conservative than that of Wilhelm's institute. For instance he quotes photographic prints as having a ten-year indoor life and six months to one-year outdoor life. Un-laminated inkjets using dye-based inks, he assesses as one to two months indoors. (Otsuki, 2000). His assessment is purely from the viewpoint of a graphic producer and vendor, based on eleven years of running a digital output business.

Wilhelm (1999) also outlined some of the aspects that his organisation looks at when determining the longevity of digital prints. These include setting up test files that illustrate a comprehensive range of colours and tones, as uneven fading of certain inks is often only noticeable in the grey areas. Other tests evaluate the effect of humidity and heat on colour densities and bleeding. It must be pointed out that although these tests do not satisfy all possible large format digital print applications, they are however conducted with all applications in mind. The test results can therefore be of great help to both entrepreneurs and operators as an indication of how long it will take for large format digital prints to fade in outdoor environments.

D.7 SUMMARY

It seems that is will take some time before consensus on testing for image permanence will be achieved to the satisfaction of both entrepreneurs and commercial clients. This chapter indicates that the two groups appear to have a great deal in common. Both would like to have good quality large format digital prints than can be used for promotion, display and within installations. The other conclusions are discussed in the next chapter.

For this study, the following were considered important findings:

The entrepreneur needs to make informed choices when choosing a digital print medium, in order to select from an existing range of applications

Both commercial and fine art applications offer potentially useful information

ANNEXURE E

OUTSIDE FACTORS THAT INFLUENCE DIGITAL PRINTING QUALITY

E.1 INTRODUCTION

It is common knowledge that the printer is not the only factor that effects large format digital print quality. Scanning, colour management, operator competency and other factors also influence print anomalies and therefore how accurately a print will match the original images. These factors have, where possible, been eliminated or standardised in the digital images used for printing the practical tests described in Chapter Ten. However, as they are obviously direct influential parts of the digital printing process they will be addressed in this chapter, in order to further define the delimitation and assumptions of the research.

E.2 DIGITAL CAPTURE OF THE ORIGINAL

E.2.1 Input

Artwork can be captures using a flatbed scanner, digital camera or a studio camera with a digital background. Another approach is for the artwork to be photographed onto film and the film scanned, using a drum or film scanner. The dimensions and surface qualities of the original artwork generally dictate how the image will be captured. As Malek (1999:63) describes, " for oil paintings, which might have lumps, transparencies or digital camera captures are preferred because of shadow detail might be lost with a scan." Capturing an image at the correct resolution is critical. Generally, the input device, the size of the original image as well as the size of the envisaged output dictates the scan or capture resolution.

Scanner resolution is normally quoted in terms of samples per inch (spi) (in the industry inches rather than centimetres are the standard unit of measurement). This can be directly translated into pixels per inch (Ppi), which is the standard unit of measurement that image processing software uses. The basic guidelines for scanning are to use the quality factor of 1.5 times the screen ruling of the printed image. Agfa give the following formula for scanning for the production of halftone images: scan resolution = screen ruling x quality factor x sizing factor (Agfa-Gevaert, 1994:21). The sizing factor = desired size / original size. For example a screen ruling of 133 Lpi x 1.5 x a sizing factor of 2.5 (original was 20 cm and the desired size was 50 cm) would me scanning in at approximately 500 spi. When it comes to continuous tone photographic devices, such as film recorder, scans can be made at the identical resolution. Scan resolution = output device resolution x sizing factor. Output device resolution = maximum addressable pixels / longest side of output film (Agfa-Gaveart, 1994:23). Burkholder (1994:43) points out the importance of the image capture stage by saying "just as there is no substitute for a properly exposed and developed negative, there can be no replacement for a good scan that faithfully captures shadow and highlight detail."

Unfortunately many desktop flatbed and film scanners do not have colour calibration charts or calibration software. As bulbs age and change colour, or mirrors and lenses collect dust, no adjustments can be made to compensate for this, unless a calibration chart is scanned with the scanner set to neutral and then software is used to analyse the image created. Calibration software compares the values of the scanned image to stored standard colour values. If there are any discrepancies, a scanner profile for that particular device will be written. Whenever the profile is used it will automatically compensate for the unique aspects of that particular scanner. Most digital camera backs have a grey balancing software that is used to calibrate the camera each time it is used (Phase One, 1996:35) and profiles can be created for camera backs.

With some cheaper scanners a lack of sharpness can occur, as is pointed out in the "Agfa Guide to Colour Separation" booklet. "The scanning process may cause some of the loss of details and edge definition in an image" (Agfa-Gevaert, 1995:6). Making use of the unsharp masking filter in Photoshop can compensate for this. Basically, the mask identifies pixels that differ from the pixels around them and increases the contrast between them (Adobe, 1998:128). The mask has three variables – amount, radius and threshold, which have to be set when trying to sharpen an image. The amount refers to the increase of contrast desired, radius dictates the area around the identified pixels that will be effected and threshold indicates how much of a brightness difference the pixels should have in order to be identified. If the unsharp masking is applied repeatedly a halo effect will appear around the edges of the object (Agfa-Gevaert, 1995:6).

Some of the newer desktop scanning allows for greater control over the scanning process. The operator can specify the input media, such as particular files types, and output targets, such as the printer to be used. In addition to this there are normally adjustments for resolution, colour, brightness, contrast, and sharpness. Drum scanning software offers far greater control over the process, but also requires greater expertise on the part of the operator. According to Malek (1999:62) “capturing an image is the most critical aspect of Giclée reproduction, so a great deal of focus is placed on the specialists who do this job.”

E.3 COLOUR COMMUNICATION

Lippert (2000) argues that Colour Communicates. Colour sells. Colour is the sizzle that drives the sale of virtually every consumer product in the world. It evokes a wide range of emotions that draw a buyer to the product. As design, graphics, and imaging professionals, it is know that colour is a crucial part of the selling process because it is an important part of the buying decision. If the operator uses colour effectively in the manufacturing and marketing of an item, potential buyers will perceive added value in that product (Lippert, 2000).

To use colour effectively, it must be kept under tight control. The colour workflow begins with the designer’s ideas and customer’s specifications. From there, these colours must be communicated among several different individuals who will render and reproduce the colours on many different devices. At each stage of production, output from the previous stage becomes the input for the next process. Every exchange brings the colour into a new colour space – from photographic film to monitor RGB to CMYK process proofing and printing on a variety of systems, every evaluation is made by a different viewer under new viewing conditions (X-Rite, 1999)

So, how do the entrepreneurs and operators ensure that original ideas and specifications will remain intact throughout this complicated process? This chapter is designed to answer that very question. In short, the answer is colour measurement – if the operator can measure colour, then they can control it. The remainder of this chapter explains the fundamentals of colour communication, measurement, and control.

E.3.1 The Challenge: Colour Communication

Consider the many different individuals who "pass the baton" of responsibility for keeping the customer's colour specifications intact:

Content Specifier/Client: defines message; determines image concept; provides general or specific colour and paper specifications.

Graphic Designer: Provides images, art, and page files and printed or digital specifications.

Pre-Press Service Provider: provides final colour separated films; colour break information; printed or digital colour specifications.

Printing Ink Supplier: provides inks that meet colour specifications; considers paper specifications.

Printing Company: Provides final printed piece; meets colour specifications. Each step in the colour reproduction process adds value and content to the message. Good colour specifications ensure that each process provides accurate colour content based on the input received. (X-Rite, 19960 :4)

As operators strive to create dazzling, high-quality colour documents and designs, operators struggle to control colour at each production phase. Each viewing situation presents its own interpretation of the same colour for example:

The original scene contains a wide range of natural, vivid colours.

A photograph of the scene captures much of the scenes colour, however some of the dazzling tones are lost when the image is scanned into RGB data. Still more colours are lost or change when the scan is display on different monitors.

As artwork gets moved between imaging, illustration, and layout programs, the colours are specified in different ways. For example, specifying 87 % magenta / 91 % yellow produces a slightly different colour in Photoshop, Freehand, QuarkXpress.

When artwork gets printed, the colours get colour-separated from RGB data into CMYK data. The colours are interpreted a bit differently on different devices – on laser copier, trade shop's proofing system, and on press.

When output gets checked, one views the colour under different lighting conditions that affects the colour appearance in different ways. Also, different people perceive colours based on their own vision skills and memory. (Agfa-Gaevart, 1994)

The underlying question throughout this process is: which device is telling the truth? Unfortunately, no individual viewer, no program, nor any device can uncover the true identity of a colour. Eyes and peripherals are simply concerned with the way colours appear – and a colour's appearance is subject to lighting and viewing factors as discussed.

E.3.2 The Solution: Colour Management and Control

Measurement is the key to total production control. Operators measure size in inches in millimetres; weight in pounds and ounces. These scales allow us to establish precise measurement standards that can be repeated in the production process. This ensures that all manufactured items are identical and within tolerances for quality, fit, and finish. Using measured colour data, it can do the same for colour – it can monitor colour at each stage of production and check the "closeness" of colour matches using repeatable, standardised numerical data. (X-Rite, 1996)

So, what properties of colours allow them to be discretely identified and measured? One can find out by examining these properties – how colour happens in nature and in our minds; how it is reproduced on screen and on paper; and how colour can be communicated as reflectance values (spectral data) and as three-dimensional values (tristimulus data).

Figure E.1. From idea to press: the graphic arts workflow begins with the customer. The challenge we face is to present the customer with consistent colour results at every stage. (X-Rite, 1996:3).

To help you clearly understand how colour is measured, one should first study the fundaments of colour's physical and physiological properties.

Colour results from an interaction between light, object, and the viewer. It is light that has been modified by an object in such a manner that the viewer – such as the human visual system – perceives the modified light as a distinct colour. All three elements must be present for colour as it is known to exist (Green, 1997: 12-14).

E.4 COLOUR MEASUREMENT AND CONTROL

Now that entrepreneurs are familiar with the fundamentals of colour and the different way it can communicate colour data, let's look at the ways the operator can collect this data. It has to be measured on two instruments that measure colour – spectrophotometers and colorimeter. First, operators have to take a more detailed look at these instruments, along with a third commonly used graphic arts instrument, the densitometer. Then, operators have to take a look at different types of colour measurements and how it is used during specific phases of the digital imaging and graphic arts production workflow.

E.4.1 Instrumentation

It has been discussed about the many scales for communicating and describing colour – either by its primary colour attributed, its perceptual attributed, or its actual spectral data. These models provide units of measurement similar to "inches" and "ounces". All one needs is a set of “rulers” that can measure a colour in terms of numeric expressions such as CIE L*a*b*. Today, the most commonly used instruments for measuring colour are densitometers, colorimeters and spectrophotometers. (O’Leary, 1998)

E.4.2 Gathering Colour Measurements

Colour measurement instruments “receive’ colour the same way our eyes receive colour: by gathering and filtering the manipulated wavelengths of light that are reflected from an object. A combination of light, object and viewer causes to perceive a colour. When an instrument is the viewer, it “perceives” the reflected wavelengths as a numeric value. The scope and accuracy of these values depend on the measuring instrument – they can be interpreted as a simple density value by a densitometer: a tristimulus value by a colorimeter: or as spectral data by a spectrophotometer.

E.4.3 Assigning Numeric Values to Colours

Each type of colour measurement instrument does something that our eye cannot do: assign a specific value to the colour that can be consistently analysed in terms of numeric tolerances and control limits. Each instrument makes this conversion differently.

Of these instruments, a densitometer is the most commonly used. A densitometer is a photo-electric device that simply measures and computes how much of a know amount of light is reflected from – or transmitted thorough – an object. It is a simple instrument used primarily in printing, pre-press, and photographic applications to determine the strength of a measure colour.

Figure E.2. Densitometers …

Such as X-Rite's X-Scan system simply measure the amount of light reflected from the object to determine its density or "strength". In our example, the solid magenta patch on the measured colour bar has a density of **D 1.17**. This value helps the press operator make necessary adjustments to process ink keys. (X-Rite, 1996:23)

A colorimeter also measures light, but it instead breaks the light down into its RGB components (in a manner similar to that of the human eye, a monitor, or a scanner). A colour's numeric value is then determined using the CIE XYZ colour space or one of its derivatives, such as CIE L*a*b* or CIE L*u*v*. These measurements are visually interpreted in a colour space graph. (X-Rite, 1999)

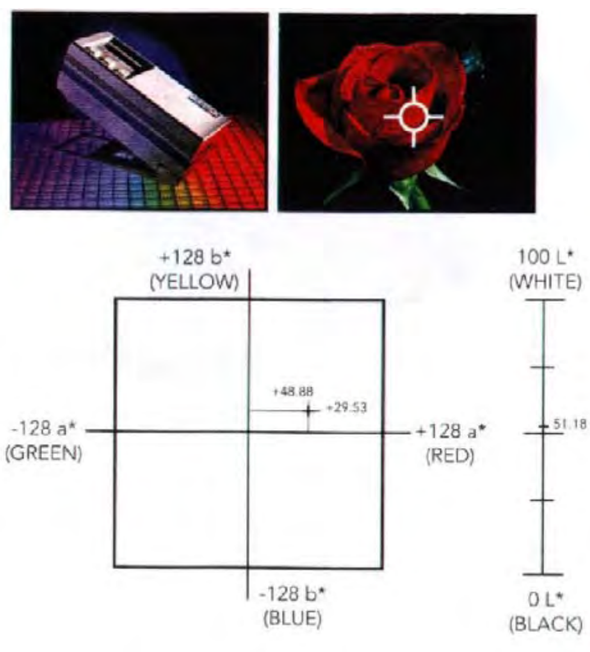


Figure E.3. Colorimeters…

Such as X-Rite's model 938 measure the amount of red, green, and blue light reflected form the object. Using CIE XYZ as the reference colour space, this colourimeter data is converted into L*a*b* co-ordinates. In our example, the measured L*a*b* value is "pin-pointed" as: L* 51.13, a* +48.88, b* +29.53(X-Rite, 1996:24).

A spectrophotometer measures spectral data – the amount of light energy reflected from an object at several intervals along the visible spectrum. These measurements result in a complex data set of reflectance values, which are visually interpreted in the form of a spectral curve. (X-Rite, 1999)

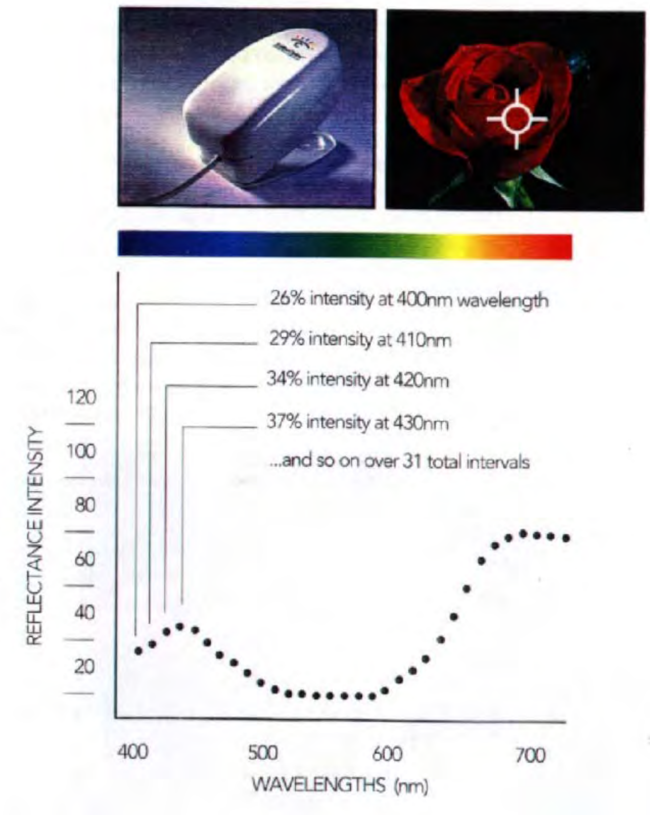


Figure E.4. Spectrophotometers…

such as X-Rite's Digital Swatchbook build a spectral "fingerprint" by examining how a surface affects light at different wavelengths. (X-Rite, 1996:25).

E.4.4 Scale for Measuring Colour

Munsell originated a colour ordering system – or colour scale – that is still used today. The Munsell System of Colour Notation is significant from a historical perspective because it's based on human perception Moreover it was devised before instrumentation was available for measuring and specifying colour.

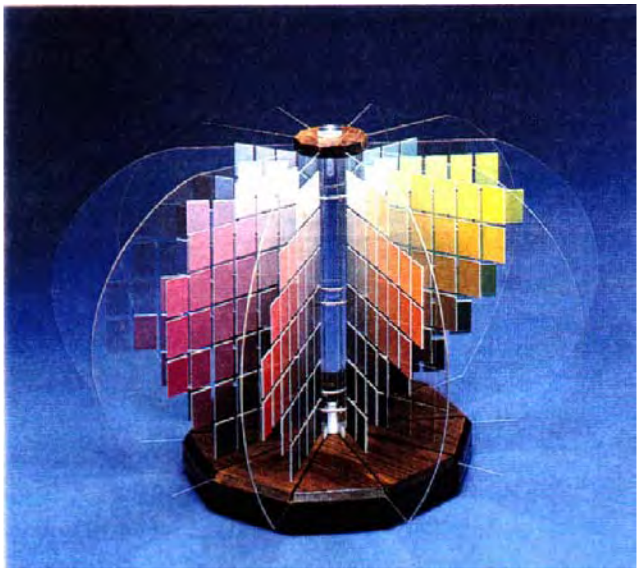


Figure E.5. Munsell Colour tree (X-Rite, 1996)

The Munsell system assigns numerical values to the three properties of colour; Hue, Value and Chroma. Colour samples represent equal intervals of visual perception. The model in Figure 8.5 depicts the Munsell Colour Tree. The vertical axis represents the value (lightness) of colour. The innermost colour squares represent a descending gradation of white to black with shades of grey in between.

The colours of the spectrum are divided into 10 basic hues as represented on the vertical slices branching from the centre of the model. The horizontal axis represents chroma (saturation) which identifies a colour's horizontal distance from the central grey axis. The purest, most saturated colours are located at the model's perimeter.

Today, colour systems rely on instrumentation utilising mathematics rather than physical samples like the Munsell scale. By far the most important of these systems is the CIE – Commission Internationale de l'Eclairage (translated as the International Commission on Illumination, the body responsible for international recommendations for photometry and colorimetry).

In 1931, the CIE standardised colour order systems by specifying the light source (or illuminants), the observer and the methodology illuminants), the observer and the methodology in which to derive values for describing colour.

From the commission's work was also derived the concept of a standard observer, based on the average of the human population with normal colour vision Figure 8.6. In short, it represents specific numerical values for the responses of the average human to different wavelengths of light. The standard observer also provides a means for converting any spectral curve into three numbers, known as tristimulus values XYZ that identifies any colour (Agfa, 1996)

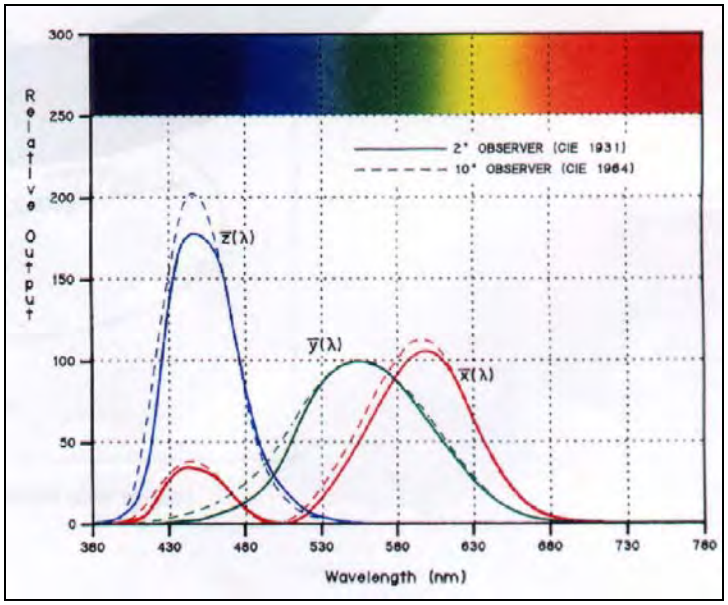


Figure E.6. CIE 2 and 10 Standard Observers (X-Rite, 1996)

E.4.5 Chromaticity values

The tristimulus values, unfortunately, have limited use as colour specifications because they correlate poorly with visual attributes. While Y relates to Value (lightness), X and Z do not correlate with Hue and Chroma.

As a result, when the 1931 CLIE Standard Observer was established, the commission recommended using the chromaticity co-ordinates xyz. These co-ordinates are used to form the chromaticity diagram in Figure 8.6. The notation Yxy specifies colours by identifying

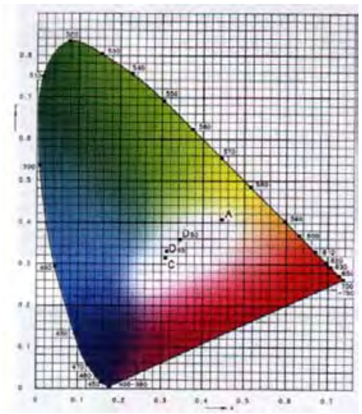


Figure E.7. CIE 1931(x,y) Chromaticity Diagram (X-Rite, 1996)

As a result, when the 1931 CLIE Standard Observer was established, the commission recommended using the chromaticity co-ordinates xyz. These co-ordinates are used to form the chromaticity diagram in Figure8.6. The notation Yxy specifies colours by identifying value (Y) and the colour as viewed in the chromaticity diagram (X,Y) (Agfa, 1996)

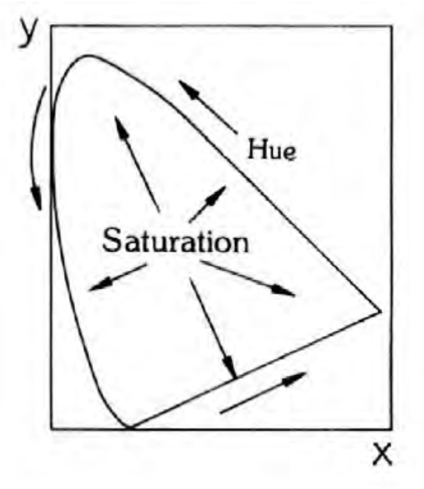


Figure E.8. Chromaticity diagram. (X-Rite, 1996).

As Figure E.8 shows, hue is represented at all points around the perimeter of the chromaticity diagram. Saturation, or Chroma, is represented by a movement from the central white (neutral) area out towards the diagram's perimeter, where 100% saturation equals pure hue.

The diagram in Figure E.9 Is the CIE 1976 Uniform Chromaticity Scale diagram, often referred to as the Yu'v' diagram (pronounced Y u prime, v prime). The intended advantage of the u’,v’ diagram over the x,y diagram is it reduces the effect of non-uniform distribution – when equal perceptual differences are not represented by equal distances on the diagram. The u’,v’ diagram also correlates much better with CIELUV, or L*u*v* , as described in the next section.

Each point on the 1976 Chromaticity Diagram’s perimeter represents a pure hue – this is 100% saturation. Each hue’s saturation is decreased by moving toward the diagram’s neutral centre where red green and blue mix into white (X-Rite, 1999)

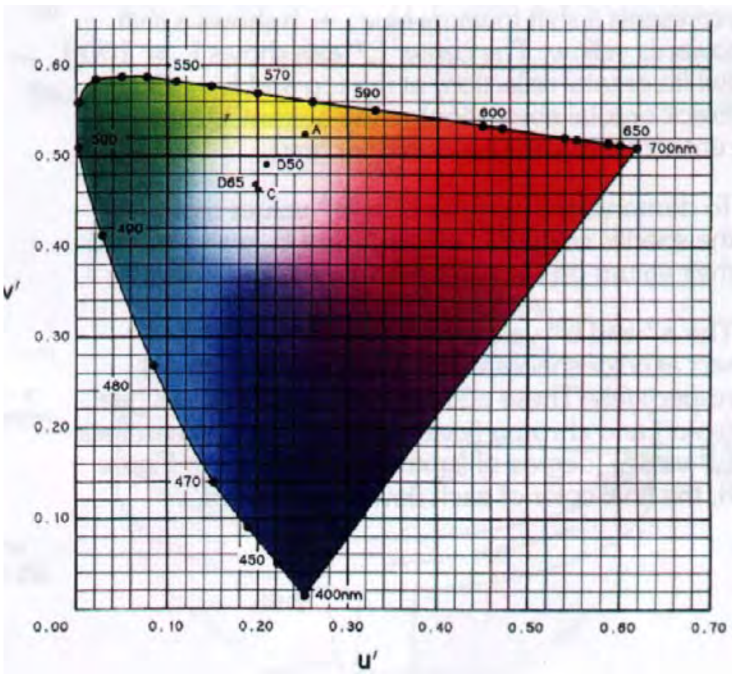


Figure E.9. CIE 1976 UCS (u’,v’) Chromaticity diagram (X-rite, 1996).

E.5 MEASUREMENT APPLICATIONS IN THE GRAPHIC ARTS WORKFLOW

Different types of colour measurement instruments are used in various stages of the graphic arts production workflow. A precise measurement programme can ensure consistent colour results from initial ideas to the final printed piece – and all the exchanges from device-to-device in between. Different types of measurement are appropriate for specific production stages. For example, spectral data is the best measurement format for pinpoint colour specifications: while simple density measurements are more appropriate for monitoring press sheet colour bars over the course of a four-colour process press run.

First, the operator should re-emphasise this important point: the typical RGB colour space is much smaller than the range of colours that is visible to the human eye, and the CMYK printing process can achieve an even smaller gamut. Also, lighting conditions and materials such as colorants and substrates place additional limits on the gamut of reproducible colour. Scanning and display technology continues to improve colour bit depth and push the capabilities of RGB outward: the new printing technologies such as Hi-Fi colour have widened the process printing gamut. However, variations will always exist between original natural colours, their reproduction via scanners and monitor display, and their reproduction via different printing processes (X-Rite, 1999)

Colour measurement allow one to achieve the best possible colour production results:

Minimal colour variation between devices and production stages.

These variations are predictable, and overall outputs are consistent; and

Any problematic colour variations are quickly identified and corrected with little waste of time or materials (Agfa, 1996)

Next, we will discuss how specific types of colour measurements can be applied to optimise colour variations and quality in some key stages of the production workflow:

Specification (by client and content creator)

Colour Management (by content creator and service provider)

Control (by printer)

Verification (by printer, client and content creator)

Note that this workflow is a full circle – the key is to present a finished product that matches the client's original colour specifications as closely as possible (Agfa, 1996)

E.6 COLOUR SPECIFICATION

The most compete way to define a colour is with spectral data. Now that technological advances have made spectrophotometers widely available, spectral data is the logical best solution for describing, specifying, or identifying colours. Spectral measurements are especially crucial for colours outside the traditional CMYK colour description – such as out-of-gamut spot colours and Hi-Fi process colours. Spectral descriptions remain the same at any workflow stage because they are device-independent. In addition, RGB, CMYK and custom ink formulations can be accurately derived from spectral data (Green, 1997)

X-Rite's DIGITAL SWATCHBOOK system allows the operator to "point and click" its hand-held spectrophotometer on a colour sample, then instantly view the colour on your computer monitor. The measured colour's spectral data is stored as a digital "swatch". A collection of swatches can be saved in a "swatchbook", which can then be imported into other graphics programmes such as Adobe Illustrator Swatchbooks are also accessible form Photoshop via the Apple Colour Picker. Beginning the colour production workflow with spectral descriptions means this precise, device-independent data can be utilised at other phases in the process – at service providers by the client, and by the printer (X-Rite, 1999)

Figure E.10. (X-Rite, 1996:27)

Any real-life colour can become part of Digital Swatchbook's digital "palette". Swatchbooks can be saved as EPS files that contain spectral data – along with RGB, CMYK and other types of data – for each of their stored colours.

E.7 COLOUR MANAGEMENT

It is noted that there are as many RGB colour spaces as there are monitors, and as many CMYK colour spaces as there are printers. This situation creates a great deal of ambiguity and guesswork for designers who create and proof colours on their desktop devices. Scanned colours don't look the same when they are displayed on a monitor; on-screen colours do not match the printed proof, and the colours in image files display and output differently at each production site (design studio, service bureau, printer). Colour management systems (CMS) help solve these problems at the desktop level, and in turn provide solutions "downstream", as well.

A colour management system identifies the RGB and CMYK colour spaces that are crucial to your work – those belonging to your scanner, monitor, and printer. Descriptions of these devices are appropriately named profiles, or also referred to as characterisations. Macintosh and Mac OS-compatible computers provide a built-in framework – called Apple Color-Sync – for implementing and handling these device profiles. Another prevalent CMS is Image Color Matching (ICM) for the Microsoft Windows 95 platform. Colour measurement instruments are used in conjunction with the CMS and CMS-supported software to gather the important performance data that comprises the device profiles, and to periodically monitor and adjust the performance of the devices. Utilising your CMS, CMS-compatible software utilises and Plug-Ins, and colour measurement instrumentation, you can achieve desktop colour consistency in two major steps – device calibration and device characterisation (X-Rite, 1996).

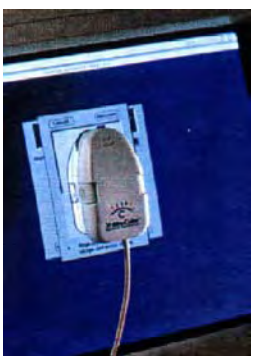
E.7.1 Device Calibration

Device calibration is the first step in the desktop colour management process. The monitor and output device performance capabilities can change over time – phosphor instability is a principle cause of monitor drift: and changes in colorants and room humidity can throw printer performance off course. Monitor and printer calibration procedures utilise different types of devices (Agfa, 1996).

E.7.1.1 Monitor calibration

Monitor calibration is most accurately achieved using a colorimeter – such as X-Rite's Monitor Optimiser or model DTP92 – and compatible calibration software. For example, the Monitor Optimiser sensor attaches directly to the monitor positioned over a colour target displaced on screen by the software utility. The target area flashes a series of colours – 100% red, 100% green, 100% blue, the various shades of grey. The colorimeter measures each patch: then, the software collects the measurement data. This data is analysed to determine where any performance drift has occurred. The monitor's gamma, white and black point, and colour balance are adjusted and corrected accordingly.

In addition to calibration, the operator can do some other things to ensure reliable monitor viewing: set brightness and contrast knobs at the desired level; choose a neutral grey pattern for your on-screen "desktop "; avoid locating brightly-coloured artwork adjacent to the monitor; avoid locating the workstation near windows or room lighting that is glaring or that changes frequently; and even shield the monitor on top and at the



sides with a cardboard "awning" (X-Rite, 1999).

Figure E.11. Monitor Optimiser (X-Rite, 1996)

E.7.1.2 Output device calibration

Output device calibration is typically achieved using a densitometer and accompanying software. Calibration adjusts a device's output to correlate with the values requested by the software. In the case of a colour printer, calibration ensures that the correct levels of cyan, magenta, yellow, and black colorants are printed. A typical test image features rows of patches – one row for each colour the device can print. Each row's patches represent different percentages, usually arrange in 5% or 10% increments from solid to zero coverage. In the case of film imagesetters, on the other hand, output values are verified for a single separation film's tone values.

These patches are measured to calculate the device's linearity – its ability to properly image the percentages assigned from the calibration software. An auto-scanning densitometer such as X-Rite's model DTP32 makes these measurements fast and easy by automatically scanning an entire row with one pass through the reading slot. The resulting measurements are communicated back to the software, where internal adjustments are made to the PostScript commands that control the colour values sent to the output device (X-Rite, 1999).

Figure E.12. X-Rite DTP32 densitometer (X-Rite, 1996)

E.7.2 Device Characterisation

Devise characterisation is the second step in the colour management process, following device calibration. Characterisation is the process of actually creating device profiles for your scanner, monitor, and printer. While many device manufacturers ship factory-generated, generic profiles on disk with their products, custom profiles that you create for the specific devices are more accurate and reliable and therefore will yield better colour results.

E.7.3 Scanner characterisation

Scanner characterisation involves using a scanned test print or transparency such as an IT8 Target, and then running a scanner characterisation utility programme. The IT8 test pattern consists of dozens of different colour patches that represent a uniform sampling of the CIE XYZ or L*a*b* colour space. The target comes with a data file containing the XYZ values for each patch. The utility compares these known values to the scanner's device-dependent RGB representation of each colour. Any differences between the two values are calculated. From this data, the scanner's colour space can be determined. This unique colour space information is saved as part of your scanner's custom profile (X-Rite,1996).

Figure E.13. IT8 target for reflection scanners (X-Rite, 1996)

E.7.4 Monitor characterisation

Monitor characterisation is accomplished using the same instrumentation (such as Monitor Optimiser) and on-screen target sequence that is used for calibration. For characterisation, the colourimetric data from the device is compared to the monitor's ability to render these colours, so the software can calculate how the monitor's colour space relates to the XYZ colour space. This unique information is the central component of the monitor's custom profile (O'Leary, 1998).

E.7.5 Printer characterisation

Printer characterisation is similar to scanner characterisation in that it measures a test pattern to determine the device's range of achievable colours. For printers, the test pattern is a uniform sampling of overprinted CMYK tints that are imaged using the output device.

Software from printer characterisation contains a test image with as many as 500 different patches. This image is output to the printer. The patches are then measure, and the resulting colourmetric data is calculated into colour space information for that specific printer, as it relates to the CIE XYZ colour space. This information becomes the central component in the print's custom profile.

Because characterisation is concerned with the printer's ability to render a range of different process colours - not specific colorant densities – a colorimeter or spectrophotometer must be used to gather the measurements (X-Rite's Digital Swatchbook spectrophotometer, or DTP51 Auto Scan Colorimeter).

Figure E.14. X-rite DTP51 Auto scan colourimeter

E.7.6 Proofing system and press characterisations

Proofing system and press characterisations can help clients and designers accurately predict the way colours will reproduce at later stages of the production process. Service bureaus and printers who utilise colour measurement and management systems can consider supplying clients with custom profiles of their output devices. Knowing the capabilities of all the output devices in the workflow can further enhance our ability to make important colour control decisions during the desktop design stage of production. Achieving colour control early in the process can save review cycle time and wasted materials downstream (Agfa, 1996).

E.8 ANATOMY OF A DEVICE COLOUR SPACE

A device colour space is “constructed” based on its ability to scan, display, or render different points in the CIE XYZ colour space. Most target patches represent various hues at maximum saturation – the first two colour space dimension. Various tints of black and the primary colours are also included to determine the device’s capabilities for rendering different levels of lightness, as well.

The characterisation software “knows” the device-independent gamut. These known colour values are compared to the device’s actual, measure performance. The amount of difference at each point is determined, and the measured points are “mapped” in relation to the known points. The resulting information provides the characterisation software with a detailed description of the device’s unique capabilities.

Profile –generating systems store device profiles in a specified location in your operating system software. Programmes that utilise device profiles – such as the Digital Swatchbook software and Adobe Photoshop – allow you to activate the desired device profiles from the storage location via menus within the programmes’ operating environment.

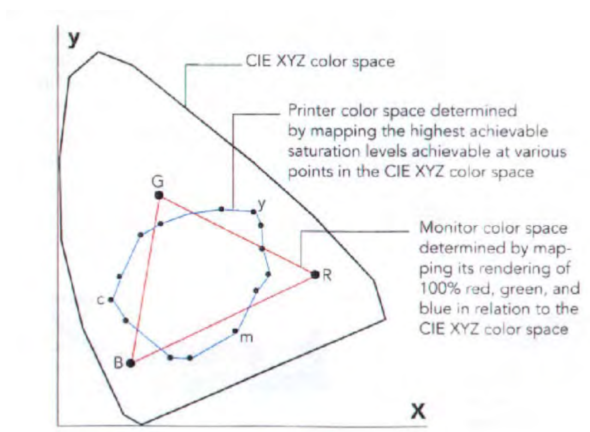


Figure E.15. (Agfa, 1996)

E.9 HOW COLOUR MANAGEMENT SYSTEMS WORK

The diagram in Para 4.8 showing smaller RGB and CMYK colour spaces "mapped" inside the XYZ gam7ut demonstrates the process of gamut compression. This process; happens frequently when one moves colours through the production process: the original scene contains colours that are not captured on photographic film; some colours in the photograph are not within the scanner's colour space, or gamut; and still more colours are lost or replaced when the scan is displayed in a monitor's gamut. By the time the image is printed on proofing devices and on press, its original gamut has been compressed considerable. At each stage, out-of gamut colours are replaced with the nearest approximate achievable colours.

For example, the Apple ColorSync colour management system helps you keep gamut compression predictable and under control. It utilises the peripherals' profile information to calculate a "common ground" colour space within the framework of CIE XYZ. When the operator uses the profiled peripherals in conjunction with ColorSync, the operator will work only with colours that are in the device colour space areas that "overlap". Within this area, colour space information can be easily translated from one device colour space to the next. For example, the operator can more accurately predict the output colours based on what one sees on the monitor (X-Rite, 1999).

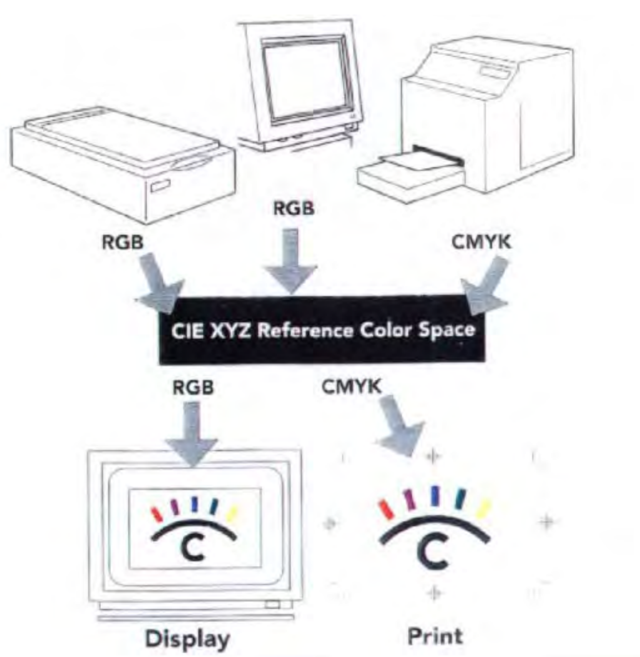


Figure E.16. This diagram demonstrates how a CMS converts scanner, monitor, and printer colour information into CIE XYZ co-ordinates.
Using CIE XYZ as a universal colour "language", the CMS calculates display RGB values that more accurately represent your printer's specific output capabilities.(X-Rite, 1996:34).

E.10 COLOUR FORMULATION

Custom formulation for special spot colours is based on spectrophotometric measurements of various ink and paper combinations. The ink manufacturer typically does this. Now, technological advances in measurement instrumentation and software have brought ink formulation to the printing site, where the actual production paper can be calculated into a custom ink formula that will match the customer's specifications. These affordable solutions, such as X-Rite's QuickInk system, utilised supplied spectral date, specification from existing colour guides, or measurement of the actual sample or swatch.

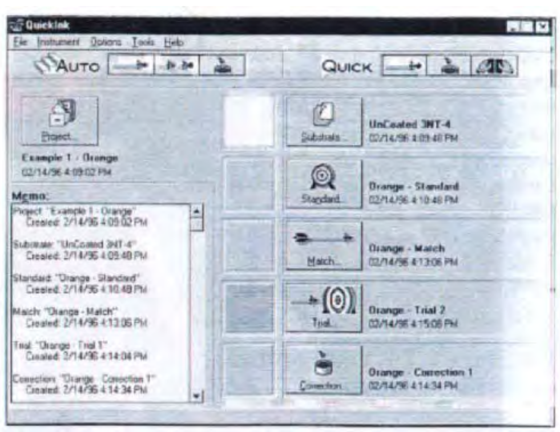


Figure E.17. Quicklink software formulates custom inks to match colour data (X-Rite, 1996).

E.11 COLOUR CONTROL

Colour control – or process control – is critical to achieving consistent, quality colour throughout an entire print job, across different shifts, between printing press operators, or between batches of materials. In any printing or imaging application, colour can vary on a single printed page, and from one page to the next. Measurement information can be used to control these colour variations.

For example, densitometers are used to read colour bars, which are basically small versions of test forms that are printed in unused areas of the printed page. Generally, colour bars provide sample patches (of solid inks, tints, overprints, and special patterns) to test critical print characteristics. Calculations such as density, dot area, dot gain, print contrast, and apparent trap allow press operators to troubleshoot on-press colour problems. Comparing colour bar measurements between printed sheets clearly identifies any changes in printing characteristics.

These densitometric measurements indicate how the press is performing at that time. By comparing measurements of several press sheet colour bars at various intervals during the press run, the press operator can:

Monitor overall press performance over time;

Monitor the performance of the individual ink keys over time; and

Document print quality for clients.

Measurements are analysed in relation to control limits that have been established for the press. Any measurement data that is not within acceptable range of the control limits indicates a possible problem with the process or equipment. Having this information close at hand allows operators to quickly pinpoint problem areas and make fast, seamless adjustments to press settings with minimal waster of materials (X-Rite: 1999).

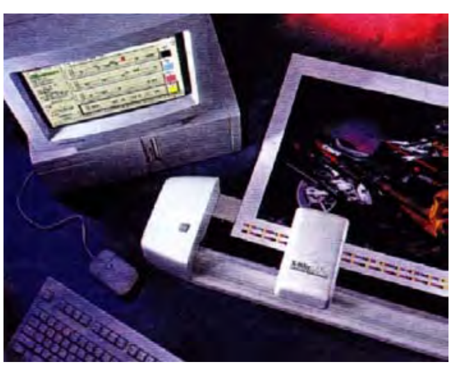


Figure E.18. X-rites Auto tracking Spectrophotometer System automatically measures press sheet colour bars at various intervals throughout the press run.

Measurement data is displayed on a nearby computer in the accompanying ATS software interface.(X-Rite, 1996:36)

Today's newest printing technologies such as Hi-Fi's colour can often be monitored and controlled more effectively with colorimetric or spectral measurement. Hi-Fi printing applications that use CMYK + RGB, or custom touch-plate or bump colours are especially well-suited to process, control using these tools, such as X-Rite's model 938 hand-held spectrophotometer, or the ATS System. As the achievable gamut of Hi-Fi colour printing expands, spectral data will play an increasing role in controlling Hi-Fi's expanded palette of achievable process colours.

E.11.1 Control Limits

As mentioned in paragraph 8.11, any press run will vary in its colour output from sheet-to-sheet, from start to finish. Some variation is normal and acceptable. Control limits are established to ensure that the press run's variation remains normal and acceptable, as drivers typically make subtle steering adjustments. Problems can occur, however, if the vehicle – or the press' performance – suddenly veers beyond the lines.

Control limits are most commonly monitored using frequent densitometric measurements taken from press sheet colour bars. For example, the Auto Tracking Spectrophotometer system features an accompanying software package displays the measurement data in graphical formats that show press performance trends over times. These linear graphs quickly identify any ink density measurements that are much stronger or weaker than acceptable.

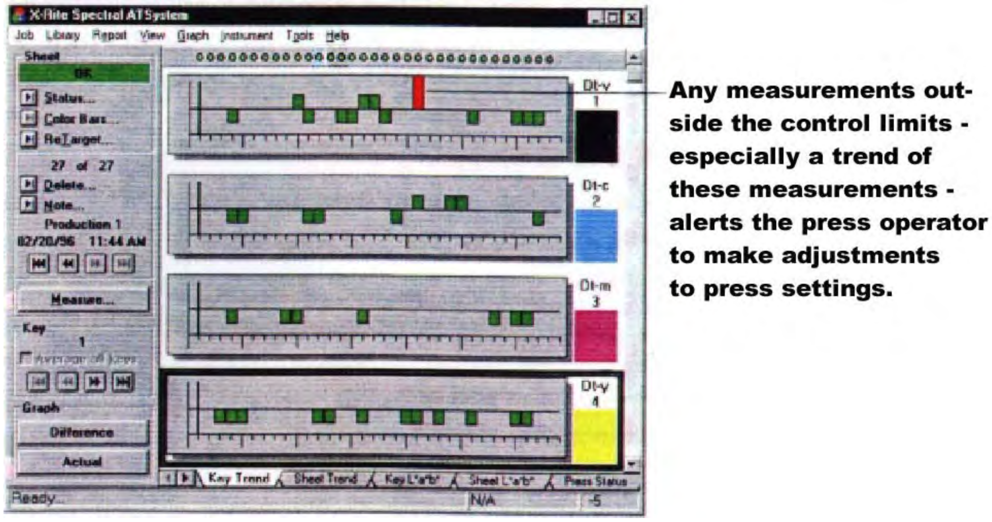


Figure E.19. These graphs in the ATS software represent multiple colour bae measurements over time.

The horizontal centre line of each graph is the optimal density value, and the lines above and below the centre line are the acceptable limits for density variation (X-Rite, 1999).

E.12 COLOUR VERIFICATION

Another key benefit of colour measurement is the ability to monitor colour accuracy at each stop of the reproduction workflow, and ultimately verify that customer specifications have been achieved as closely as possible.

Verifying that the actual ink colours are correct – especially non-process ink colours – requires the capabilities of a colorimeter or spectrophotometer (a densitometer can also be used on these special colours, but typically only to measure strength). Because spectrophotometers can function as densitometers and colorimeters, they are the most logical and versatile method for controlling and verifying the quality of colour reproduction (O’Leary, 1998:76-82).

E.12.1 Colour Tolerances

Verification between colour specifications and actual colour results in achieved by using tolerances that are based on numeric colour measurement data. Colour tolerancing involves comparing the measurements of several colour samples (the colour output) to the data of a known colour standard (the specification or input). Then, the "closeness" of the samples to the standard is determined. If a sample's measured data is not close enough to the desired standard values, it is unacceptable and adjustments to the process or equipment may be required.

While control limits and colour tolerances are separate considerations, the production workflow and print job should be set up with both parameters in mind. In general, a project should never have customer specifications that cannot be achieved within the printer's control limits (X-Rite: 1999).

The amount of "closeness" between two colours can be calculated using a variety of colour tolerancing methods. These methods calculate the "distance" between two sets of measurement co-ordinates within a three-dimensional colour space such as L*a*b*. The most common methods are CIELAB and CMC.

E.12.2 Setting up Images for Printing

Images can be resized using image-processing software such as Adobe Photoshop. Merely enlarging the image can result in the pixels appearing bigger and jagged edges forming around objects. If interpolation is applied this effect is avoided, but at the cost of a reduction in sharpness and edge definition (Agfa-Gevaert, 1996:26). Most references recommend that sizing be done at the image capture stage.

E.12.3 Sizing Images

There is a range of file formats that images can be stored and used in. In the graphics industry tagged image file format (tiff) and encapsulated postscript (EPS) are the most common formats (Agfa-Gevaert, 1994:36). Files created for digital printing are often of large size, between 5 MB and 100 MB. Most image compression software causes a reduction in image quality and so CDs, optical discs, Zip discs and other devices are often used for storage.

E.12.4 Colour Modes

File formats offer the options of storing images in a particular mode. Image processing software can transform images from one colour mode to another. Common modes are RGB, cyan, magenta, yellow and black (CMYK), Lab colour and greyscale. It seems to be accepted that the best option is to leave the file in its original scan format and to allow the operator or raster image processor (RIP) software to do the conversion to CMYK or any of the extended gamut modes (Muller, 2000).

Bureaux generally give clients detailed information regarding all of these aspects. Stonehouse Graphics gives clients a hand out on “File Preparation for Digital Printing” which covers media, file formats supported, application programmes supported, file preparation, scanning, colour, orders and deadlines (Alfresco, 2000).

E.12.5 Image Manipulation Software

Making colour, brightness and contrast corrections using image-processing software, is standard practice. To Adobe Photoshop 5.0 Users Guide contains a chapter on “Reproducing Colour “Accurately” (Adobe, 1998:79 – 101) and correcting the colour and tonal range of an image (Adobe, 1998: 105 – 130). Within the image manipulation software, images can be changed from one mode to another. This can be a highly influential factor, when it comes to both colour accuracy and tonal range. In some colour copier machines, if an image is sent to the RIP in RGB mode instead of CMYK, the print can appear to be washed out, with de-saturated colours and the black areas will print as greys (Parker, 2000).

Another type of software, which assists in achieving colour accuracy, is colour management software. This is an extensive field on its own, what follows is a brief explanation.

E.12.6 Colour Management

These days colour management includes software and hardware that can adjust the colour of images when they are captured, designed or processed by computer software or RIP, viewed on monitors, and when images are printed. Very simply what colour management does is to relate each device's colour gamut to a standard colour space (Agfa-Gevaert, 1994: 34). It can assist in achieving certain results, as DiCosola (1998:71) writes, "the goal of colour management is to reduce waste and increase productivity. This is achieved by giving you more consistent, automated predictable colour results – in other words, getting the colour correct the first time." O'Leary (1998:77) however, emphasises the technological side of colour management "'Colour management' as we are currently hearing about it, really pertains to the landslide of standalone [sic] calibration and profiling software (generally classified as Colour Management Systems or CMS), along with colour-measurement instruments with which they interface."

E.12.7 Colour Models

There are a number of models used for representing colour values, such as the CIE (Commission Internationale de l'Eclairage) and Munsell systems. The CIE LAB system has been the standard model since 1976 (Agfa-Gevaert, 1994:33). LAB colour is device independent and based on the colour range that a standard observer can distinguish. The goal of such a model is to provide a universally recognised system for colour matching or "to develop a repeatable system for colour communication standards for manufactures of prints, inks, dyes, and other colorants" (X-Rite, 1996: 16).

In Figure 8.20 this model is represented, with L,A,B axes. A denotes the green/red value, B the yellow/blue value and L the lightness of the colour. When colours are allocated LAB values they can be moved from one colour space to another and will retain their accuracy.

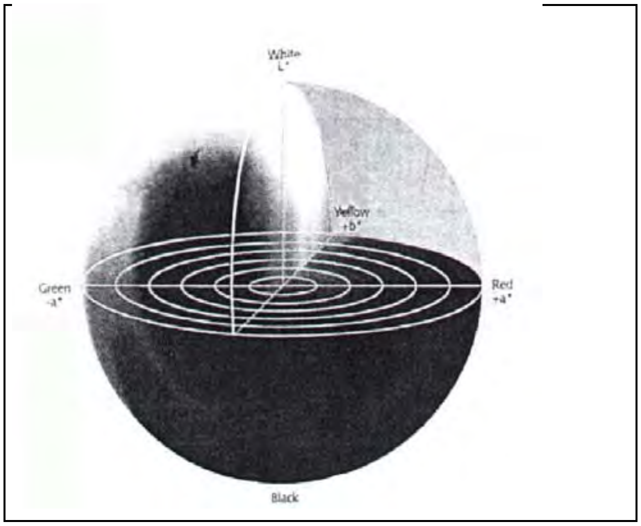


Figure E.20. The CIE lab model for representing colours.
(Agfa-Gevaert, 1994, p. 33)

E.12.8 Colour Space

A bitmapped image represents all its areas (pixels) as numbers or a series of numbers. In order to represent a coloured area the numbers need to specify very precisely, what tone of what colour is in a particular area.

Each piece of hardware in the image capture, processing and reproduction process has what is termed its own colour space. Aaland and Burger (1992:84) give a simple explanation of this, “a ‘colour space’ is just a mathematical model used to describe the colours of an image.” Most scanners, digital cameras and monitors operate in the RGB space while digital printers often use the CMYK space

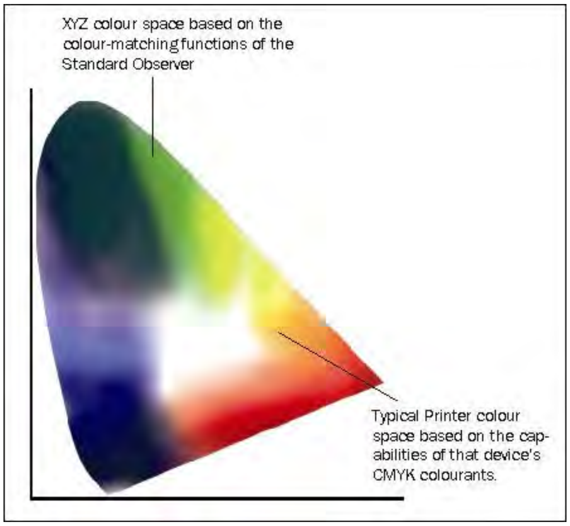


Figure E.21. Colour gamut of a typical CMYK colour printer.
Adapted from (X-Rite, 1996: 15)

Unlike the human eye, which can recognise millions of colours, scanners and digital printers can only capture and reproduce a limited range or gamut of colours. A typical CMYK printer gamut is illustrated in Figure 8.21. Because of gamut limitations, compression of colour information from the original artwork occurs at each stage. When a scan is made the gamut limitations of the scanner will cause compression, as will the gamut limitations of the monitor or the printing device. In most cases colours that approximate the original colours replace out-of-gamut colours.

To ensure that colour information received from the input device, viewed on the monitor and then output to the printer, remains accurate colour management software is essential. To this end a number of companies have brought out appropriate software, the aim being to bridge the gaps caused by moving information from one colour space into another.

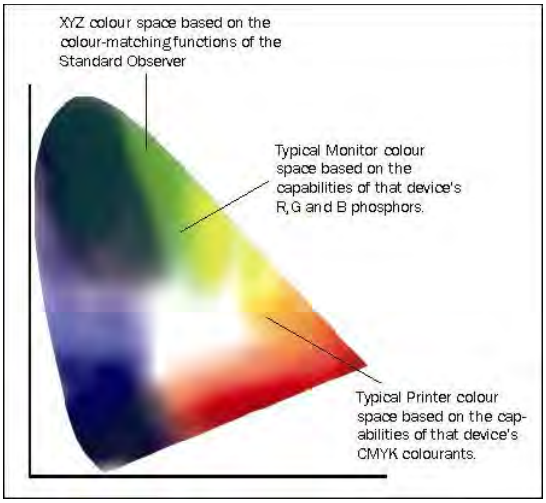


Figure E.22. Comparison of the gamut seen by a standard observer and then reproduced by a monitor and a CMYK printer.
Adapted from (X-Rite, 1996: 15)

An example of colour management software that is relatively freely available to e-entrepreneurs is ColorSync. In principle what ColorSync is designed to do is to tag information onto a file, that will stay with it from scan to output stage. At the scan stage an International colour Consortium (ICC) profile of the image is tagged onto the file. This profile can contain information regarding the original source, the scanner characteristics and the final output device and its characteristics If the output device has a colour management system that can read ICC profiles it will be able to read the tagged information and make the appropriate adjustments (Green, 1997:12 –14). Theoretically, this will result in better colour and tonal results; however there has been some criticism of the system. As O'Leary points out, embedding profiles at the scan stage leads to compression of the colour gamut, limiting the final output (1998: 78).

When images are sent to a printer, the RIP is instructed to treat them according to a specified profile. This will influence the appearance of the final print, some profiles will result in warmer or cooler colours, and others will increase the saturation of the colours and alter the tonal range (Van Eck, 1999).

Even with colour management, many experts still feel that expertise on the operator's part is an intrinsic aspect to achieving accurate colour (O'Leary, 1998:78 – 82). What does seem obvious is that colour management is becoming more available to the individual artist. Hopefully, in the future the use of expensive measuring devices can be eliminated and colour calibration, management and measurement could all be built into a reasonable priced and easy to use package.

E.13 OUTPUT

In order for digital printers to print colour as accurately as possible, their colour performance needs to be maintained and they need to be able to cope with unusual or out of the ordinary images and still produce accurate colour. These aspects are controlled by calibration, software systems and printer profiles. Most printers have a basic calibration process where the amount of ink or toner laid down is measured and adjustments made to compensate for this. This calibration can also take care of aspects such as head alignment and whether the substrate is feeding through the machine correctly. This type of calibration is done whenever the ink or the substrate is changed. Some devices are sensitive to humidity and temperature changes and so need to be calibrated more often.

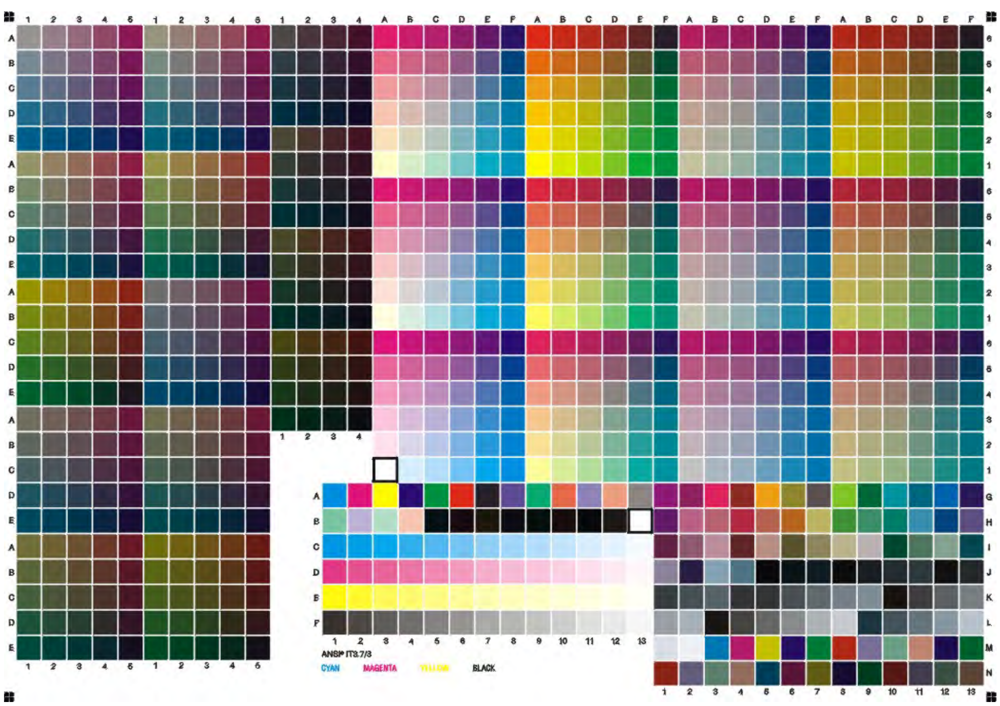


Figure E.23. IT8.7/3 reference chart for output characterisation.
(Agfa-Gevaert, 1994:35)

When used with colour management software (CMS), calibration becomes more complicated and sophisticated. A standard reference file such as the IT8.7/3 seen in Figure 6, consisting of a range of different colours, black, white and tones of grey is printed. A colorimeter or spectrophotometer is then used to measure the densities achieved in the various colours. This information is fed back to the CMS and a profile is created (Agfa-Gevaert, 1994:35). A profile for each ink or substrate combination can be generated.

E.14 THE PRINT OPERATOR

In an ideal situation "studios still need to have a fine art printmaker on staff, otherwise they are going to loose contact with artists" (Duganne, 1999:52). In South Africa bureaux print mostly for commercial clients with fine art clients providing less than 1% of their business (Maio, 2000). Very few commercial bureaux have operators that understand fine art printing. Operators are often skilled at printing images if an accurate proof, material swatches, or the original artwork is provided. This is even the case at some fine art print companies in the USA as Malek (1999:60) points out, "even when working from transparencies, most printmakers still prefer having originals in-house."

E.15 FINISHING

Digital prints are often of large scale and exhibiting them can require them to be finished in a particular way. This is in order to ensure that they can be transported and displayed easily, that they are not easily damaged, that they will not fade quickly and to enhance their appearance. In the commercial world, lamination, mounting and liquid clear coats are standard finishing techniques applied to digital prints, especially inkjets. For the fine artists, framing and other finishing techniques might also be applicable.

Lenticular prints are fashionable printing and finishing techniques at present. The technique, which uses a variation of the old Lenticular colour process devised by Lippmann, creates an "illusion of movement, depth, animation, morphing, or three-dimensional space" (Krause, 1999: 46). The print can be made up of a number of different images that are broken up and printed as thin strips next to each other. Strip plastic lenses, angled at different pitches, are placed in front of the image. This enables the viewer to only see one image at a time, but if he or she moves a new image is revealed.

E.15.1 Lamination

Most lamination material consists of a layer of film onto which adhesive is coated. Laminates can be applied to the front side only or to both sides (encapsulation) of a print. There are four main types of laminates:

- Cold, which uses pressure only,
- Hot of thermal, making use of heat only and
- Multi-heat or heat assisted laminates, which make use of heat and pressure.
- Wet transfer laminates allows the colour of a digital print to be embedded into the laminate, after which the paper substrate is peeled off. This system has very specific applications and is more geared for sign making than continuous toned images.

Cold laminates are made up of plastic film, a layer of clear adhesive and a release sheet. The release sheet is peeled off and under pressure the laminate adheres to the print. Thermal laminates consist of an outside layer of polyester film combined with an inside layer of polyethylene. They require temperatures of between 200 and 300 degrees Fahrenheit to bond with the print (Edlund, 1996: 50).

The laminating film is classified according to the process, the thickness and the surface of application. Some of the surface types that are available are glossy, matt, black, white, magnetic backing, dry erase for writing on, pebbling, leather and embossed. Although the method of quoting thickness varies, they generally range between 3 and 10 mm (IRGA, 1998:7).

Figure E.24. A laminating machine, with laminate on the top and bottom rollers. (Lamination Station. 1999).

Laminating prints can vastly influence their longevity. Edlund (1996:84) points out that "a laminates ability to protect an image from UV light varies greatly between standard laminates and specifically formulated UV laminates. The differences between then can translate into a vastly extended life of the graphic." Professional laminating is a complex process requiring the operator to fee the film and print through a machine while ensuring that the temperature, pressure and speed are all correctly set. Matching lamination material to the print and image type is also critical, as thermal wax and some piezo inkjets, cannot withstand heat laminating and would be damaged by the process. The visual appearance of an image can also be enhanced or degraded by lamination. Glossy films tend to enhance brilliant colours, while a matt surface will reduce contrast and subdue colours. The fact that the print can be sealed off from the environment will also protect if from chemicals, water, scratching, and graffiti and may other damaging factors.

E.15.2 Mounting

Through mounting, graphics are attached with adhesive to a rigid substrate, once again adhesives that are activated by pressure along or heat and pressure may be used. For commercial applications, polystyrene and polyvinyl chloride (PVC) foam sheets are the most popular, but prints can be stuck to almost any support (IRGA, 1998: 17). Once again great care has to be taken to use the correct materials combination to match the final application of the print.

Figure 8.25 shows a photograph of an inkjet print that was laminated on the front, and then attached to a porous plastic substrate. When it rained the water passed through the plastic backing and the water-soluble ink leached out of the print (Pretorius, 2000).

Figure E.25. Photograph of the discoloration caused by ink leaching out of a thermal inkjet poster.
(Alfresco, 1999)

E.16 SUMMARY

This chapter has introduced the operating entrepreneur to the subjects of colour communication, measurement, and control in a format that has been clear and interesting (see Annexure E). Behind each concept and process briefly covered in this chapter for knowledge of colour production. However, the information in this chapter will help the entrepreneur get started in the world of colour measurement and control, by providing a basic explanation of colour science and theory, the different tools used to measure colour, and the different stages of the production process where colour measurement is important. With this knowledge in hand it recommends that the entrepreneur continue their studies by reading the excellent literature that is listed in the bibliography.

The key point to remember is if the entrepreneur can measure colour, then they will be able to control colour. Without measurement, describing and verifying colour can be ambiguous and unreliable. With numerical measurement data, however, colours can be described and verified with precision and confidence.

It can be seen from the scope of factors addressed in this chapter, that to achieve perfect print quality is the goals of numerous manufacturers of materials, hardware and software, as well as groups of experts in the fields of colour standardisation. The input stage is critical as it is highly influential in determining the colour balance, tonal range, highlight and shadow detail, sharpness, resolution and the size of the final print. Additional aspects, such as corrections made by the print operator, or automatically by colour management software will also affect print quality. If the operating entrepreneur wants to achieve print accuracy, this chapter emphasises that all the equipment used must be correctly calibrated. The following chapter identifies the Commercial applications of large format digital prints.
For the purpose of the study, the important findings from the chapter are:

- The entrepreneur needs to have a sound understanding of colour communication, measurement, and control in order to ensure that their product and service is consistent
- The entrepreneur needs to consider the external factors such as hardware, operators, and software that will influence the final product

ANNEXURE F

LARGE FORMAT DIGITAL PRINTING TECHNIQUES

F.1 INTRODUCTION

After a brief outline of the large format digital printers available, this chapter deals with the types of printers that are available to the entrepreneur. Gathering technical information about the various digital printers relatively easy, with most companies publishing comprehensive brochures both on paper and on-line. However, detailed technical information about how some large format digital printers print images is not as easy to find. Many companies are not prepared to publish detailed descriptions of the technology or the materials used. There are a number of good sources of information on the inkjet processes, but information on for instance the Fuji Pictography process is not readily available. Some processes therefore, are discussed in more detail than others are.

Where possible the technique each printer uses to lay down colour, will be described in detail and in Table 7.1 aspects such as dpi, maximum print size, available substrates and other aspects will be listed.

A separate section on inks and substrates is included in this chapter, as these are technical aspects that effect print quality.

F.2 PREPARATION FOR PRINTING

An image viewed by a graphic designer on a computer screen goes through a number of stages before it can be printed. There are many software programs available to the graphic artist who can use them to create images or to manipulate existing images. A small sample of the software programs that are available, are Adobe PhotoShop, Adobe

Illustrator, Macromedia Freehand, QuarkXpress, Adobe PageMaker, Fractal Design Painter and Corel Draw.

Some programs create images as vector graphics where each point on a line or curve would be defined by a mathematical description. Printers are not capable of understanding of printing this type of information and so all vector images must be converted to bitmapped or raster images in order to be printed. A bitmap image consists of a grid made up of pixels. Each pixel has a location and can be assigned a colour value. Bitmap images are very commonly used to produce imagery, because they can represent subtleties of tone and gradations of colour accurately. Raster Image Processors (RIP) are needed to process all vector images into bitmapped images. Some RIP is built into the printers themselves as print controllers. Others are purchased separately and can act as document servicer RIP, or stand-alone RIP software can be installed into an existing workstation. The workstation can also be used to run other application.

F.2.1 Raster Image Processors

RIP has four main functions: rasterizing images for output, scaling images, controlling colour and driving one or more output devices. The first step in the process is to separate the image into the appropriate colour values. These can be CMYK for most inkjets, RGB for digital enlargers and other variations for extended gamut inkjets.

Unlike traditional printing processes, most digital printing does not require images to be screened. However, because most digital printers build up an image by laying down minute dots, images are broken up into dot patterns. The system used to control this is called dithering. The most common form of dithering is stochastic screening; it can also be called frequency modulated (FM) screening. The stochastic screening system relies on using very small dots of the same size to build up an image and varying the spaces in-between the dots, thereby producing a seemingly random pattern. Second order FM screens vary both the dot sizes and the spaces between the dots in a random pattern (Somerville, 1999:1).

RIP have colour management software built into them and can transform images to match the ink limitations of specific devices. When a dot is printed onto a substrate, the substrate's absorbency will significantly effect the size and density of the dot achieved, dot gain or dot loss will occur. When processing images, RIP can be instructed to take the final output media into account and will therefore make adjustments regarding dot gain. This will be described in more detail in section 3.9 when substrates are discussed. RIP control how solid black is printed, using pure black ink or building it up as a combination of black and the other inks, the latter takes less time to print and improves drying times and finishing capabilities. Specific image characteristics can also be taken into consideration when images are processed, for instance, if the image is photographic or contains process colours; the RIP will make appropriate adjustments to achieve the best results.

F.3 DIGITAL PRINTERS

The following printing devices were identified as operating in the South African large format digital printing industry: thermal inkjet, piezo-electric inkjet (piezo inkjet), continuous flow inkjet, airbrush/aerosol inkjet (airbrush inkjet), thermal wax, dye sublimation, digital enlargers, film recorders, image setters, Fuji Pictography, laser, colour copiers and large format electrostatic.

F.3.1 INKJET PRINTERS

Inkjet printers come in a variety of sizes from desktop models that take 1300mm wide paper sheets, to super large format devices that print on 6,4000 cm wide rolls of media. Most wide format digital printing originated from the reprographics industry and today it is an extensive growth market.

The company IT Strategies predicts a continuing growth in the number of wide format inkjets, from 62,895 machines in the USA in 1998 to 259,386 by the year 2003 (IT Strategies, 1999:16). Otsuki predicts that the display models in Europe will increase from

2,000 in 1994 to 70,000 by the year 2000 (1996:4). It is generally accepted that this type of printer will dominate the commercial large format digital printing market for some time to come.

Large format printers usually consist of a sturdy stand onto which the print head, paper rolls and paper advance machinery is attached, see Figure 7.1. There have been some recent developments of flat bed inkjets, where the inkjet heads can be positioned above a rigid substrate. In both systems the print head unit contains print heads for each colour (CMYK), the unit runs above the surface of the substrate, while spraying on the inks. Some inkjet heads only spray while the unit moves in one direction, the faster models spray on ink while the head runs in both directions these are called bi-directional machines.

Figure F.1. An example of a large format inkjet printer.
Adapted from Alfresco, 2000

Each print head may be a sealed unit, which has to be replaced when the ink is used up, or the head may be refilled, these heads are usually attached to refillable ink containers by thin tubes. Figure 7.2 shows the four inkbottles that can be refilled.

Figure F.2. The refillable CMYK ink containers (Alfresco, 2000)

In the vertical units, the print head unit moves across the substrate horizontally, the substrate is fed through the machine vertically, thus a line (or many lines) of ink are sprayed, the substrate advances and the next line of ink is sprayed. The inkjet heads spraying ink onto the substrate are illustrated in Figure 7.3.

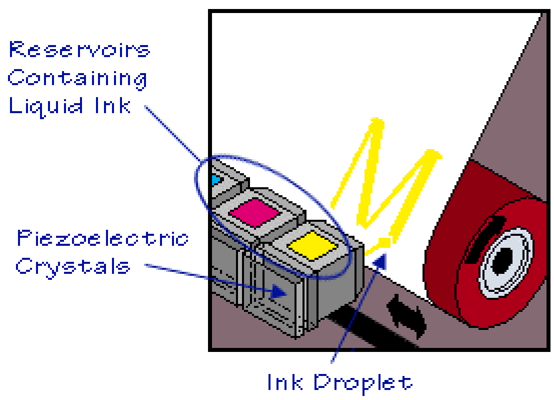


Figure F.3. Inkjet heads moving over the substrate while spraying on ink droplets. (Eastman Kodak, 1999)

Take-up spools and fans for drying the printed section are options that some manufacturers offer. Other than the super wide (5 to 6.4 m's') devices, most can be placed into an average sized room and do not require any special ventilation. Inkjets can be divided into two broad categories, continuous flow and drop on-demand inkjets (Le, 1998). Within these categories are further refinements as to how the technology is used.

The following list of inkjets is divided into general categories using the commercially recognised names.

F.3.2 Thermal Inkjet

Although the thermal inkjet (see Figure 7.4) technology had been invented by Canon scientist in 1979 (Le, 1998), it was only in 1993-94 that Vivigraf, Encad, Hewlett Packard and Lasermaster applied it to large scale printing (Otsuki, 1998:2). In the print head a resistor heats the water-based ink until it expands, creating a micro-bubble of air, which forces out a droplet of ink onto the substrate. This is illustrated in Figure 7.5. Once the ink droplet is released, the temperature of the ink in the head drops and the cycle begins again. A complete cycle can take as little as 5,000 MHz (cycles per second) (IRGA, 1998:3). The resulting printed droplets are tiny, between 50 and 60 microns in diameter (Anderson, 1998).

Figure F.4. A large format thermal inkjet printer (Selex, 2000)

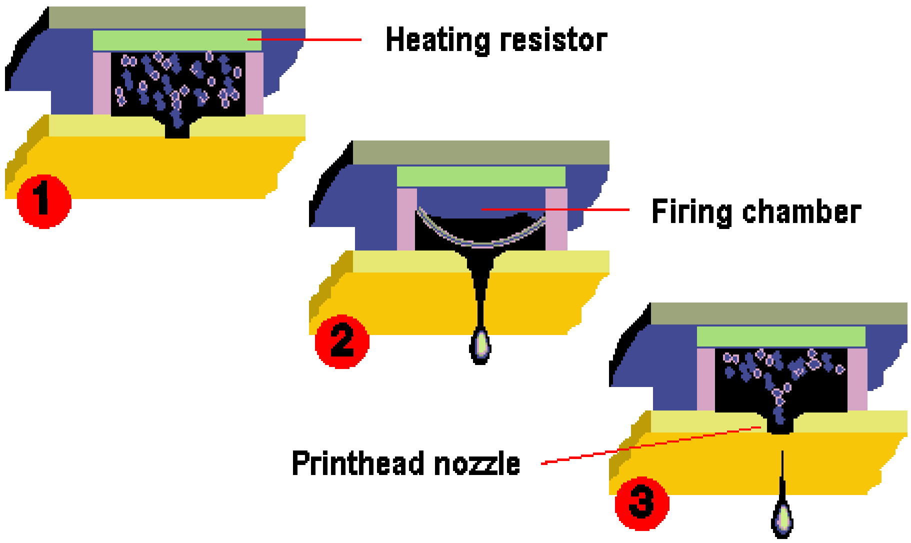


Figure F.5. The heating and firing cycle of a thermal inkjet head (Anderson, 1998)

The thermal inkjet printer is relatively maintenance free and reliable, it can deliver a wide range of colours, but tends to print rather slowly. In early models only dye-based inks could be used because of the heating of the ink. Today some manufacturers provide pigment inks. The high temperatures that are required to heat the ink may cause problems such as kogation. Kogation, which is the accumulation of deposits at the nozzle of the print head, will cause the nozzle to clog up resulting in uneven printing. A further drawback pointed out by the IRGA (1998:4) is "thermal inks … are extremely dependent upon the receptor coating of the printable media for everything from basic adhesion to print characteristics."

Because of these drawbacks, thermal machines appear to be reaching the end of their usefulness. Jordaan (2000) of Xerox SA has indicated that the company has already started phasing out thermal printers and replacing them with piezo machines.

F.3.3 Piezo-electric Inkjet

Piezo inkjet technology, developed by Epson, was introduced into the large format digital printer market in 1997 (Otsuki, 1998:2). Epson and other manufacturers continue to use this system in their desktop printers. The print head has a number of piezo crystals placed behind the inkwells; an electrical charge is applied to the crystal causing it to oscillate, thereby forcing the ink out of the nozzle. Figure 7.6 provides an illustration of this process.

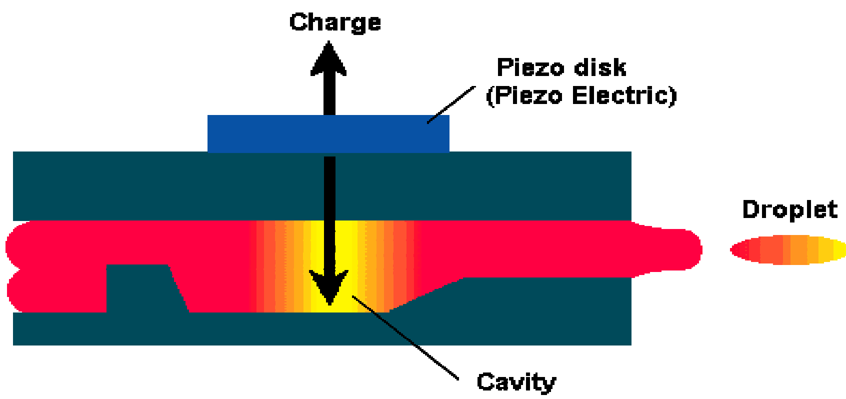


Figure F.6. A droplet of ink fired out of the ink chamber by a piezo crystal (Anderson, 1998)

This system allows for smaller droplets and control over the shape, size and position of the ink droplets. The inks do not have to withstand heat and so can be designed with fast drying and longevity qualities in mind and pigments and solvent inks can be used (Anderson, 1998). Print heads for these machines are semi-permanent, which make them more reliable, and brings down running costs. The piezo inkjet machines are becoming more and more popular, offering excellent image quality. This applies to the desktop models and the super wide printers with widths of up to 6,400 cm and the ability to print onto a variety of substrates, fabric, and floor covering and including carpets.

F.3.4 Extended Gamut Inkjet

Recently a number of companies have introduced extended gamut printers, once again some desktop models offer this option, as do some large-scale printers. There are a number of approaches used by manufacturers to extend the printing gamut. ColorSpan brought out an eight-head machine that has three cyan and three magenta densities, plus the usual yellow and black, this falls into the Super CMYK category. Lexmark and Roland have taken the option of including two cartridges, one containing CMY and the second containing black, (G) green and (O) orange, the hi-fi option.

More recently ColorSpan introduced a twelve-head machine, (see Figure 7.7) that offers the option of mixing a number of ink colours. They offer a hi-fi set with CMYKOG, a red and blue set with CMYKRB and an orange, blue, set with CMYKOB. In addition to this are high-resolution variations, which would include light and medium cyan and magenta, as well as the other standard inks (ColorSpan, 1999:7). Manufacturers claim that the additional inks enable the printer to truthfully reproduce a far greater range of colours and to render subtle gradations as well as vibrant colours far more effectively. The hi-fi inkjets were designed primarily to produce proofs for the traditional Pantone six colour HexaChrome printing system that also makes use of additional colour plates and inks. The heads used in these printers often use piezo technology.

Figure F.7. Twelve print heads on an extended gamut inkjet
(ColorSpan, 1999:4)

F.3.5 Continuous flow inkjet

Iris Graphics developed a version of continuous flow technology in which ink is forced at high pressure through nozzles made of glass. In the nozzle a micro-crystal oscillates, breaking the stream of ink and so separating the flow of ink into millions of droplets. Some droplets are allowed to exit the nozzles and others are not, this achieved by applying an electrical charge to selected droplets, uncharged droplets are diverted back into the ink stream. This is illustrated in Figure 7.8. The software controls the selection of the droplets and where they fall on the substrate.

Figure F.8. Continuous flow ink jet printer.
(Scitex, 1999)

In most continuous flow machines the media is taped onto a drum that spins while the print head transverses it. The distance between the head and the media in some machines is adjustable, meaning that a wide variety of substrates can be used, even for instance, hand made paper. When prints use specific inks and substrates are printed using this technology they are referred to as Giclée prints. See Figure 7.9.

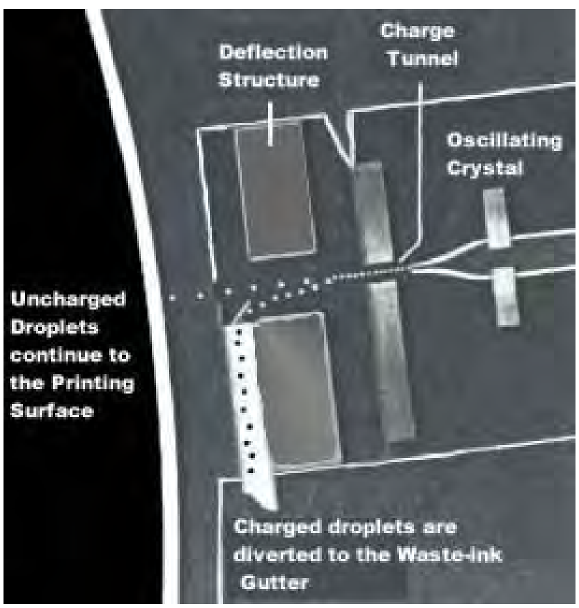


Figure F.9. Illustration of a continuous flow inkjet firing system
(Understanding digital, 1999)

These machines, with an effective dpi of about 1,800 can print exceptionally high quality images because according to IRGA (1998:5)"each dot is a mixture of CMYK and dot size can be varied." This overlapping dot is illustrated in Figure 7.10. Continuous flow inkjet machine s are generally used as proofing devices, but Iris have brought out a modified machine, the IrisGPRINT, designed specifically for fine art applications.

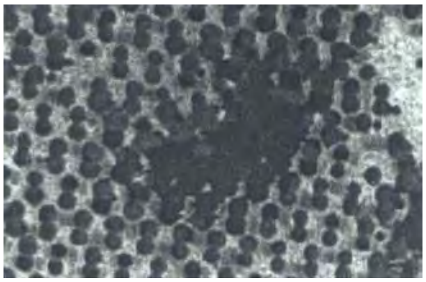


Figure F.10. Close-up photograph of dots printed by the Iris Continuous flow inkjet printer (Lowe, 1996:3)

Unfortunately, there are no IrisGPRINT machines in Africa (Solomon, 2000). There is one bureau in South Africa that does offer the option of printing on more permanent inks and substrates, though not with an IrisGPRINT machine (Streak, 1999). The Iris machines are expensive, rather slow and need to be well maintained. Prints have been tested at the Wilhelm Imaging Research Inc. (Grinnell, IA) and with the right combination of inks and substrate are predicted to have an indoor display life of up to 150 years (Wilhelm, 1999).

F.3.6 Airbrush / Aerosol Inkjet

These systems are used for large-scale printing such as billboards and truck-sidings. A variety of substrate are available for indoor and outdoor use, some machines are even designed to print onto fabrics and carpets. Once again, it seems that piezo machines are gradually replacing these printers. An example of an airbrush machine is illustrated in

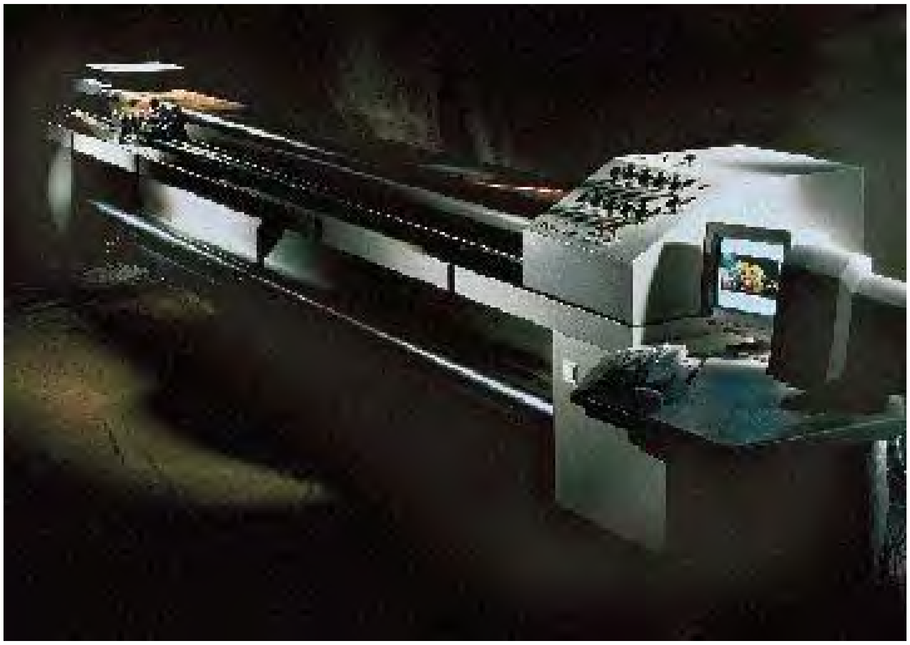


Figure F.11. An airbrush inkjet printer.
(WFDIC, 1998)

F.3.7 Phase-change / Solid Ink inkjet

Solid ink technology is available in a number of machines today. Phase-change relates to the change that takes place when a substance changes from one form to another, such as liquid to solid or vapour to liquid. During the process, solid ink sticks, made up of fatty amide waxes, rosin ester and dye, are melted and the warm liquid is squirted onto the substrate where it solidifies (Tektronix, 1997). To produce a good surface texture the material is then run between two rollers cold-fusing it onto the paper. Some of the advantages of this system are that the inks can be printed onto virtually and substrate that can be handles by the printer.

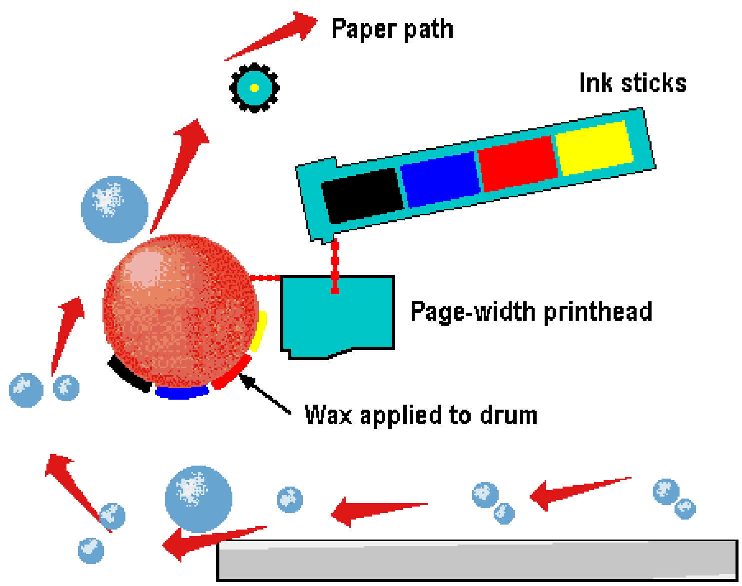


Figure F.12. An illustration of the phase-change Inkjet process (Anderson, 1998)

Le (1998) describes the process slightly differently, more in keeping with the illustration in Figure 7.12. Le's (1998) description follows that the printing process begins by coating a silicon layer onto a rotating aluminium drum followed by ink being jetted onto this drum. When the entire image is printed, the image is then transferred onto a preheated media from the drum by means of a pressure nip.

F.4 DYE SUBLIMATION

Dye sublimation printers were originally developed for textile printing and they rely on the melting of one material in order to transfer its colour onto a substrate. The printers usually have four sheets of plastic film, sometimes in continuous transfer rolls. Each sheet is coated, with either cyan, magenta, yellow or black dye. The sheets are fed across a print head, which contains over 2000 heating elements, these heat the solid ink, changing it into gas, which diffuses onto the paper surface, as is illustrated in Figure 7.13.

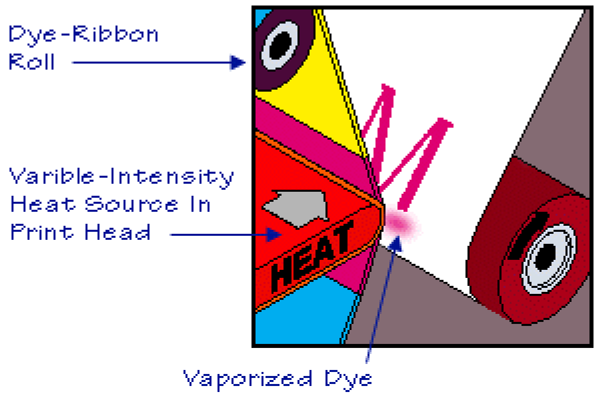


Figure F.13. Heating element of dye sublimation printer vaporising ink
(Eastman Kodak, 1999)

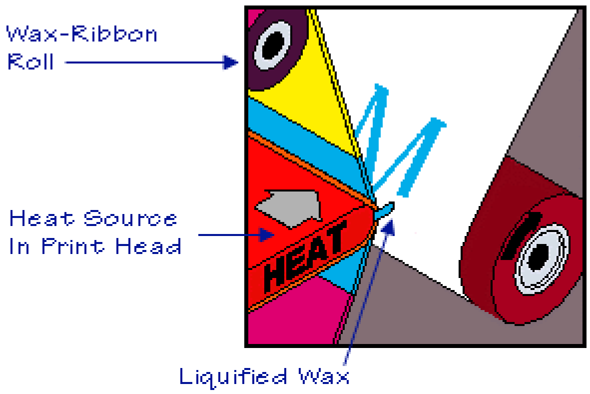
The temperature achieved by each element can be varied thereby influencing how much ink is melted and the colour density of each dot transferred onto the paper. This process results in an image, which is almost continuous tone with a photographic appearance. As apose to a dithered dot appearance, the dyes blend together giving a softer more evenly toned look, as can be seen in Figure 7.14.

Figure F.14. Close –up on the diffused ink pattern from a dye sublimation printer
(Lowe, 1996:2)

Because the four sheets have to be brought into contact with the heads and the substrate at different stages, registration problems can occur, consumables are expensive, only specially prepared paper may be used, the printers are relatively slow and print size is limited.

F.5 THERMAL WAX PROCESS

A similar process to dye sublimation is used in the thermal wax process; in fact some manufacturers offer both processes in one machine. The difference in the thermal wax process is that the ink is not vaporised, merely melted and deposited onto the substrate



and in some machines, the CMYK inks are coated onto ribbons rather than plastic sheets. This is illustrated in Figure 7.15.

Figure F.15. A thermal wax-heating element melting wax onto a substrate
(Eastman Kodak, 1999)

The image is reasonably weather resistant, but the inks may crack when the substrate is

folded. The printing process is relatively fast and office type laser paper may be used. Colours produced are vivid and the process is relatively inexpensive. Image can be transferred onto T-shirts and ceramics and much research has gone into creating large-scale models that are designed to print onto fabric. A number of thermal wax machines are being replaced with phase-change printers.

Figure F.16. An example of a combination dye sublimation and thermal wax printer
(Roland, 1997)

F.6 FUJI PICTOGRAPHY

Fuji introduced the unique peel-apart thermal dye transfer process and these printers produce photo-quality images on a small scale. The machines are small and relatively easy to operate, as they may require water and cassettes of donor and receiver material.

Figure F.17. A Fuji Pictography 4000 printer
(Fuji, 1996:2)

Laser diodes are used to expose the photosensitive donor material and water and heat are introduced to activate the dye image. The dye image on the donor paper is brought into contact with the receiver paper and the image is transferred using heat and pressure. The receiver paper is peeled apart and the donor paper disposed of.

F.7 ELECTROSTATIC SYSTEMS

The following section discusses electrostatic systems namely colour laser printers and large format electrostatic printer.

F.7.1 Colour Laser

The laser printer (see Figure 7.18) has at its centre an organo-photoconductor (OPC) or drum that has a light-sensitive surface. While the drum is rotated past an array of electrodes, its surface is electrically charged. A laser beam is directed by a set of mirrors and lenses at the drum. Where the original image is to be black, the laser beam exposes the drum. Areas that are exposed change polarity and unexposed areas maintain the drums charge. The transfer of ink occurs when toner powder is introduced which in turn is attracted to the exposed areas and repelled by the drum that has the same charge. The toner is transferred onto a sheet of paper that has the opposite charge heated rollers fuse the toner by melting it onto the paper (see Figure 7.19). The drum is scraped clean and ready to go through the next cycle of printing.

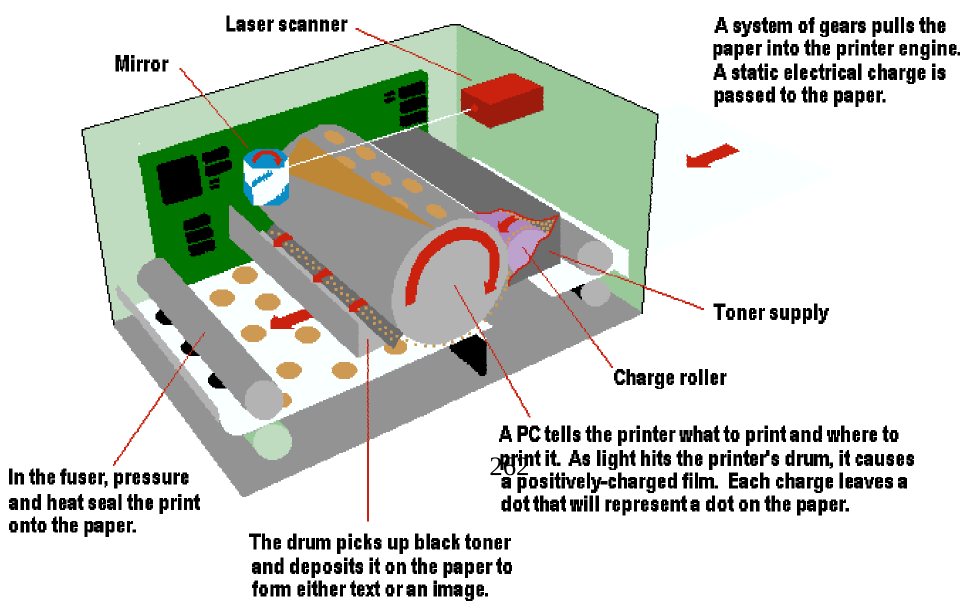


Figure F.18. The main components of a laser printer
(Anderson, 1998:2)

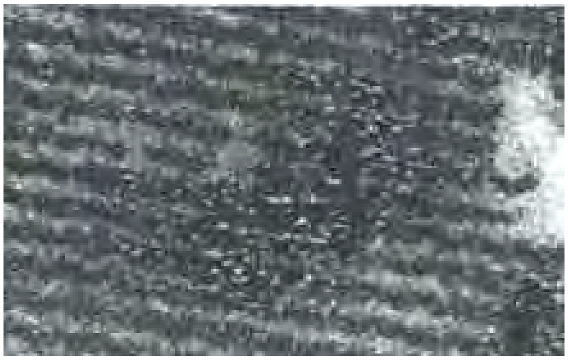


Figure F.19. Close-up photograph of toner fused into the paper
During laser printing (Lowe, 1996:4)

Colour laser printers go through this process four times with the appropriate CMYK toner being introduced. Some cheaper laser printers use LED's instead of lasers. They tend to have a lower resolution.

Colour laser printers produce good quality images and they cannot be matched in terms of speed of output. The chemically inert toners are stable and enhance the longevity of the prints. A small variety of paper and surfaces can be printed on, but size is limited.

F.7.2 Large Scale Electrostatic

Larger format electrostatic systems (see Figure 7.20) were introduced into the market in the late 1980s, costs were initially rather high and resolution low (200 dpi) but today it provides on of the cheapest forms of digital output. The electrostatic system works on the same principal as colour laser or colour copier machines, but prints are generally large scale. The large dot pattern is illustrated in Figure 7.21.

Figure F.20. Large format electrostatic printer
(WFDIC, 1998)

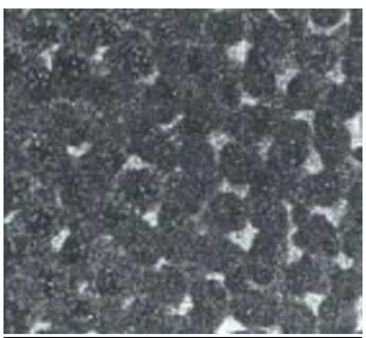


Figure F.21. Close-up of dots of toner printed with the electrostatic process
(Lowe, 1996:4)

The process gives a durable product and print speeds are fast. Substrates can be used for primary graphics or for use as sublimation transfers. This means that the images can be transferred onto the fabric, glass, wood, metal, ceramic, plastic and other materials. This widens the applications for the process, but the process for transferring images onto secondary materials adds to material, equipment and labour-costs. Jordaan points out that inks designed for sublimation transfer are dye-based, and because heat and pressure is used, they penetrate the receiver material and are then partially shielded from UV radiation (Jordaan, 1997:4).

Most electrostatic printers should be operated in a controlled environment with the temperatures maintained between 18 and 25 degrees centigrade and with a relative humidity of between 42 and 55 percent (Jordaan, 1997:39). Prints in the 25 to 250 piece ranges are reasonably inexpensive, depending on the substrate selected. A growing market for electrostatic printing is the fabric printing industry, where images can be transferred onto almost any type of material. Even with the advantages, that this process has to offer, IT Strategies predicts that the number of electrostatic machines in the U.S.A will decrease from 3271 in 1998 to 1902 by the year 2003 (Wilhelm, 1999:16).

F.8 INKS

Inks are made up of a number of different substances and have varying characteristics. It is almost impossible to discuss all the types of inks available for every type of digital printer, and so this document will concentrate primarily on inkjet printer inks. This is because inkjet printers are amongst the most accessible to fine artists and information on these inks is readily available.

Inkjet printer inks have two main components, a carrier base and a colorant. The carrier base makes up between 80 to 90 percent of the inks composition. Most inkjet inks use water as a carrier base, but piezo systems use water, oil (such as glycol ether), solvents or even UV curable carriers (IRGA, 1998:2).

Colorants can be either dye type or pigment based. The dye particles used are minute, less than 50nm and they give excellent colour and a wide tonal range but are not particularly light fast. Dye particles are soluble in water and they pass through print nozzles easily, they tend to be absorbed into un-coated substrates and so an optimum colour gamut is achieved on coated substances. Pigments, which are bigger (between 50 and 100nm), are insoluble and more fade resistant, but do not offer the same colour range. Because they are larger they tend to clog the print nozzles and are not easily absorbed by the substrate; instead they remain on the surface (IRGA, 1998:3)

Water based inks can cause a number of problems. Inks can take some time to dry and while damp, they are prone to smudge and run. Often machines have a built in fan that blows directly onto recently printed-paper enabling it to be rolled up moments after it has been printed.

Environmental issues regarding inks and toners are to a large extent, still being studied. Jones (1999) from the Graphics Arts Foundation points this out in his presentation at the 1999 DIMA (Digital Imaging and Marketing Association) conference. However there are a number of hazardous substances used in inkjet inks such as cyclohexanone, methoxyl – 2 –propanol acetate and diethylene glycol, plus the resins, pigments and dyes. In electrostatic systems, some use naphthol spirits, arsenic alloys, selenium and cadmium salts, as well as pigments and resins (Jones, 1999). While it seems that the inks and toners have to be used in large quantities to attract official notice, care has to be taken with ventilation when machines are placed in working environments. As environmental regulations are tightened, these could become major issues for printers.

F.9 SUBSTRATES / MEDIA

There are wide varieties of substrates available for use with different type of digital printers. These include paper, vinyl, canvas, and polyester, cotton, carpeting, silk, mesh, polymer and clear film, polyethylene, static cling, nylon and vellum. In addition to these, almost any photographic material can be used as a substrate with the appropriate photographic process. Materials are available for reflection prints or for transparent or translucent films.

Paper remains the most common substrate for inkjets and certainly the most popular output media (IRGA, 1998:7). Otsuki estimates the media split for inkjet material is as follows “photo papers 41%, premium coated papers 31%, photo film 15%, backlit film 5%, vinyl 3%, clear film 2%, canvas 1%, others 2%, (Lowe, 1996:11). Papers can be coated or uncoated, generally inkjets achieve better results with coated papers. “The coated sheet holds the dye or pigment high on the surface, unprotected from the effects of the light, while allowing the full colour gamut to show (Boulter and Ingraham, 1999:64).

Inkjet media consists of a base structure, a top receptor coating and sometimes a base or barrier coating. The receptor coating also influences the drying time, which is further, influenced by temperature, humidity and ink coverage. The receptor coatings of substrates are often designed by manufacturers to be used with specific inks. If the substrate and ink are not matched, dot-gain, colour gamut, drying times, reaction to laminates and longevity characteristics can be adversely affected.

For inkjet printing the other materials such as film, vinyl and canvas, all have their own unique characteristics. Generally, the film materials, which can be either white or opaque (for backlit applications), are made out of polyester. Film is often coated on both sides and has the characteristic of remaining very flat. The high gloss finish assists in achieving saturated colours. As the film does not absorb the inks there is little bleed or dot gain, drying times are short and the polyester material is very durable. Vinyl material is both durable and flexible. It can be made with an adhesive backing and it gives good colour and good definition. Artist's canvas is treated with a special embedded protective pre-coating, giving it a very white gloss finish and eliminating fibre peaks. This has the advantage of increasing and reducing dot gain. The material can be stretched across frames, metallic silver and gold foils, which can be manufactured with adhesive backing.

With the specialised fine art Iris machine the range of substances that can be printed on is extended. Smolen (1999:43) quotes Jamie Cook of Cook Editions in Atlanta, GA. "What's so beautiful about Iris and digital printing are the substrates you can print on: board paper, rice paper, garlic paper, paper with bugs or flowers in it, or newsprint."

Laser copiers and colour copiers offer some options when it comes to using variety of substrates. According to Turner (1991:98) "In theory any uncoated paper of a suitable weight (usually around 80gm) can be used on plain paper copiers." Generally paper that is of similar weight to the mass-produced paper used in copiers should work, lightweight tissue paper, flecked and fibrous papers, thin card, handmade paper, foil and tracing paper can be used. As colour copiers feed the paper through the thin channels and electricity and heat are applied to the media, care has to be taken not to damage the machine itself. Some substrates will produce excessive dust while others might feed unevenly and cause jams. Prints made on laser and colour copiers can be transferred onto the receiver materials using acetone, and this expands the options in terms of substrates.

F.10 SUMMARY

The digital printers identified in this chapter can roughly be categorised into printers that spray ink, printer that use heat to melt inks (dye sublimation and thermal wax), printers that use hybrid photographic processes and those that use charged toner particles to form a colour image. The printers all have their specific limitations for instance the laser, colour copier, phase-change inkjet, dye sublimation and thermal wax printers are all limited, in the size of the print that can be made, to approximately 1300mm. Other inkjet printers range from small desktop models to huge super wide models that are over 6.5 meters wide. The technique that each printer uses to create colour influences the quality or the resolution of the image, what inks can be used on what substrates, what colour gamut and tonal range can be achieved and the permanence of the image. The actual appearance and qualities of the prints made out by these machines are tested and discussed in the next chapter, where print anomalies are identified.

ANNEXURE G

RAW RESEARCH DATA

			1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	3R Print, Durban,RSA	3	3	5	1	4	4	4	4	4	3	4	4	5
2	1	Bloemfonten Repro services, RSA	3	3	5	1	3	5	5	4	4	3	4	4	4
3	1	Boegertman Krige,JHB,RSA	3	1	2	2	4	4	5	3	5	4	4	4	4
4	1	Commercial Silk-screening, JHB,SA.	3	1	4	1	5	4	4	3	4	3	4	4	4
5	1	Screening Printers, JHB, S.A	3	2	3	2	4	4	5	4	3	3	4	4	5
6	1	Print Bandies, JHB,S.A	3	3	4	2	5	5	5	4	3	4	4	4	5
7	2	Interpred Graphics Gaberone, Botswana	2	2	5	1	4	4	5	4	4	5	4	4	5
8	3	Color FX, Windhoek, Namibia	3	3	5	1	4	4	5	4	3	4	4	4	5
9	4	Advertising Industries, Harare, Zimbabwe	3	3	4	1	4	4	5	4	4	3	4	3	5
10	4	Omni Graphics, Harare,Zimbabwe	2	3	4	2	5	5	5	5	2	3	3	3	4
11	1	Atage,RSA	3	1	5	1	4	5	5	4	4	4	4	4	4
12	1	Grant Format Digital CC,RSA	3	1	5	1	4	4	5	4	4	3	3	3	5
13	1	Omni Graphics, Cape Town,RSA	3	3	4	2	4	4	4	4	4	3	4	4	4
14	5	World Wide Digital, Sussex, England	3	3	5	1	4	5	5	5	5	5	5	4	5
15	6	The Printway, Doughkeepsie, New York,USA	3	3	5	2	4	5	5	5	5	5	4	4	5
16	6	Page One Digital Printing,Irvine,CA,USA	2	2	5	1	4	5	5	5	5	4	4	4	5
17	5	Mikro Graphics,Llandudno Junction,CC31,9NT UK	2	3	4	1	4	5	5	5	5	5	3	3	4
18	6	Kubin Nicolson,chicago,USA	4	3	5	2	5	5	5	5	5	5	5	5	5
19	5	Digital Prints LTD,Bramley,Leeds	3	4	5	1	4	4	5	4	4	4	4	4	5
20	6	A&E Digital , Houston,Texas,USA	3	3	5	1	3	4	4	4	4	4	4	5	5
21	7	Metro Media Technologies INT. Victoria,Australia	3	4	5	2	3	5	5	5	4	5	5	5	5
22	7	Cartus Maging, Melborne, Australia	2	4	5	1	4	5	5	5	5	5	4	4	5
23	8	Large Format Poster Printing, Toronto, Canada	2	2	5	1	3	5	5	4	5	4	3	3	5
24	5	Aba Banners, Christchurch, England	3	2	4	1	4	4	4	3	4	4	4	3	4
25	6	Gray Graphics, Santa Barbara, CA. USA	2	3	5	1	4	5	5	4	4	4	4	4	5
26	1	Alfresco Full Colour Outdoor Graphics.CC,RSA	2	1	6	1	4	4	4	3	4	4	4	3	4
27	6	Dataconcept Printing, Warminsra, USA	3	4	6	1	3	5	5	5	5	3	4	5	5
28	6	Concept Imaging, San Diego, California, USA	3	3	5	2	4	5	5	5	3	4	4	5	5

29	6	Britton Media Banners, Michigan, USA	4	3	5	2	3	5	5	4	4	4	4	5	4
30	6	Sprint Graphics, New York, USA	2	3	5	1	4	5	5	5	4	4	4	4	5
31	6	Eye Candy Graphics, Denver Colorado, USA	2	3	5	1	4	5	5	4	4	4	4	4	5

14	15	16	17	18	19	20	21	22	23	24	25	26	28	29	30	31	32	33	34	35	36	37	38	39	40	41
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4	4	4	4	4	2	4	1	4	4	4	4	4	4	4	4	5	5	4	3	4	3	4	4	4	3	3
4	5	4	4	5	4	5	3	5	5	5	5	5	5	5	5	5	5	4	4	4	3	4	4	4	4	4
4	5	5	4		2	5	4	5	5	5	4	4	5	5	4	5	5	4	4	4	2	4	4	4	4	4
4	4	4	4	4	1	3	1	4	4	4	4	4	4	4	4	4	4	3	3	3	2	4	4	3	4	4
4	4	3	4	4	3	4	2	3	4	4	4	4	4	4	2	5	5	3	3	3	2	3	4	3	3	3
4	4	4	4	4	2	5	1	4	4	4	3	4	4	4	3	5	5		3	4	1	3	4	3	3	4
4	4	4	4	4	2	5	2	5	3	3	4	4	5	4	4	5	5	2	2	4	3	4	4	3	4	4
4	5	3	3	4	1	4	2	4	4	3	4	4	4	4	4	5	5	4	4	4	3	4	4	4	4	4
5	5	4	4	5	1	4	2	5	5	5	5	5	5	5	3	5	5	4	3	4	2	4	4	4	4	3
4	5	4	4		3	4	1	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	4
4	5	4	3		3	4	2	4	4	4	4	4	4	4	4	5	5	3	3	4	3	4	4	4	4	3

4	4	4	4	4	3	4	1	5	5	5	4	4	4	5	5	5	5	4	4	4	2	4	4	3	3	4

69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
3	4	4	4	2	2	4	1	4	2	2	4	2	5	5	4	5
3	4	4	4	2	3	3	2	4	2	3	3	1	5	4	4	4
3	4	4	4	2	2	3	1	4	3	3	4	1	5	5	4	5
3	4	4	4	2	3	3	1	4	3	3	3	1	4	4	4	4
4	4	4	4	2	3	3	1	4	3	3	3	1	3	4	4	4
3	4	4	4	2	3	4	2	4	2	4	4	2	3	4	4	4
4	4	4	4	2	3	4	2	4	2	3	4	2	3	5	5	5
3	4	4	4	2	3	4	2	4	3	4	4	2	4	5	4	5
3	4	4	4	2	3	3	2	4	2	3	3	2	3	5	4	5
4	4	4	4	3	3	4	2	4	3	3	3	2	4	4	4	4
2	3	4	4	3	3	3	2	4	3	3	3	2	4	5	5	5
2	3	4	3	3	2	3	2	3	3	2	3	2	4	5	4	4
3	3	4	4	3	3	4	2	4	3	3	4	2	5	5	5	5
3	3	4	4	3	3	3	1	4	3	3	3	1	5	5	3	5
3	4	4	4	3	3	3	2	4	3	3	3	2	4	5	5	5
3	4	4	4	4	2	4	2	4	4	2	4	2	3	5	4	5
3	3	4	3	3	3	3	1	3	3	3	3	1	4	4	4	4
4	3	4	4	3	4	4	2	4	3	4	4	2	5	5	5	5
4	4	4	4	2	3	3	1	4	2	3	3	1	3	4	4	4
3	4	4	4	2	3	4	1	4	2	3	4	1	4	4	3	5
4	4	4	4	4	4	4	2	4	4	4	4	2	5	5	5	5
4	4	4	4	3	3	3	2	4	3	3	3	2	5	5	5	5
2	4	4	4	3	4	4	1	4	3	4	4	1	3	4	4	4
4	3	4	3	3	3	4	2	3	3	3	4	2	5	4	4	4
4	4	4	4	4	4	4	1	4	4	4	4	1	4	5	5	5
3	3	4	4	2	3	3	2	4	3	3	3	1	3	2	4	5

3	4	4	4	4	4	4	1	4	4	4	4	1	5	5	5	5
3	3	4	4	2	3	4	1	4	2	3	4	1	5	5	5	5
4	4	4	4	2	3	4	1	4	2	3	4	1	5	5	5	5
3	4	4	4	2	3	3	1	4	2	3	3	1	5	5	4	5
3	3	4	4	2	3	3	1	4	2	3	3	1	5	5	4	5

WORKED DATA

Sample Size = 31								
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
B1_1	31	3.94	0.57	3.00	4.00	5.00	3.73	4.15
B1_2	31	4.58	0.50	4.00	5.00	5.00	4.40	4.76
B1_3	31	4.81	0.40	4.00	5.00	5.00	4.66	4.95
B1_4	31	4.23	0.67	3.00	4.00	5.00	3.98	4.47
B1_5	31	4.10	0.75	2.00	4.00	5.00	3.82	4.37
B1_6	31	3.94	0.73	3.00	4.00	5.00	3.67	4.20
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C1_1_1	31	3.97	0.48	3.00	4.00	5.00	3.79	4.14
C1_1_2	31	3.97	0.66	3.00	4.00	5.00	3.73	4.21
C1_1_3	31	4.68	0.48	4.00	5.00	5.00	4.50	4.85
C1_1_4	31	3.87	0.76	1.00	4.00	5.00	3.59	4.15
C1_1_5	31	3.61	0.50	3.00	4.00	4.00	3.43	3.79
C1_1_6	27	4.44	0.51	4.00	4.00	5.00	4.24	4.64
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C2	31	4.81	0.40	4.00	5.00	5.00	4.66	4.95
C3	31	4.71	0.46	4.00	5.00	5.00	4.54	4.88
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C4_1_1	31	2.84	0.69	2.00	3.00	4.00	2.59	3.09

C4_1_2	31	3.16	0.45	2.00	3.00	4.00	2.99	3.33
C4_1_3	31	3.16	0.58	2.00	3.00	4.00	2.95	3.38
C4_1_4	31	3.10	0.87	1.00	3.00	4.00	2.78	3.42
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C5_1_1	31	2.68	0.65	2.00	3.00	4.00	2.44	2.92
C5_1_2	31	3.10	0.40	2.00	3.00	4.00	2.95	3.24
C5_1_3	31	3.13	0.62	2.00	3.00	4.00	2.90	3.36
C5_1_4	31	3.03	0.87	1.00	3.00	4.00	2.71	3.35
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C6_1_1	31	2.74	0.58	2.00	3.00	4.00	2.53	2.95
C6_1_2	31	3.23	0.56	2.00	3.00	4.00	3.02	3.43
C6_1_3	31	3.00	0.63	1.00	3.00	4.00	2.77	3.23
C6_1_4	31	3.03	0.41	2.00	3.00	4.00	2.88	3.18
C6_1_5	31	3.32	0.65	2.00	3.00	4.00	3.08	3.56
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C7	31	4.39	0.62	3.00	4.00	5.00	4.16	4.61
C8	31	4.45	0.72	2.00	5.00	5.00	4.19	4.72
C9	31	4.52	0.68	3.00	5.00	5.00	4.27	4.76
C10equit	31	3.06	0.96	1.00	3.00	5.00	2.71	3.42
C10debt	31	2.84	0.93	1.00	3.00	5.00	2.50	3.18
C11	31	4.26	0.44	4.00	4.00	5.00	4.09	4.42
C12	31	4.48	0.57	3.00	5.00	5.00	4.27	4.69
C13	31	4.71	0.46	4.00	5.00	5.00	4.54	4.88
C14	31	3.90	0.91	1.00	4.00	5.00	3.57	4.24
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi

C15_1_1	31	3.74	0.82	1.00	4.00	5.00	3.44	4.04
C15_1_2	31	3.97	0.55	3.00	4.00	5.00	3.77	4.17
C15_1_3	31	4.35	0.61	3.00	4.00	5.00	4.13	4.58
C15_1_4	31	3.74	0.77	2.00	4.00	5.00	3.46	4.03
C15_1_5	31	3.71	0.53	3.00	4.00	5.00	3.52	3.90
C15_1_6	18	4.17	0.62	3.00	4.00	5.00	3.86	4.47

Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C16	31	1.97	0.87	1.00	2.00	4.00	1.65	2.29
C17	31	4.13	0.56	3.00	4.00	5.00	3.92	4.34
C18	31	1.48	0.85	1.00	1.00	4.00	1.17	1.80
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
D1_1	31	4.00	0.68	2.00	4.00	5.00	3.75	4.25
D1_2	31	3.90	0.60	3.00	4.00	5.00	3.68	4.12
D1_3	31	3.84	0.82	1.00	4.00	5.00	3.54	4.14
D1_4	31	4.03	0.80	1.00	4.00	5.00	3.74	4.32
D1_5	31	4.00	0.68	2.00	4.00	5.00	3.75	4.25
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
D2_1	31	4.10	0.60	2.00	4.00	5.00	3.88	4.32
D2_2	31	4.16	0.45	3.00	4.00	5.00	3.99	4.33
D2_3	31	3.77	0.67	2.00	4.00	5.00	3.53	4.02
D2_4	31	4.65	0.66	2.00	5.00	5.00	4.40	4.89
D2_5	31	4.87	0.34	4.00	5.00	5.00	4.75	5.00
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
E1	30	3.27	0.78	1.00	3.00	4.00	2.97	3.56
E2	31	3.16	0.82	1.00	3.00	4.00	2.86	3.46

E3	31	3.81	0.40	3.00	4.00	4.00	3.66	3.95
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
F1_1	31	2.39	0.62	1.00	2.00	3.00	2.16	2.61
F1_2	31	3.77	0.43	3.00	4.00	4.00	3.62	3.93
F1_3	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
F1_4	31	3.29	0.59	2.00	3.00	4.00	3.07	3.51
F1_5	29	3.48	0.51	3.00	3.00	4.00	3.29	3.68
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
F2	31	3.68	0.65	1.00	4.00	4.00	3.44	3.92
F3	31	3.23	0.62	2.00	3.00	4.00	3.00	3.45
F4	31	3.68	0.48	3.00	4.00	4.00	3.50	3.85
F5	31	4.00	0.00	4.00	4.00	4.00	4.00	4.00
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G1_1_1	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
G1_1_2	31	2.61	0.72	2.00	2.00	4.00	2.35	2.88
G1_1_3	31	3.03	0.55	2.00	3.00	4.00	2.83	3.23
G1_1_4	31	3.52	0.51	3.00	4.00	4.00	3.33	3.70
G1_1_5	31	1.52	0.51	1.00	2.00	2.00	1.33	1.70
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G2_1_1	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
G2_1_2	31	2.77	0.67	2.00	3.00	4.00	2.53	3.02
G2_1_3	31	3.13	0.56	2.00	3.00	4.00	2.92	3.34
G2_1_4	31	3.52	0.51	3.00	4.00	4.00	3.33	3.70
G2_1_5	31	1.48	0.51	1.00	1.00	2.00	1.30	1.67

Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G4_1	31	4.58	0.67	2.00	5.00	5.00	4.33	4.83
G4_2	31	4.29	0.59	3.00	4.00	5.00	4.07	4.51
G4_3	31	4.68	0.48	4.00	5.00	5.00	4.50	4.85

Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
B1_3	31	4.81	0.40	4.00	5.00	5.00	4.66	4.95
B1_2	31	4.58	0.50	4.00	5.00	5.00	4.40	4.76
B1_4	31	4.23	0.67	3.00	4.00	5.00	3.98	4.47
B1_5	31	4.10	0.75	2.00	4.00	5.00	3.82	4.37
B1_1	31	3.94	0.57	3.00	4.00	5.00	3.73	4.15
B1_6	31	3.94	0.73	3.00	4.00	5.00	3.67	4.20
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C1_1_3	31	4.68	0.48	4.00	5.00	5.00	4.50	4.85
C1_1_6	27	4.44	0.51	4.00	4.00	5.00	4.24	4.64
C1_1_1	31	3.97	0.48	3.00	4.00	5.00	3.79	4.14
C1_1_2	31	3.97	0.66	3.00	4.00	5.00	3.73	4.21
C1_1_4	31	3.87	0.76	1.00	4.00	5.00	3.59	4.15
C1_1_5	31	3.61	0.50	3.00	4.00	4.00	3.43	3.79
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C2	31	4.81	0.40	4.00	5.00	5.00	4.66	4.95
C3	31	4.71	0.46	4.00	5.00	5.00	4.54	4.88

Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C4_1_2	31	3.16	0.45	2.00	3.00	4.00	2.99	3.33
C4_1_3	31	3.16	0.58	2.00	3.00	4.00	2.95	3.38
C4_1_4	31	3.10	0.87	1.00	3.00	4.00	2.78	3.42
C4_1_1	31	2.84	0.69	2.00	3.00	4.00	2.59	3.09
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C5_1_3	31	3.13	0.62	2.00	3.00	4.00	2.90	3.36
C5_1_2	31	3.10	0.40	2.00	3.00	4.00	2.95	3.24
C5_1_4	31	3.03	0.87	1.00	3.00	4.00	2.71	3.35
C5_1_1	31	2.68	0.65	2.00	3.00	4.00	2.44	2.92
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C6_1_5	31	3.32	0.65	2.00	3.00	4.00	3.08	3.56
C6_1_2	31	3.23	0.56	2.00	3.00	4.00	3.02	3.43
C6_1_4	31	3.03	0.41	2.00	3.00	4.00	2.88	3.18
C6_1_3	31	3.00	0.63	1.00	3.00	4.00	2.77	3.23
C6_1_1	31	2.74	0.58	2.00	3.00	4.00	2.53	2.95
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C13	31	4.71	0.46	4.00	5.00	5.00	4.54	4.88
C9	31	4.52	0.68	3.00	5.00	5.00	4.27	4.76
C12	31	4.48	0.57	3.00	5.00	5.00	4.27	4.69
C8	31	4.45	0.72	2.00	5.00	5.00	4.19	4.72
C7	31	4.39	0.62	3.00	4.00	5.00	4.16	4.61
C11	31	4.26	0.44	4.00	4.00	5.00	4.09	4.42
C14	31	3.90	0.91	1.00	4.00	5.00	3.57	4.24
C10equit	31	3.06	0.96	1.00	3.00	5.00	2.71	3.42
C10debt	31	2.84	0.93	1.00	3.00	5.00	2.50	3.18

Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C15_1_3	31	4.35	0.61	3.00	4.00	5.00	4.13	4.58
C15_1_6	18	4.17	0.62	3.00	4.00	5.00	3.86	4.47
C15_1_2	31	3.97	0.55	3.00	4.00	5.00	3.77	4.17
C15_1_4	31	3.74	0.77	2.00	4.00	5.00	3.46	4.03
C15_1_1	31	3.74	0.82	1.00	4.00	5.00	3.44	4.04
C15_1_5	31	3.71	0.53	3.00	4.00	5.00	3.52	3.90
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
C17	31	4.13	0.56	3.00	4.00	5.00	3.92	4.34
C16	31	1.97	0.87	1.00	2.00	4.00	1.65	2.29
C18	31	1.48	0.85	1.00	1.00	4.00	1.17	1.80
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
D1_4	31	4.03	0.80	1.00	4.00	5.00	3.74	4.32
D1_1	31	4.00	0.68	2.00	4.00	5.00	3.75	4.25
D1_5	31	4.00	0.68	2.00	4.00	5.00	3.75	4.25
D1_2	31	3.90	0.60	3.00	4.00	5.00	3.68	4.12
D1_3	31	3.84	0.82	1.00	4.00	5.00	3.54	4.14
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
D2_5	31	4.87	0.34	4.00	5.00	5.00	4.75	5.00
D2_4	31	4.65	0.66	2.00	5.00	5.00	4.40	4.89
D2_2	31	4.16	0.45	3.00	4.00	5.00	3.99	4.33
D2_1	31	4.10	0.60	2.00	4.00	5.00	3.88	4.32
D2_3	31	3.77	0.67	2.00	4.00	5.00	3.53	4.02
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi

E3	31	3.81	0.40	3.00	4.00	4.00	3.66	3.95
E1	30	3.27	0.78	1.00	3.00	4.00	2.97	3.56
E2	31	3.16	0.82	1.00	3.00	4.00	2.86	3.46
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
F1_3	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
F1_2	31	3.77	0.43	3.00	4.00	4.00	3.62	3.93
F1_5	29	3.48	0.51	3.00	3.00	4.00	3.29	3.68
F1_4	31	3.29	0.59	2.00	3.00	4.00	3.07	3.51
F1_1	31	2.39	0.62	1.00	2.00	3.00	2.16	2.61
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
F5	31	4.00	0.00	4.00	4.00	4.00	4.00	4.00
F4	31	3.68	0.48	3.00	4.00	4.00	3.50	3.85
F2	31	3.68	0.65	1.00	4.00	4.00	3.44	3.92
F3	31	3.23	0.62	2.00	3.00	4.00	3.00	3.45
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G1_1_1	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
G1_1_4	31	3.52	0.51	3.00	4.00	4.00	3.33	3.70
G1_1_3	31	3.03	0.55	2.00	3.00	4.00	2.83	3.23
G1_1_2	31	2.61	0.72	2.00	2.00	4.00	2.35	2.88
G1_1_5	31	1.52	0.51	1.00	2.00	2.00	1.33	1.70
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G2_1_1	31	3.90	0.30	3.00	4.00	4.00	3.79	4.01
G2_1_4	31	3.52	0.51	3.00	4.00	4.00	3.33	3.70
G2_1_3	31	3.13	0.56	2.00	3.00	4.00	2.92	3.34
G2_1_2	31	2.77	0.67	2.00	3.00	4.00	2.53	3.02

G2_1_5	31	1.48	0.51	1.00	1.00	2.00	1.30	1.67
Variable	N	Mean	S.D.	Min.	Median	Max.	95% Lo	95% Hi
G4_3	31	4.68	0.48	4.00	5.00	5.00	4.50	4.85
G4_1	31	4.58	0.67	2.00	5.00	5.00	4.33	4.83
G4_2	31	4.29	0.59	3.00	4.00	5.00	4.07	4.51

Location	FREQ.	PERC.
RSA	10	32.3%
Botswana	1	3.2%
Namibia	1	3.2%
Zimbabwe	2	6.5%
UK	4	12.9%
USA	10	32.3%
Australia	2	6.5%
Canada	1	3.2%
TOTAL	31	100.0%
BMDP TABLE: 2		
A_2	FREQ.	PERC.
2000-01	0	0.0%
1990-99	10	32.3%
1980-89	19	61.3%
1970-79	2	6.5%

1960-69	0	0.0%
TOTAL	31	100.0%
BMDP TABLE: 3		
A_3	FREQ.	PERC.
CC	5	16.1%
SoleProp	5	16.1%
Partners	17	54.8%
PtyLtd	4	12.9%
TOTAL	31	100.0%
BMDP TABLE: 4		
A_4	FREQ.	PERC.
PreGr12	0	0.0%
Gr12	1	3.2%
Certif	1	3.2%
Diploma	7	22.6%
Degree	20	64.5%
PostGrad	2	6.5%
TOTAL	31	100.0%
BMDP TABLE: 5		
A_5	FREQ.	PERC.
Yes	21	67.7%
No	10	32.3%
TOTAL	31	100.0%

ANNEXURE H

FORM FOR EVALUATING PRINT ANOMALIES OF DIGITAL TEST PRINTS

H.1 INTRODUCTION

The aim of the tests (refer to chapter 10) was to assess different types of digital prints, so that the print processes can be matched to fine art images. The fine art images would then be printed using the most suitable digital print process. The digital processes are not expected to mimic art techniques and processes, but it is hoped that they will provide an acceptable means to reproduce fine art images or act as an additional technique/media for fine artists to use.

The test image was recorded on a digital back and the same image was used to make each print. Some of the original objects are displayed and their colours can be compared when assessing the prints.

Rate the first 8 questions on a scale in a range from 1-5. Allocation: 1 terrible, 2 bad, 3 reasonable, 4 good, 5 excellent.

	1 Terrible	2 Bad	3 Reasonable	4 Good	5 Excellent
1. Colour accuracy					
2. Tonal range					
3. Ability to render highlight and shadow detail					
4. Sharpness (ability to render fine detail)					
5. Visible dot/line/screen pattern					
6. Surface texture					
7. Size limitations					

8. Variety of substrates					

H.2 INTERPRETATION OF BOX AND WHISKER CHARTS

Each property is a characteristic used to identify the print anomalies. Eleven box plots were drawn to compare the printers according to these properties. The dot in the middle represents the sample mean score. The true mean score for the relevant property lies between the two extremes of the box plot with 95% confidence.

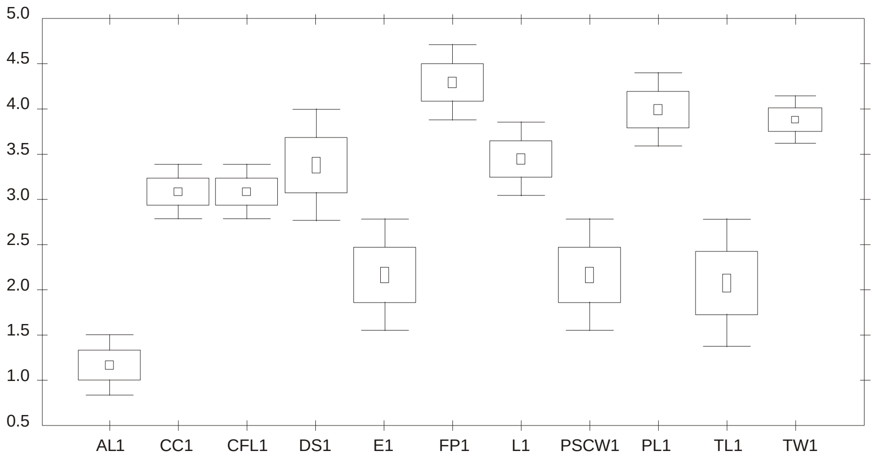
The most important observation is that it two box plots do not overlap, there is a significant difference between the two specific printers with relation to that property. The higher up the box, the better that specific printer scored for that property. If the box plot ranges over a big area, it means that the respondents gave a wide variety of grading to the printer.

Key:

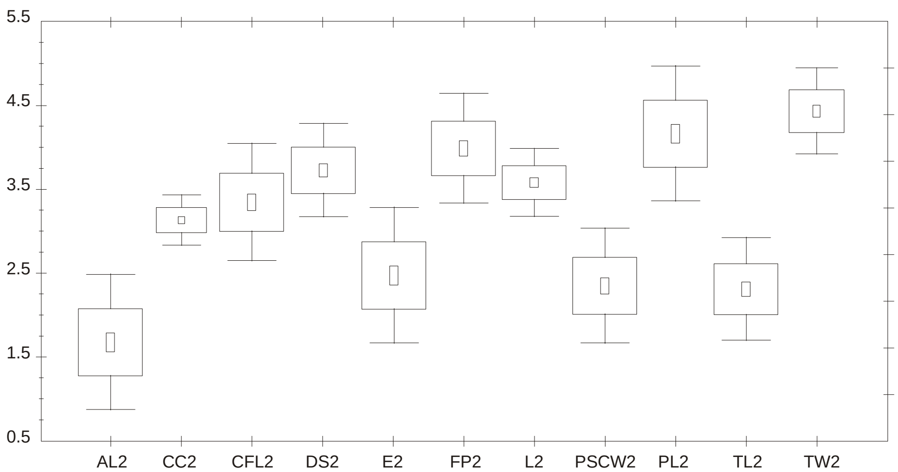
AL:	Aerosol Inkjet
CC:	Colour Copy
CFL:	Continuous Flow Inkjet
DS:	Dye Sublimation
E:	Electrostatic
FP:	Fuji Pictography
L:	Laser
PCSW:	Phase Change Solid Wax
PL:	Piezo-electric Inkjet
TL:	Thermal Inkjet
TW:	Thermal Wax

The Department of Mathematical Statistics, Port Elizabeth Technikon, compiled this statistical analysis.

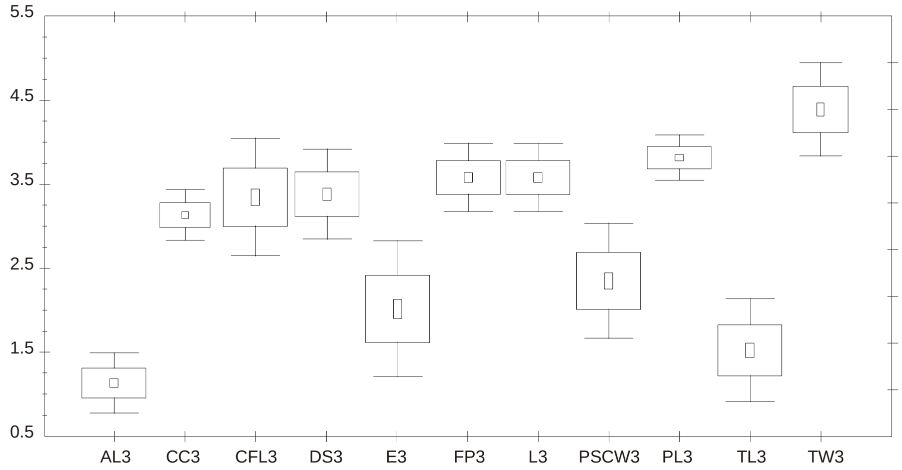
Property 1 Colour Accuracy of Printers



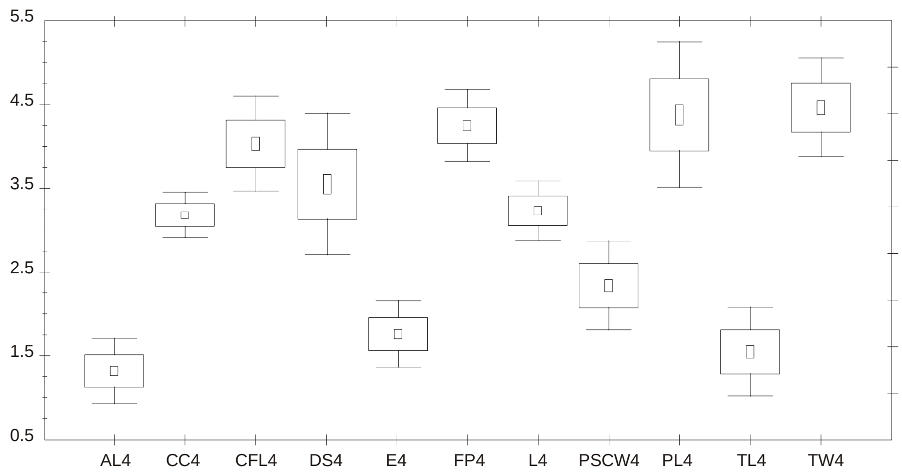
Property 2 Toner Range



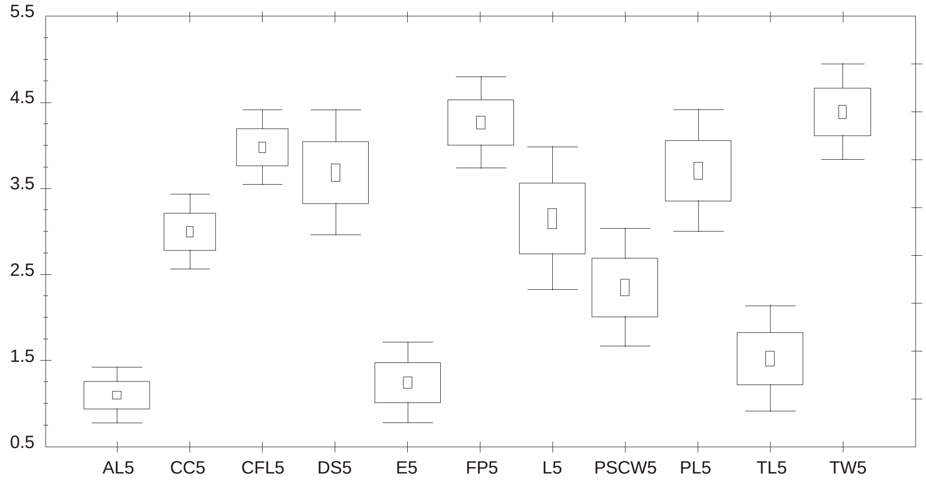
Property 3 Ability to Render Highlight and Shadow Detail



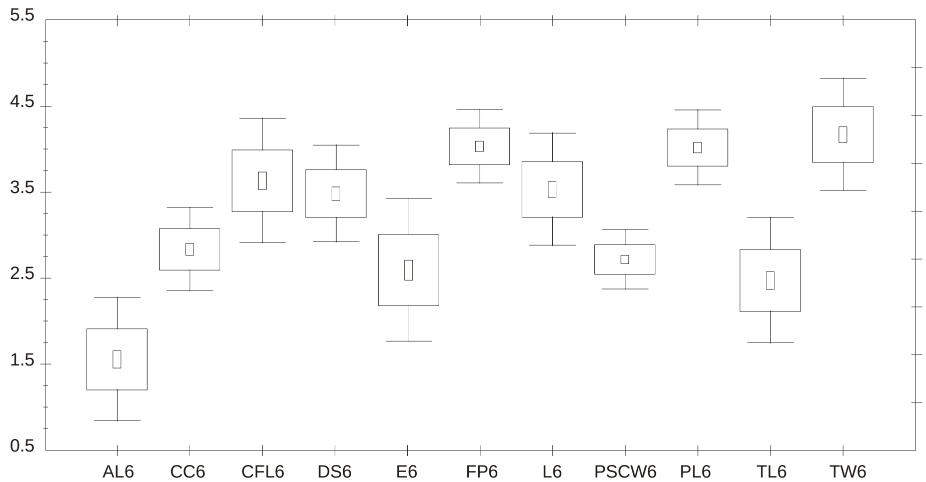
Property 4 Sharpness



Property 5 Visible dot/line/screen Pattern



Property 6 Surface Texture



Property 7 Size Limitations