MANAGING AND IMPLEMENTING TECHNICAL INNOVATIONS

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DECLARATION

I declare that this project report is my own, unaided work. It is being submitted for the degree of Master of Science in Engineering at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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ABSTRACT

A survey of selected South African companies was conducted (included in the appendix) to gauge the status of management and implementation of INNOVATION, NEW TECHNOLOGIES and CHANGE.

The dissertation considers management of technology as a profession which overlaps with engineering and business management. A summary of information gathered from the literature and the author's experience is presented.

The dissertation covers education at secondary and tertiary levels, supports a dual promotion scale in a company, looks at how to deal with Hedgers and defines the Champions and Assassins of change.

Market dimensions with respect to technology are considered and incremental changes are proposed. Measures are given to determine how technically progressive a company might be.

The concept of "company within a company" is discussed and joint ventures between small and large companies are proposed. The importance of monitoring is stressed and the post innovation idea is presented.

Points to consider when implementing a change are listed. These include cross-fertilisation of ideas between departments and cooperating institutions. Simple and focused innovations are the most effective.

The solution to handling change is COMMUNICATION.

ABBREVIATIONS

The following are abbreviations used in the text.

DFA	Design for applicability
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
MIS	Management Information Systems
DSS	Decision Support Systems
CEO	Chief Executive Officer
CNC	Computer Numerically Controlled
SACPE	South African Council for Professional Engineers
CSIR	Council for Scientific and Industrial Research
ISCOR	Iron and Steel Corporation of South Africa
NUMSA	National Union of Metalworkers
COSATU	Congress of South African Trade Unions
UNISA	University of South Africa

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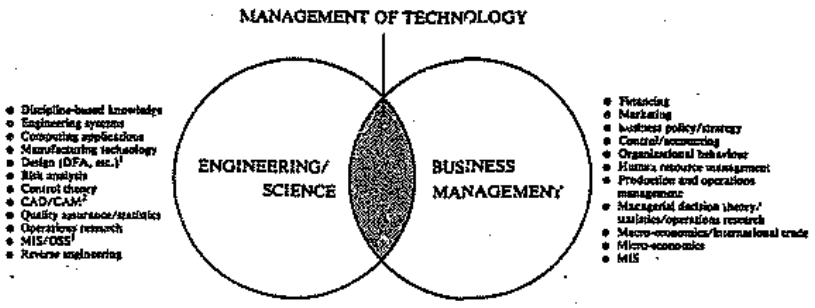
A SURVEY OF A FEW INNOVATING SOUTH AFRICAN COMPANIES

1 INTRODUCTION

Management of Technology (1) is a field that links the disciplines of engineering, science and management in order to plan, develop and deploy technological capabilities so as to shape and accomplish the strategic and operational objectives of an organisation.

The practice of technology management can be defined as;

> *'The design, implementation and administration of the activities, functions and relationships needed within organisations to achieve economic and social objectives through technological innovation.'*



[1]DFA: Design for applicability
[2]CAD/CAM: Computer-Aided Design and Manufacturing
[3]MIS/DSS: Management Information Systems and Decision Support Systems

Figure 1 Issues and responsibilities, Management of Technology (1)

The key elements (1) of Management of Technology in industrial practice are;

1. The assessment of technology options, including identification and evaluation,
2. Research and development itself, including determination of projects feasibility,
3. Integration of the company's overall effort,

- Implementation in a product and/or process
- Obsolescence and replacement.

Any innovation requires an Entrepreneur and a Manager to implement it. This process implies that there is a change taking place. In this text, innovation, entrepreneur and change are all seen as synonymous. Likewise for new technologies, although innovation does not necessarily mean that new technologies are being used.

Numerous publications exist on the subject of innovation, change and their implementation, but very little has been published with respect to the South African conditions.

A survey was done on a select number of innovating South African companies. The companies ranged from large semi-government affiliates to small one-man operations. In each company more than one employee was interviewed. Representatives from as close to the upper and lower ranks of the company as possible were interviewed. In the case of the large semi-government company, a representative of nearly all the different hierarchy levels was interviewed. Findings are included in this text. For more detail on the survey, consult the appendix.

In this dissertation, the author discusses the topic drawing references and points from a wide range of literature, the survey and his personal experience in the engineering development field.

Useful measures are quoted for companies to use as a self-measure of their performance as an innovating or technical progressive company.

A chapter has been included where the United Kingdom

and Germany are discussed so that the reader may obtain an insight to the situation elsewhere in the world.

2 INNOVATION

2.1 Introduction

People of genius set great things going;
Industrious people finish these for them.

This dissertation deals not only with the managing and the implementing of new technologies, but also with innovation. The author believes that the two cannot be separated and should be considered together. New technologies tend to imply that there is a new discovery; this may well be the case for the company involved, but before it can be used, it has to be implemented. This is where innovation takes place.

Many people believe that research is THE mainspring of innovation. However, innovation sometimes follows circuitous paths whose scientific origin, if there is one, is in the distant past.

The term "innovation" is that used most often to describe the process that results in a continuing flow of new, better or more useful products and services to meet the needs of customers, whether industrial or individual. Viewing innovation as something scientifically and technically interesting may excite research workers, but is unlikely to lead to profitable exploitation of a scientific idea or discovery.

Innovation is the commercial exploitation of a new idea from whatever source, and as such it is much more complex and multifaceted than a scientific discovery. Innovation is the synthesis of the needs of the consumer (and thus the market need) and the technical means of satisfying the need to secure profitable exploitation. It is crucial to stress this concept of

market dimension. The idea of innovation seeking and securing a market, although it occasionally happens, is not one that is either productive or attractive. It is essentially that the needs of the market-place are known and understood, and so an important prerequisite to innovate is the analysis derived from market research into the needs of the consumer, with all that this implies for pricing, design, production and distribution.

Innovation does not stem from the work of clever individuals. It is a matter of teamwork, and there is a need to discipline the many functions involved and to pull them together in a coordinated way.

2.2 Principles of Innovation

You either keep up with the "state of the art",
just stop trying.
The thrust of technology however waits for no-one.

Traditionally, innovation is considered to take two forms - product and process. Young industries will be characterised by extensive and radical product innovations. As the industry matures, so the growth and/or lack of further avenues for product development (or rising costs of further product development) shifts the emphasis to improving the way in which the product is made - inter alia, better quality and lower manufacturing cost. It took the entrance of a new participant, for one of the companies studied, to innovate and launch a new generation of product.

Industries tend to depend on incremental innovation as they mature. This can be linked to competitiveness. As industries mature so they become

susceptible to competition from a wider range of sources. Their room to manoeuvre becomes increasingly constrained and success depends on the ability to make incremental improvements in productivity or design. In turn, these enhancements become more and more difficult and costly to make. This increases the pressure to develop completely new products or processes (or to acquire these via takeover), since these options will allow the firm to make a fresh start ahead of the competition. However, there is no guarantee of success in new product or process development. Many industries become trapped in a highly competitive position, endeavouring to stay ahead on the basis of incremental innovation in their manufacturing processes. This is very much the pattern of mature industries.

Radical innovation involves a few key people. Incremental innovation involves the whole environment and ethos of the firm over a sustained period of time. It is continuous and diffuse.

The introduction and improvement of products and processes from the core of the activity is known as technical innovation. As far back as 1912, when Joseph Schumpeter (2) formulated his theory of economic development, technical innovation was presented as a three-phase process. In the first phase, entrepreneurs were stimulated to innovate because of the prospect of profits derived from monopolies. In the second phase, the technical or marketing advantages perceived by the entrepreneurs were gradually reduced as new entrants began to imitate the original ideas. In the third phase, monopoly profits have disappeared or been reduced to a very low level. The economic system, having absorbed the innovation into its structure, re-

turns to new equilibrium. To some extent, the literature on technical innovation exhibits a similar division of labour. There are those who study innovation as a discrete event examining the preconditions that led entrepreneurs to innovate in the first place. In second and third phases there are those who follow the diffusion of an innovation and the structural adjustment of the economic system to it. The former group analyses the set-up when the innovation is launched commercially, while the latter follows the progress of the product or process as it is adopted by the user-firms. As a consequence, it has often appeared that the impulse of innovation and its diffusion are discrete processes with little or no overlap between them.

Yet if Schumpeter is right, every innovation will be followed by imitation and, rather than simply watching their monopoly profits being eroded by imitators, entrepreneurs might be expected to respond energetically to maintain them. Here one is at the heart of the competitive process and it is a process in which technological innovation and diffusion are intimately related. Industrial products and processes are in constant flux, not only because the relative costs of supplying labour and capital are shifting, but also due to entrepreneurs, have long since discovered that the ability to deliver a succession of technical improvements is one way to keep the rules of the game open. Imitation there certainly is, but it is not a slavish copy of the insights of others. It is rather the intelligent and deliberate exploration of the possibilities presented by technological opportunities and market needs.

It is the relative openness of both the agenda for

development of any particular technology and its correlative market environment that is one source of the risks experienced by entrepreneurs and managers who have embarked on the path of innovation.

A business which has the germ of a new idea is not always well prepared to further the idea. A certain self-censure inhibits the potential for innovative techniques, which are accompanied by a deterioration in relationships with a firm's suppliers. This is the reason why the lasting success of large firms who continue to innovate, cannot be attributed solely to the merits of those directly responsible for production or to the researchers.

A successful approach is cited from the Royal Dutch Shell Group. This company is well known for the resources it devotes to innovation and also for the results obtained in, inter alia, agrochemistry and biotechnology. This Group considers that the proper functioning of activities depends, in the first place, on installing a system which permits the introduction, within the industry, of useful scientific innovations which come from the world outside. One of the ways of assuring a continuous transfer of scientific discoveries into the business is to set aside a part of the R & D budget for this purpose.

Innovation increases the range of opportunities available to a business with enterprising initiative. For example new techniques engender new categories of goods and services which can adapt and revitalise a declining activity. Thus, the industrialisation of a new section of the Third World stimulates not only a demand for raw materials but also for prospecting and exploitation techniques in hither-to unknown geoclimatic conditions. The progressive extinction of any

competitive production of raw mineral materials in Europe has led groups, such as the French and British coal industries, to sell in place of coal, extraction and transformation techniques for coal. Those firms which went into these new fields, checked their decline.

A pessimistic view of the dynamics of innovation tends to emphasise the negative impact innovation can have on former products which lead to difficulties for suppliers. However, this dynamism can damage competitors.

In the case of an innovation substitution with respect to a supplier's product, the innovating firm develops a new product which reduces the demand for the supplier's traditional components. This effect has to be deducted from the eventual and more positive results otherwise generated. It can, however, be taken up as a challenge by the supplier and gives him the chance to bring his range of products up to date, and, in particular, to adapt his supplies to the new product.

When the innovation substitution involves a new process, the innovating firm can economise (due to the new process) on its purchases from the supplier. The net effect on the supplier's turnover will depend on the price elasticity associated with the innovating firm's product.

These two cases are obviously unfavourable to the supplier. Experience shows, however, that this handicap can be overcome if and when the supplier uses it as a challenge and an opportunity to renew the firm's range of products, reduce the prices or innovate by diversification.

Consider when the innovation is complementary to the

supplier's product and or process. Taking the product, the supplier benefits directly and the positive effects which follow add to any initial effects. This reflects the mutual interest between the innovating firm and the supplier.

Considering the process, considerations linked to the transfer of technology and to competence are particularly important because in changing a process, the innovating firm must consult with the supplier about materials and parts which the latter must manufacture.

Single motive innovation is very rare. Bessant and Grunt (3) discuss the idea of "constellations" or clusters of innovation motives and suggest that there is a relationship between these and other characteristics of the firm. During the author's interviewing, support for this view was obtained. Firms usually had a combination of several motives for any innovation. Multiple motives appear to be particularly common in manufacturing innovation, where the pattern is essentially one of regular incremental improvement and development of all aspects of the production process.

Equally, the impact of manufacturing innovation tended to spread out across the organisation, giving a pattern (intended or otherwise) of multiple effects as well as of multiple motives. For example, investment in a CNC (computer numerically controlled) machine not only affects the production process in terms of improved accuracy, speed, quality, precision and reduced setting times but it also affects maintenance, work organisation, production planning and monitoring, quality control - and the range of products which the firm can make.

There is no innovation without an entrepreneur - a businessman endowed with a keen sense for seizing opportunities, for threats to be averted, a creative person concerned with experimentation. That is to say, a person able to marry practical experience with an idea.

An entrepreneur's imagination is very different from an inventor's.

Like all concepts of a pragmatic nature, innovation conceals a heterogeneous collection of realities. One would be inclined to distinguish between

- Innovation consisting of the promotion of an idea by means of a manufactured product (the pocket calculator and the surfboard) not available on the market at the moment of its launching

- Innovation destined to resolve, circumvent or eliminate a technical difficulty in manufacturing or to improve services (the ceramic tool bit)

- Innovation destined principally as an input saving concept (energy conservation, automation of a product, robotisation)

- Innovation destined to improve conditions of work (security, safety measures).

Good inventors have the customer in mind, but their vision is usually incomplete unless they are also entrepreneurs. An entrepreneur, on the other hand, having seen the promised land, moves back to the present and takes on the rather mundane and practical task of turning the prototype into a marketplace success. This, too, requires an enormous imagination.

The more independent, aggressive, and less politically oriented a nonconformist becomes, the more of an entrepreneur he will be.

Entrepreneurs, generally, cannot tolerate strong, authoritarian father figures, so they avoid paternal companies and strike out on their own. Successful corporate leaders, as a rule, want to please their fathers and by extension, their bosses and their mothers. This need not necessarily be the case. The boss of an identified entrepreneur can create an environment within the large organisation for the entrepreneur to blossom.

It is well known that athletic success depends on having the right mental preparation. So it is with firms. Those which succeed will not only carefully react to their competitors initiatives, but also develop strategies which will give them flexibility to move into a controlling position at various stages of the race.

Unexpected successes and failures are such productive sources of innovation opportunities. Most businesses dismiss them, disregard them, and even resent them.

Purposeful, systematic innovation begins with the analysis of the sources of new opportunities. Depending on the context, sources will have a different importance at different times. Because innovation is both conceptual and perceptual, would-be innovators must also go out and look, ask and listen. Successful innovators use both right and left sides of their brains. Both formal and informal (lateral) thinking must be encouraged.

To be effective, an innovation has to be simple and it has to be focused. It should do only one thing other-

wise it confuses people. The greatest praise an innovation can receive is for people to say: "*This is obvious! Why did I not think of it? It's so simple!*"

Effective innovations start small. These are ideal for one to cut one's teeth on. They require little finance and the results can quickly be seen.

Above all, innovation is work rather than genius. It requires knowledge. It often requires ingenuity. And it requires focus.

In their article on the United Kingdom and Germany, *Bessant and Grunt (3) describe the process of innovation* in the following manner. "*At first, small firms have an edge because they can use old and depreciated plants and can often undercut on prices and hold their own in the market place. But soon the problem becomes one of rising technological standards and they are trapped. The adoption of an innovation or technical advance starts with a network of small decisions which lead to a commitment of resources. Within the firm this means considerable informal discussion and debate about priorities, options, experience and so on. This process forms the basis of innovation planning within the company and is usually formalised into some form of submission for the following year's budget.*"

The author found that there is a strong association between successful innovation and subsequent growth of the firm. The converse was also found to be true.

2.3 Sources of Innovation

Grouping the sources of innovation, one can consider

- The situation within a company or industry and

this includes unexpected occurrences and process needs to name two

- The environment outside a company or industry which includes demographic changes, changes in perception and new knowledge.

Individuals are an essential ingredient in the development of the innovation process in two separate ways. Firstly, they frequently identify useful areas in which to work. This often results from years of experience with a given product, product type or industry, but sometimes it reflects a long-standing, but non-professional, interest. Secondly, they often encourage enthusiasm for the project, secure the appropriated resources at the right time and generally take a direct and personal interest in the outcome of the project.

An analogy might be drawn (3) between the manufacturing innovation process and a mechanic, constantly tuning his car to achieve better and better performance. Obviously most mechanics would prefer a new car which incorporates state of the art advanced technology as part of the basic design. However, faced with the financial limitations of doing this, they have the skills and experience to make the best of the present vehicle. Much the same situation exists with most of today's companies.

Many of the "sources of innovation" have been given names by various authors. The names are not always consistent with each other, but here are a few of the more popular versions as supported by the interviews.

The vast majority of manufacturing innovation is the need pull variety. Amongst others of relevance are competitor pressure, technological push, technological starvation and legislative pressure.

- Market pull (Also called Need Pull or Customer Need)

  This is a traditional form of innovation stimulus and refers to the demand in the market place for new or modified products. The innovation process is considered to have been initiated by a perception in a need, which may have been prompted by a market search or a customer request.

- *Competitor pressure*

  This is also a strong force and often refers to those cases where the competition introduces a change in product or process which must be matched or improved upon, if the firm is to remain competitive. "Technological bandwagon" - unless the firm moves quickly it may be too late to catch up at any later stage. Thus the firms likely to succeed are those which entered this technological field at an earlier, cheaper stage and innovate as the technology develops.

- Technological push (Discovery push)

  Innovation is often to be found in the form of novel solutions or completely new approaches to the process or parts of it. As such, it often involves "imports" of ideas or technology from outside the firm or the sector. Technology push is often associated with "champion" figures prepared to push the organisation forward and into new areas.

A technological discovery is a more frequent stimulus than a scientific one, while a market need occurs as a stimulus marginally more frequently than a management need.

- Technology starvation

This is a characteristic of small firms working in highly specialised sectors and refers to the situation in which firms are forced to innovate and develop their processes because there is no suitable off-the-shelf equipment to purchase.

- Legislative pressure

A result of the implementation of new or altered laws affecting the manufacturing or consuming environment. For example, pollution control, working conditions and user safety. This has two effects; it either affects an existing market and thus one has to change one's products in order to stay in the market, or it creates a new market.

- Invention/development

This encompasses
- Suppliers (ie. invention incorporated in off-the-self package)
- The private inventor
- The in-house inventor inspired either by a market pull or technology push
- Consultants who have been commissioned either by the company or the company's clients
- Joint ventures with suppliers of technology
- Academic institutions

- Government laboratories
- Trade research associations

It is not so much a case of having the inventive resources in-house as being able to tap into other sources.

2.4 Barriers to innovation

2.4.1 SOCIAL

There are many barriers to innovation, embracing both social and intellectual attitudes.

Novelty in product and process challenges accepted ways of doing things and threatens long-established skills. These threats can throw a company, including its top management, into areas where it feels inept and uninformed. Some technological advances can require major changes in social organisation, upsetting established hierarchical structures and undermining the security of positions built up on traditional products and practices.

Even those who recognise and believe in the importance of innovation, do not always fully appreciate its potentially disturbing effects. One has to examine the nature of innovation and try to provide for it in the existing social and business frame work. What needs to be asked is

How do the barriers to change arise?
How are they to be avoided?

The essential feature in innovation is the creative element involved both in the development of technology and in the synthesis with market need. This creative aspect involves overcoming a series of hurdles, both intellectual and social. Both new market needs and new technology are different from established ways of

thinking and doing things and society and individuals resist the unfamiliar. Donald Schon (4) described the attitude of society to change as "controlled conservative *dynamism*". *He meant* that society cannot easily accept change, otherwise there would be chaos. Rather, it has to maintain a mildly dynamic equilibrium by being ambivalent to change. It must eventually accept change, but at the same time resist it.

How will technological change affect human resources practices in an organisation? Young et al (5) believes that it disrupts existing employee relationships. The literature shows that there is a common, but fallacious, belief that automation is bad for people. Technological change can, in fact, provide equally beneficial opportunities to the people in an organisation. Changes are inevitable, but whether they improve or damage the quality of work-life in organisations is a question for management.

Lawrence (6) believes that most people do not resist technical change and that most of the resistance which does occur is unnecessary. The key to the problem is to understand the true nature of resistance. Actually, what employees resist is usually not technical change, but social change - the change in their human relationships that generally accompany technical change. It is useful to think of change as having both a technical and a social aspect. The technical aspect of the change is the making of a measurable modification in the physical routines of the job. The social aspect of the change refers to the way those affected by it, think it will alter their established relationships in the organisation.

An international conference held in Stuttgart, West Germany (7), concluded "*No work ... No identity*". For many, WORK is the cornerstone of their social identi-

ty. When meeting a person for the first time, the question of "Who are you?" or "What do you do?" is asked. OCCUPATION is the basis for a person's identity.

When workers feel secure in their positions, they are more willing to help make the new technological systems successful. The main human issues which are created by technological change are job design, training, career development and organisational development.

Giving subordinates the knowledge that supervisors and foremen do not have, undermines the credibility of the supervisors. This also occurs when one employs new staff with higher qualifications or experience than the existing supervisor. One frequently finds this in companies where people have been promoted beyond their capabilities. One way to deal with this kind of situation is to teach supervisors how to instruct workers about the new technology. The sessions should transmit details of the information workers require, instructions on how best to present it, guides to practice sessions, and audio-visual aids. A good implementation plan should try to identify where a loss of power may occur, so that managers can anticipate and possibly avert, any problems arising from that loss.

Hedgers are individuals who refuse to take a stand against an innovation and also refuse to support the new technology. Because these hedgers are usually waiting for signals to tell them which way to leap, astute implementation managers will see to it that they receive the appropriate signals from those higher up in the organisation. Hedgers can be found at any level in an organisation. The first and easiest solution is to persuade top management to take

some kind of quick symbolic action in support of the innovation.

2.4.2 COMMUNICATION

Organisations need to support, develop and facilitate teamwork and interpersonal communication in order to promote innovation.

It is important to prepare workers for technological change by providing for adequate communication and encouraging participation in the change process. An aware and involved work-force will feel more secure and be more supportive of the change. With adequate planning and implementation strategies, workers can help to make the change process a success.

Good internal communication within the company is essential for successful technical change, whether it be in the production area, the stores or the engineering area. This was emphasised by some of the companies interviewed, and in one case, it was part of the strategy adopted by the company when relocating.

Taylorism (teachings from F W Taylor) purports that managers should take a genuine and kindly interest in those under them. Taylor advocated the work measurement which, in one form or another, still remains the basis of production control and worker remuneration in many areas of industry and commerce. It has the unforeseen aspect of increasing the management worker communication and involvement with each other.

Schumacher (8), when commenting on how to manage industrial concentrations and size, said that organ-

isations should imitate nature, which does not allow a single cell to become too large. When it grows big, it splits. This approach ensures frequent communication and short hierarchical lines.

2.4.3 DEREGULATION

One of the fundamental changes in world view and perception of the last twenty years - a truly monumental turn - is the realisation that governmental policies and agencies are of human rather than of divine origin and, therefore, the one thing certain about them is that they will become obsolete.

As a consequence of deregulation, some companies were not only forced to become more competitive, but for many it meant learning how to compete for the first time in their history.

What is needed in an entrepreneurial society is a tax system that encourages moving capital from yesterday into tomorrow rather than one which, like our present one, prevents and penalises it. New ventures are taxed right from day one. Instead, they should be given a period of grace during their infancy to reinvest their profits back into the venture, for it is during these times that they suffer from cash shortages. There is an advantage for the tax man, for the yields will be greater and the overall net increase in taxes require tax policies that encourage the formation of capital.

Just as important as tax and fiscal policies that encourage entrepreneurship - or at least do not penalise it - is protection of the new venture against the growing burden of government regulations, restrictions, reports and paperwork. One should allow the new

venture to charge the government for the cost of regulations, reports and paperwork that exceeds a certain proportion (say 5%) of the new venture's gross revenues. - "*The steady growth in the invisible cost of government*" (9). These invisible government overheads are totally unproductive. Does a tax accountant contribute to national wealth or to productivity?

One needs to ask in respect to any proposed new governmental policy or measure, "Does it further society's ability to innovate?", "Does it promote social and economic flexibility?", or "Does it impede and penalise innovation and entrepreneurship?" Impact on society's ability to innovate cannot and should not be the determining, let alone the sole, criterion. But it needs to be taken into consideration before a new policy or a new measure is enacted. Japan is perhaps the only country where the effect of policy on innovation is considered.

2.4.4 LARGE COMPANY BARRIERS

Large companies have developed many unnoticed barriers to innovation.

Many senior executives have little contact with conditions on the factory floor or with customers who might influence their thinking about technical innovation. This can be termed as "Top management isolation".

Large companies have a corporate culture and are "intolerant of fanatics". They often view entrepreneurial fanatics as an embarrassment or as troublemakers. Their inability to handle these sources of inspiration is due to the management not being able to cope with anything out of the ordinary.

Long chains of authority, share holders and the Board of Directors cause the corporation to perceive the need to report a continuous stream of quarterly profits which conflicts with the long time spans that major innovations normally require.

The accounting practices of corporations cause the development costs of new technology to be much higher than those of the entrepreneur working in his garage. This is due to the method of assigning direct, indirect, overhead, overtime and service costs against the development project.

In the name of efficiency and control, bureaucratic structures require many approvals which cause delays at every station. A small firm could produce test components and carry out experiments in a matter of hours, whereas in a large firm, this could take weeks or even months.

Other obstacles to innovation include risk capital, scarce technical skills and suitable and compatible technology. Despite these constraints, some firms do innovate. Such innovativeness is not always the sole province of large firms well endowed with resources; in many cases - like the semi-conductor industry in the U.S.A. - it has been the small firms, with their ability to react quickly, which have been amongst the most innovative.

If scientists and engineers are not allowed to do their own market research, then a major barrier to innovation exists. They should be allowed to communicate the technical advantages of the new development and gauge the real needs of the market. The adapting of existing ideas into a saleable product can only be done effectively if the gaps in the market are assessed. Caution must be exercised, for not only are

these people the most knowledgeable on the new development, but they also know the shortfalls and limitations of the development. This is not always good for marketing.

2.4.5 SUMMARY

"There is no such thing as over communication."

During the late 1950's, automation was the process which some observers foretold would dramatically change lifestyles. Three day working weeks and retirement at forty was anticipated. Similarly, in the 70's warnings abounded that the computer would condemn thousands of white-collar jobs. But has it?

Overt resistance to an innovation often grows out of mistakes or overlooked issues in an implementation plan. Tacit resistance does not disappear, but ferments, grows into sabotage, or surfaces later when resources are depleted.

The monopolistic universal approach becomes increasingly unsuited to an environment of technological advance and a rapid diversifying range of services. Most imp tant of all, it could not cope with the need for fast, flexible response to customers' needs in an era of growing international competition.

The beginning of wisdom is to anticipate opposition. An innovation needs a champion to nurture it, and any new technology capable of inspiring strong advocacy will also provoke opposition. Where there are product champions, there will also be innovation assassins. Assassins, moreover, can fell a project with just one well-aimed bullet, but champions need to marshal forces and nurture support to implement new technology

in the face of resistance. The most common reasons for opposition to a new technology are fear of the loss of skills or power and absence of an apparent personal benefit.

3 PROBLEMS WITH TODAY'S COMPANIES

3.1 Introduction

The monopolistic universal approach has become increasingly unsuited to an environment of technological advance and a rapid diversifying range of services. Most important of all, it cannot cope with the need for fast, flexible response to customers' needs in an era of growing international competition.

This has heralded the move by certain companies to create small units within themselves. Examples of these are flexible manufacturing units and business units. Some of the reasons for this change include the need to improve communication within the company, the need to react fast to the changing market and the need for a multi-directional approach to the market.

3.2 Information Technology

Many companies are beginning to recognise information technology (via computers and communication), as a competitive weapon. For the most part, however, it is still managed only within a relatively narrow technical or organisational framework, rather than as a strategic resource. In most organisations there is still a wide gap between current applications and the potential opportunities that information technology represents. Closing the gap will become imperative as information technology becomes one of the key determinants of competitiveness in the years ahead.

Management faces a three-fold dilemma

- While top managers are generally aware that information technology helps their firms to stay competitive, they concede that these observations are largely based on intuitive feelings. Because of the paucity of solid measures and statistics to quantify the technology's relationship to performance, their approach to technology remains tentative.

- On a wider plane, it is often difficult, until after the fact, to grasp the way information technology is revising entire industry sectors and changing the external environment in which they compete. It becomes hard to grasp the "big picture" until it is too late.

- Even if information technology is accepted as a strategic concern, the challenge is to steer it towards new business opportunities. The point is not only to do a first class job at yesterday's business, but to understand how to do business *tomorrow*. Where does the executive find individuals with this talent and experience to explore these uncharted new opportunities?

Information technology allows, and in some cases demands, a rethink of a company's objectives.

3.3 ACTION STEPS

A serious competitive strategy is likely to take shape only if the chief executive officer (CEO) demonstrates a clear interest in its importance. It is the CEO's responsibility to promulgate the concept of information technology as a competitive weapon and to conduct

regular reviews on progress deploying the technology.

One approach is to bring together technical managers with non-technical or "end-user" departments (which is, after all, where much of the entrepreneurial insight and outlook will occur) to explore the technological possibilities. This cooperative effort may take the form of an internal task force of a consulting group to provide staff support, specifically to help end-user departments that want to explore strategic uses of information technology. Promising candidates for senior management positions could be assigned to lead such task forces as a regular and recognized part of their management development process.

Effects on competition is discussed in literature under the headings of obsolescence and out-dated equipment, the setbacks of the first innovator, the outstanding successes of the early imitators, and the progressive glut on the market caused by the arrival of later imitators.

In order to regenerate the innovation potential of a country, one must know how to encourage firms and to respect the dynamics of capital stock. It would doubtless be advisable to stimulate innovation by lowering taxation on capital stock and retained earnings (3).

Much of the difficulty in innovation within larger organizations is due to friction between differentiated groups both vertically and horizontally. This friction can be anything from a difference of opinion arising from different ways of seeing the same problem right up to full-scale obstruction or internal politicking over the control of resources. This is a form of empire building. Many firms deny that it takes

place.

Firms remain loyal to their chosen process technology, investing in it as long as it generates profits above normal, even though other, superior processes will generally be available.

3.4 Empire Building

One reason for the need of a major change into the 21st century for every manufacturer in our country, is that too many of our business systems are really not systems. Often, the result is a company with uncoordinated systems representing little more than a collection of empires built by departmental heads who are fiercely loyal to their own particular function. Such department heads often sustain hostility towards other departments with little or no sympathy towards a common corporate systems approach. In fact, such departmental heads fear that a common corporate systems approach would destroy the walls that they built around their empires. Even modern technology, such as the computer, has failed to crack these impenetrable walls. Instead, each department has bought its own computers and has jealously guarded its software and data. As can be imagined, such companies are inherently weak when they have to face the competition.

In some of the companies interviewed, it was found that the CEO had each department set its goals for the year and measured each department against the other with respect to their goals. No concrete effort was made to further corporate goals or to encourage efforts which might lead to the betterment of the company. The result was departmental empires which competed against each other and squandered resources which could have been pooled for the company's advancement.

4 EDUCATION OF STUDENTS

A problem-rich environment fuels
the spirit of inquiry

The education of students in technology management is limited, and not based on the rigorous understanding of the needs and factors involved. Engineering students need a better conceptual understanding of global economics and the business of technology, while the students of business need a better conceptual understanding of science and technology. A joint effort from industry, academic institutions and governments is needed to define appropriate incentives to improve the management of technology.

There are two fundamental errors in the education system. Firstly, one is taught the science of Engineering in isolation from all its other dimensions, and secondly one is taught to believe that one is immediately qualified for a job on completion of one's technical training. Engineers get little time to become articulate at University. There is little opportunity in the crowded schedule for business skills. South Africa is not the only country with this problem. Walmsley (10) mentions that Britain also suffers from this phenomenon.

Industry should commit itself to the educational process in the following ways

- Being open to the message that the management of technology can be substantially improved through research and education.
- Working with academia in identifying and addressing internal needs of the company
- Employing management of technology graduates and providing them with the opportunity to make an

impact.

University administrators and faculties must recognise the increased importance of problem orientated research and education in cross-disciplinary fields by adjusting their policies governing promotion, tenure and reward.

Engineers of the 21st century must be capable of working in, or leading, a multi-disciplinary team. The skills of marketing, project management, finance and international collaboration are just as important as the more familiar elements of design development and engineering production.

Cross fertilisation of ideas comes from open contact and exchanges with colleagues in the same and related fields, (including the challenge of the market-place and that of very demanding customers). In this sense, the creative human resource is challenged by "*real-world*" problems.

However, companies keep technical personnel from innovation stimulating challenges, with administrative problems, through early promotion into management. It is important to separate working scientists and engineers from the day-to-day accounting and administrative type jobs (11).

There should be encouragement of the personal championing of new ideas. To encourage people to grow and advance in the job, companies should encourage an extensive programme of continuing education, whether it be within the company or with an outside institution.

One needs to encourage habits of flexibility, of continuous learning and of acceptance of change as

normal and opportune - for institutions as well as for individuals.

If a broad school base could be achieved, the scope of opportunities for pupils at all levels would increase, with consequent benefits to the engineering profession. However, they would only follow up such opportunities if the image of industry and the engineering profession were a positive one. It is not always so and all too often it is perceived, on scant knowledge, to be an occupation which should be avoided at all costs, rather than as an exciting challenge. The only sector of the industry that has, for many years, carried out some advertising at the school level, has been the mining sector. This has resulted in a very biased view of the Engineering profession. Industry and the profession (S.A.C.P.E.) can do much to counter this erroneous view.

A broad school base should be used to make students aware of technologies and basic physical laws of their own planet. An understanding of what technology can do, and how to use it in the service of man, is desirable.

Does one need specific vocation-orientated courses or a broad grounding in principles on which one can later build, as required, through further training, application and experience? There are exponents of both schools of thought. The author believes that the student continues to need a whole range of courses, some broad, some narrow and deeper, but with more emphases on continuous evolutionary change within a strict budget of time.

However one proceeds, educationalists must be ever mindful of the job market into which students will be pitched on graduation. They must be attuned to the

world of industry, not only to the academic environment (as is still too often the case). Updating through short courses, particular weekend courses or for a few days covering a specific subject will become more popular. Busy people need to be able to update their knowledge in specific subjects as, and when, required.

Specific technology orientated courses should be left to the post graduate years when the student can become a specialist in a particular direction.

The newly qualified engineer often joins a company with a high opinion of himself and a false view of the importance of engineering within the organisation. By his mid 20's however, the engineer recognises how quickly his technical knowledge has become obsolete.

To maintain an engineer in a purely technical role is to stifle his personality and deprive the company of critical judgment in design and development.

The engineer should appreciate the implications of his work in each of the other four areas, namely

Marketing. Does the customer want it in a particular form?

Production. Can it easily be assembled or serviced?

Personnel. Is it safe to operate?

Finance. How much will it cost to develop and what will be the return?

Engineers need to become better managers of their own time and resources, finance and people. In short, they must be fully capable of managing all aspects of the business of engineering.

As any engineering student knows, Engineering is not a soft option and never has been. Industry needs people

capable of coping with engineering and still have sufficient reserves of personality for hobbies, sport and appreciation of the arts. They should be able to play a full part in society at large. It is a challenge which will surely appeal to many of the most able young people who will work in the 21st century.

Parker (12), takes education one step further and says that the impact of education and training must be radically rethought. He says that one needs to consider the place of education and training in an era of "non-working". Another way of viewing the "decline of work" is to see it as a "growth of leisure". Whether such leisure be a pleasure or a curse, of course, is another debate. Preparing for leisure must include education for leisure; and the educational establishments must recognise the important role that leisure will play in their students' lives. Currently, the primary and secondary education system (starting at 5 and finishing at 17 years of age for many) must surely be regarded as obsolete in the fast changing, technological based society. "Recurrent education" seems to be the only conclusion. Recurrent education is a strategy for the achievement of continuing, or lifelong, education, implying the alternation of periods of work and regular education or training. Thus, leisure can be seen as an important area for self identity, where the individuals' self esteem can be constructed. One's position in society may be judged not on occupation, but how one spends one's time outside that of employment.

5 MANAGEMENT OF TECHNOLOGY AND INNOVATION

A company's mission, its organisation, its R & D environment, and the way in which information flows within its confines are the most important factors contributing to its creativity and its overall success. Therefore, the flow of information within a company forms part of the technology management.

5.1 Innovation

Teamwork is the key
where everyone can make a contribution!

The management of a company must be committed to growth through innovation and must set up mechanisms by which projects can be started and structured so as to minimise the barriers and difficulties that always occur during the project development.

The term innovation is that used most often to describe the process that results in a continuing flow of new/better/more useful products and services to meet the needs of consumers, whether industrial or individual.

The discoveries of science are producing new technologies at an ever-increasing rate and this fast-moving situation poses an important new challenge for all in the latter part of the 20th century. It is a tremendous challenge to harness the immense potential of advancing technology and to channel it to our national economic advantage. Those who can do this will prosper and those who cannot will have difficulty in remaining viable. An internationally competitive

factor in industry is a driving force for technology-led innovation. But technology is not enough. There is a market dimension to innovation which is vital to ensure the profitable exploitation of the appropriate technology.

It is unlikely that without some formal organisational structure, the exploitation process will take place smoothly. In all new ventures there will be snags, unforeseen difficulties and perhaps unwarranted time or cost constraints. If a new product fails, no single person in the organisation is free of blame.

Durham (13) proposed the following rules to help a company exploit technology. These are

- *Top management of the company must be visibly committed.*

- *There must be a well-thought-out project plan covering the process from research through to market exploitation.*

- *The company must keep the number of major projects relatively small.*

- *There must be continuity, as far as possible, in the project team. This is especially true of the project leader, who must see the project through to the end.*

- *The company must try to keep the number of information and technology transfer points in any project to an absolute minimum.*

- *The company must try to give everybody involved in the project enough information about the conse-*

quences of their activities and of the commercial value of the project to keep irrational reactions as low as possible.

Innovation success involves an open and flexible approach which corresponds closely with *Technical Progressiveness* (3). This approach involves an *integrated* view of innovation, seeing it as an essential part of the overall activity of the firm rather than a special event or the responsibility of a specialist group.

Knowledge and information is the result of regular and extensive flow of information - particularly at the early stages of the innovation process where a number of different proposals may be under consideration. Inputs include developments in science and technology, what competitors are doing, what the market requires and what suppliers can offer.

Freeman (14) points out that "*innovation is a coupling process and the coupling first takes place in the minds of imaginative people ... the test of successful entrepreneurship and good management is the capacity to link together ... technical and market possibilities by combining the two flows of information*". Therefore one can conclude that good communications (information links inside and outside the firm) are important factors in determining the success or failure of the innovation process.

Bessant and Grunt (3) listed some sources of information for innovation

- *Suppliers (via technical representatives and trade literature)*
- Trade literature and advertising
- Technical journals and books

- Consultants
- Universities / Technikons / Colleges
- Trade Associations and Research Associations.
- Government sources, including laboratories, advisory centres (such as the CSIR), and the grant giving bodies like the Small Business Development Corporation. Also some formal awareness raising campaigns, such as the information campaign sponsored by the Department of Industry and Commerce in the "Engineering Week" newspaper.
- Regional/local sources such as Chambers of Commerce, Productivity Associations, Employer's Federations and so on
- Trade Unions
- Competitors (both direct and indirect information about what they are doing)
- Conferences
- Trade fairs and exhibitions
- Customers
- Personal networks, such as the "old boy network" and the "invisible college".

Information coming into the firm is often channelled through a "*gatekeeper*" - an individual who acts as the organisation's eyes and ears, and who keeps track of developments in the outside world. But all too frequently, company politics prevents this information from spreading through the company and the gatekeeper is seen as a threat to many a manager.

The author's findings agree with those of Bessant and Grunt (3), ie. that the lack of formally committed internal resources for innovation did not appear to inhibit the manufacturing innovation process. This is primarily due to innovation success being dependent on the ability to mobilise resources rather than the actual possession of them. Additionally, manufacturing innovation does not appear to depend on internal

resources to any marked degree - unlike product innovation.

When trying to innovate, one must ask, "What is it we are trying to do?" Frequently one hears, "To increase efficiency". But, all too often the statement is left undefined. What is missing from the definition is "how to measure". It is only by ascertaining what it is that one is trying to do that will enable one to set the objectives or goals and determine how these should be met.

The task of exploiting new technology is not an easy one, as it involves the management of the transfer of technology from research to the market place. This is a process which requires the utmost commitment from top management. The problem is how to get the ideas, generated by research, used in the company's operations. Management needs to identify the factors which inhibit or dilute the transfer of technology and to overcome them.

5.2 People

HIRE THE BEST,
GIVE THEM THE BEST,
DEMAND THE BEST!

In essence, recruit and hire the best people available. Fund them adequately. Motivate them to do their best work by providing them with a stimulating, challenging environment, continuing training and educational growth opportunities. Perhaps most important, always demand and reward a commitment to and attainment of excellence. Such recruiting poses an obligation; to work with, and contribute to, the education system - from nursery school through to

tertiary education - to see that the reservoir of trained talent does not run dry. A way of becoming involved in the local tertiary educational Institutes could be by the supporting of fellowships, visiting professor programmes, or having a campus project manager for research programmes and final year projects.

One of the keys to managing innovation cost effectively is to choose the right people to trust. Too often when managers look for intrapreneurs (an entrepreneur operating from within a company) they choose promoters. Promoters lack the ability to follow through. They are salesmen, not doers. Thus, one of the keys to managing innovation is to be able to distinguish between intrapreneurs and promoters. One of the best ways to separate the intrapreneurs from the promoters is to see how they handle, and even how they think about, barriers to their ideas. It will be very hard to think of a problem which an intrapreneur has not already thought of. Promoters will respond by saying that the problem will not occur.

An intrapreneur's examination results should contain both A's and D's. When intrapreneurial people are interested they get A's. When they are not interested they do not pretend. They are self-driven. The second hint is that any history of self-employment predicts intrapreneurial success.

When workers feel secure in their positions, they are more willing to help make the new technological systems successful. The main human issues which are created by technological change are job design, training, career development and organisational development.

It is important to prepare workers for technological

change by providing for adequate communication and encouraging participation in the change process. An aware and involved work-force will feel more secure and be more supportive of the change. With adequate planning and implementation strategies, workers can help to make the change process a success. (One of the biggest complaints of the Unions is that the workers are not informed early enough - hence their resistance).

Rather than decreasing the need for interpersonal communication, advanced office systems have made managers and professionals more aware of the interconnections among the parts of the organisation and the need for coordination and communication. Organisations need to support, develop and facilitate teamwork and interpersonal communication in order to promote innovation.

Seldom do managers fit people psychologically to their jobs. It is this kind of managerial naivety that results in repeated disappointment, failure, and even discharge of employees.

Support and protection are important, but more important is support for individual creativity. Suppose that a person's family encouraged innovative thinking and nonconformity. That it is acceptable to think different thoughts and to play with the computer while other children are out playing tennis. This person will have superb ideas but no political or personnel skills. A corporation will have to support and protect this employee, and teach him interpersonal skills.

Organisations today have to allow for the fact that younger people have higher expectations of themselves.

5.3 The Intrapreneur

Intrapreneuring (15), implies that one does not have to leave the large corporation to become an entrepreneur, ie. to start one's own business around an idea for a new product that one has invented. eg. 3M's sticky notepads. The advantages of being an intrapreneur instead of an entrepreneur are tremendous. One has no need to seek large amounts of capital necessary in starting a new business; one does not need to recruit and train employees, and further, one does not need to build new facilities, set up marketing and distribution channels and networks, establish dealerships and service centres. It all exists within the large organisation's structure.

The disadvantages associated with intrapreneurs is that traditional large-scale organisations are just not set up to recruit, to appreciate or to reward intrapreneurs.

Intrapreneurs are more at home chasing new ideas and of seeing them converted into the reality of a new product than they are of playing it safe within traditional organisational games and thereby of making it to the top. This character trait of the intrapreneur should be accommodated by the large organisation should they wish to keep the intrapreneur.

5.4 Unions

Walker and Crawford (16), found that communication was the key to the handling of the Unions overseas. A unionised company explained the types of systems it was contemplating installing. It presented the reasons which lay behind the investment and held formal

and informal meetings to convey information, training instruction and hands-on experience.

This had the effect of reducing the fear factor and increasing the knowledge base of the workers. The workers saw the investment as a guarantee for the future.

Advance warning of impending new technology deployment (of a general nature), without explanation to the workforce, appeared to cause more distress among the work-force than if the specific effects of the new technology were discussed and detailed from the beginning.

The conclusion drawn was that the vital factors associated with the successful deployment of new technology seem to be independent of whether or not the firm is unionised, of the composition of the labour force and of the prevailing market conditions. What is necessary is the level of trust between management and work-force (which can most effectively be promoted by communication) and an ability on the part of the firm to demonstrate that investment in new technology means *continuation of the firm*.

5.5 Managing Research

A problem-rich environment
fuels the spirit of inquiry

Research should not be done in an "ivory tower" atmosphere, but rather driven by an understanding of physical phenomena related to technological problems.

Bell Laboratories manage research by considering three factors - funding, focus and freedom.

- *FUNDING* refers to the SUSTAINED funding support necessary to provide continuity to long-term researchers themselves.

- *FOCUS* relates to the fact that they do not flounder about without direction, but concentrate their *efforts on areas of inquiry* dictated by the company's mission and market research.

- *FREEDOM* refers to the freedom that the individual scientist has to work within a particular arena of his choice, within the broad overall company mission: to set and evaluate specific priorities for research.

Another factor is the free *FLOW* of information with in/outside the organisation; especially between the researchers and developers. Free flow of information is the life-blood of a successful R & D organisation.

Cross-fertilisation of ideas comes from open contact and exchanges with colleagues in the same and related fields. One must also include the challenge by the market-place and very demanding customers. In this sense the creative people are challenged by "*real-world*" problems.

To encourage their people to grow and advance in the job, Bell Laboratories support an extensive programme of continuing education.

Research managers should orientate their organisations' operations towards building a bridge between the R & D department and the manufacturing department. The top manager of R & D can orientate the R & D department so that it meets the needs of the manufac-

turing department. This can be done by

- Exposing R & D people to manufacturing problems;
- Funding more manufacturing R & D;
- Enforcing greater discipline in R & D project planning.

The vast majority of R & D people in most companies are orientated principally towards the development of new technology and only secondarily towards the development of new products for the market place. The manufacturing problems involved in implementing a new technology usually rank a very distinct third (if that) amongst most R & D peoples' interests. Furthermore, many R & D people have had very little experience with the tight schedules and cost pressures that manufacturing people face daily.

Consequently, one of the biggest obstacles to improving the management of manufacturing technology is the very small "manufacturing R & D" budget.

When R & D operations are changed to meet the needs of the manufacturing department and manufacturing operations are changed to exploit the potential developed by the R & D department, a company will be able to manage the development and use of manufacturing technology more effectively.

People and company departments have become more tied together and dependent on each another. This occurs at every level of society more than at any point in world history.

5.6 The Organisation

The sophistication and complexity of modern technology

requires that organisations depend less on technical experts. Instead, technological change requires organisations to depend on multidisciplinary groups which bring representatives from all parts of the organisation together to design and implement new socio-technical systems (5).

The centralised approach, in which R & D is organised along the lines of science and engineering disciplines, offers the advantages of better technology transfer and interdisciplinary synergies within the departments. It limits duplicated effort. It offers economies of scale for costly facilities, and the ability to marshal large numbers of people and resources for major projects. It also offers better response to long-term corporate objectives and more effective direction and coordination. In addition it frequently serves to attract a higher quality of staff.

The disadvantages of the centralised approach are principally its latent inability to keep innovation flowing and its size. The size of the department may hinder the innovation process within the departments. Also, technology transfer from R & D to manufacturing and marketing is more difficult.

A decentralised approach is more advantageous when the company is involved with a large number of different technologies. Decentralisation sometimes makes it easier to channel individual entrepreneurial spirit for faster response to new opportunities. Further, it can allow the company to focus more effectively on specific projects with serious time limitations. Finally, it may provide better R & D units. This includes better intra-company communication.

The disadvantages of a decentralised approach lie in

increased costs, more facilities, services and specialised equipment. More managers are needed. Cross-fertilisation among technical specialists is less likely, and vision may be restricted, including contacts with the outside technical community. Short-term thinking may prevail, leading to parochialism and more defensive R & D focus on product-line extensions or minor product improvement. The guarding of data bases and contacts will be more jealously guarded, especially if these units are measured on an individual basis rather than on a company basis.

The argument usually favours small organisations as being more creative, innovative and entrepreneurial. And indeed, smaller groups, where possible, are desirable because they are easier to manage and encourage new ideas. They also have the advantage of a faster response than a large organisation. However, one must remember that a large organisation will have more resources available. Whether these resources are readily available is usually another matter.

A healthy business - or a healthy family - needs authority. Managers such as Tom Watson, Jr., of IBM, Reginald Jones of General Electric, and Walter Wriston of Citycorp led their companies through major transitions by taking a stand. Watson and Jones even went against their technical staff, but they set a clear direction. Once they did that, the rest of the organisation went along with them. Without a firm guide, a centre of cohesion, an organisation goes off in all directions and loses its character.

An organisation's personality, like an individual's, *can be changed, but it is not easy*, partly because of the unspoken contracts. People have to change and their psychology expectations need revision in order to change the organisation personality.

Strong leaders are necessary for organisations that must undergo significant change - not good managers or executives, but strong leaders.

The manufacturing manager must work towards better communication with R & D. He must orientate the manufacturing department so that it exploits the potential developments of the R & D department. The top manager of manufacturing can do this by

- Persuading the manufacturing department to carry out long-range planning
- Improving the capabilities of manufacturing people through better training and selective recruiting
- Transferring manufacturing people to the R & D department for temporary periods.

6 UNITED KINGDOM VS GERMANY

6.1 Introduction

In this overview of the situation in the United Kingdom and Germany, with respect to technology advancement and innovation, an insight into the situation elsewhere in the world may be obtained.

The significant differences in the economic performance of the United Kingdom and Germany are not just a post-war phenomenon. Closer analysis shows that as far back as the middle of the 19th century the pattern was already strongly established. This is important because it highlights how long term failure to adapt can lead to the creation of a vicious circle.

Britain's rise to prominence during the industrial revolution began to be challenged by about 1850. Her share of world trade fell by over 10% between 1870 and 1914, with Germany already the major competitor. More important, as Walker[1] points out, was the structural change involved. In addition to the expected higher growth rate of the newly industrialising Germany, Britain also suffered "*from a general loss of industrial dynamism in relation to both production and marketing. A declining rate of domestic investment and productivity growth was linked to the exhaustion of technical opportunity in established industries ... but, more importantly, to the failure to move resources into areas of production in which demand in the international economy was growing rapidly*".

The consequence of this slowing down was a loss of technological initiative. By 1914, the United Kingdom

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1. Quoted from Bessant and Grunt (3)

was still dominant in the coal and cotton industries but the Germans led in the newer sectors of steel, a situation which Walker calls "structural backwardness". The United Kingdom's position was further weakened by the slowness with which industry adapted to changes in the way in which production was organised to cope with rapidly increasing mechanisation, changes in the skills and equipment used and in their sophistication, increasing dependence on scientific knowledge and the emergence of functional specialisation within organisations.

Other factors undoubtedly contributed to the overall pattern of Britain's weakness. Amongst these were

- *Economic barriers*. It has been argued (3) that it was to Britain's disadvantage to be the first industrial nation, because countries which followed had the considerable advantage of learning from earlier mistakes and were not tied to an expensive capital investment in existing but obsolete technology. Additionally, the United Kingdom suffered from the factor of "cost advantage" it had by virtue of its empire. The availability of abundant supplies of cheap labour and raw materials meant that there was little incentive for the United Kingdom to follow its European competitors along the productivity improvement road.

- *Class barriers*. Both the United Kingdom and Germany had a privileged wealthy class but this was much more directly linked with industry in Germany where a belief in the development of national greatness through industrial growth was nurtured. This was in stark contrast to the United Kingdom where the aristocracy's involvement in industry was never high and where the dominant set of

values placed industry in a lowly position. Wiener[1] argues the case for linking the decline of the United Kingdom to this disdain for industry, pointing out that the first thing a successful entrepreneur did was to try and provide an education for his son as a gentleman. Thus, the son adopted the mores of the aristocracy rather than the entrepreneurial values of his father.

- *Educational barriers.* The British education system was developed essentially to serve the needs of the empire and emphasised administrative and cultural skills - as distinct from Germany where the emphasis was on a strong promotion of skills in the new fields of science and technology. As Hobsbawn[1] puts it, "... *the British ... entered the twentieth century and the age of modern science and technology as a spectacularly ill educated nation.*"

- *Financial barriers.* Kennedy[1] shown in his analysis of the pre 1914 development of capital markets that Germany had a much closer link between banks and industry. The role of the banks in maintaining the momentum of economic growth in pre- 1914 Germany is commented on by Kocke[1], "... *in general the German banks worked like big flywheels. They hardly initiated motion but they accelerated and enhanced existing tendencies ...*"

By contrast the United Kingdom had tended to concentrate its financial system in the city and was characterised by little direct participation or involvement in industry.

The first world war changed much - forcing rapid

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1. Quoted from Bessant and Grunt (3)

industrialisation and development into new areas (especially in engineering) and bringing with it increasing mechanisation, demand for new skills and a general restructuring and rationalisation. These factors together with Germany's defeat, helped to redress the imbalance which had grown up between the two countries. The United Kingdom did better during the inter-war period than might have been expected, given that the overall growth in the world economy had slowed down. Once again, though, closer analysis reveals that this was largely due to the cushioning effects of the empire which offered protected markets and sources of supply.

The pattern for Germany is well known. A near collapse of the economy under the crushing burden of reparations, raging inflation and finally the emergence of the Nazi party. Significantly, driving force behind the reconstruction of a "stron ermany" was industrial development. In particular, German industry was quick to exploit the major technical changes taking place in transport, communications and the newer industries.

The second world war mirrored the first in its impact on the level and type of industrialisation - demonstrating the unfortunate fact that war provides an excellent stimulus to innovation. It left Germany divided and in ruins and Britain in the role of somewhat hollow victor, at least in economic terms. She was weak and isolated, short of any vital resources and heavily dependent upon imports. The consequent decline of the empire was followed by a decline in manufacturing. It is clear that in many ways this was a case of chickens finally coming home to roost. That is, it demonstrated how much the empire had provided a convenient cushion against economic trends which forced change in other countries. The weakness of the

United Kingdom, reliance on old sectors, obsolete equipment, lack of skills in science and technology and lack of investment now began to show through.

Despite the sudden exposure to the force of growing world competition, the United Kingdom economy was sluggish in its response. The export-led boom of the 1960's which was so significant for West German development had only minimal impact on the United Kingdom. Most exports still went to empire-type markets and it was not until 1973 that over half the United Kingdom's exports went to European markets.

Even allowing for sectorial variations, West German *performance was consistently better in manufacturing* than that of the United Kingdom, as Panic[1] points out, "... *starting from a level of efficiency which was not all that different, the two countries went through a period of almost twenty years in which German industry achieved a significant improvement in its relative position*".

Whilst some of this difference may be due to other factors, it is clear that technical change has played *an important role. Oppenlander*[1] *found, for example,* that approximately 50% of the growth of the German economy during the twenty years following the second world war was probably due to technological advance. During the same period, British manufacturing was characterised by inefficient and outdated plant and a reluctance to move quickly into new technological areas.

As Carter and Williams[1] pointed out thirty years ago, the problem is particularly serious for the United Kingdom because its position in international trade

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1. Quoted from Bessant and Grunt (3)

"... makes it dangerous for the country to fall behind the technical progress of its competitors. The cost of industrial stagnation would not simply be stagnation in the standard of living. It would be a falling back, a mounting up of economic and social problems which would become worse the longer they were neglected ... the United Kingdom's position has, and will continue to have, something of the nightmare quality of running up a descending escalator".

Whilst it may be true to say that management in the United Kingdom was not coming to terms with the complexities of factory automation and process control as rapidly as those in Germany and Japan, it must be borne in mind that relative cost factors in these countries - particularly labour - had a strong influence on the picture.

In Britain, the problem is much more likely to lie in the attitudes or qualities of the people, who are by far the most important natural resource of a country.

It has often been said that differences in innovation between countries can be related to the availability of venture or risk capital.

There are differences in the way British and German industry operates. They reside in the

- financial system
- educational system
- government system
- industrial relations system
- organisation structure
- planning and control procedures

In the United Kingdom there has been extensive criticism of the "City" for placing too much emphasis on the dividends paid by large firms as an indicator

of the company's overall health - and thus as a determinant of stock market confidence. This means that the criteria for investment in new technology and other projects become unrealistically short term - unless a project pays for itself within a certain space of time it will not gain approval from a board of directors who have a two-way responsibility - to develop the business and keep the City and shareholders happy.

The United Kingdom model for production management tends to place value on "*coming up through the system*" and direct experience of the production process. This is an approach which stresses the "local" character and experience of the manager more and suggests that British managers are good at crisis management and at "fire fighting" activities, because they have such a highly developed familiarity with their specific operations. However, it raises questions about whether the United Kingdom local model permits the same breadth and flexibility of approach which is associated with risk taking, trying out technological alternatives, search for new options and other important characteristics of the innovation process to emerge.

At the intermediate level, ie. at technician/skilled operator level, the United Kingdom has a relatively poor record in comparison with West Germany which has a sophisticated system with an adaptive and developing syllabus covering a wide range of occupational skills. One consequence of this is that the pattern of alternate famine and plenty, which characterises the United Kingdom's experience in the labour market, does not emerge in Germany, where manpower planning is more highly developed.

Firms in the United Kingdom are increasingly forced to rely on outside sources, usually in the form of bank

loans and government grants rather than equity or loan stocks. A German report[1] indicates that a similar pattern exists. This is particularly associated with the decline in the amount of owner capital held by the family type firms. During prosperous years it has been relatively easy to retain funds from which innovative projects could be financed. However, after several years of recession these funds have declined to a point where they are almost exhausted and it becomes increasingly necessary for firms to seek external financing.

Compared with Germany, the British institutions have acquired a poor reputation for industrial lending. As one British manager put it "*..our banks want a belt and two pairs of braces*".

In Germany, the banks have long-established relationships with the companies, based on mutual trust and confidence. The banks often inform the companies about new business opportunities, a clear indicator of the type of close understanding which this relationship allows the bank manager to develop with his client.

Unlike the United Kingdom, West Germany has a regard for industry which is generally high and engineers rank alongside other professionals such as doctors and lawyers. There is some evidence that German and Japanese managers receive a much more broader based training than in the United Kingdom. eg. the Diplom. Ingeneur covers a much wider range of subjects and experience than the straight forward technical items covered in British engineering degrees (Lawrence[1]). It also appears that formal qualifications are more highly valued in Germany and there are certainly more

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1. Quoted from Bessant and Grunt (3)

graduates, particularly in technical subjects, in German industry.

From literature, one develops the impression that Germany generally has a greater flexibility than the United Kingdom.

6.2 Evaluation and assessment

One of the biggest problem areas in the innovation decision process is in evaluating different options and proposals, largely because so much of the outcome depends on subjective factors like attitudes to risk rather than on objective criteria.

One source of problems in the United Kingdom with respect to technical change is the lack of information which is passed to the workers. In Germany, the communication between the management, workers and the unions is fairly good. Here, management consults its workers at a much earlier stage than does its British counterparts.

Rosenbloom and Abernathy[1] compared the product innovation behaviour of United States and Japanese firms and related the success of the latter to management attitudes. In particular, they indicated that the qualities which Japanese management had were flexibility, speed of response, risk taking and organisational integration. This is very much within the sphere of technical progressiveness. They concluded that "*the institutional climate for innovation pertaining to considerations that are internal to the firm like management attitudes, practices and conventions are predominantly important in explaining the innovative*

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1. Quoted from Pessant and Grunt (3)

behaviour of the industry. These tend to dominate the more frequently cited external or macro-economic factors like inflation, industry structure, government regulation, the propensities to save and invest, etc." With respect to Germany and the United Kingdom, Parkinson[1] and Bergen[1], in comparative studies of the United Kingdom and West Germany, found differences in approaches to education and training project planning, financing of projects and industrial relations negotiations, which indicated greater technical progressiveness in Germany. The Systec report[1], comparing the United Kingdom, West Germany and Sweden in their responses to automation technologies also found differences, particularly in the approach of management.

In terms of general economic performance a NEDO report[1] on the non-price factors which affect international competitiveness indicated that *"the overwhelming conclusion from a number of studies over the past twenty years has highlighted British weaknesses in factors like design, ease of operation, quality, reliability, delivery and after-sales service of products"*. The performance of West German firms is very different. Their strong reputation for design and quality, the emphasis they give to punctual delivery and to after-sales service, their export orientation (arguably an indicator of active search for markets), their legal and administrative framework for smoothing the path of technical change via consultation with the work-force, their training system which anticipates future requirements for skilled manpower - all of these indicate a strong tradition of technical progressiveness.

To return to the question of whether German managers are more or less technically progressive than their

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1. Quoted from Bessant and Grunt (3)

British counterparts, Bessant and Grunt (3) found that in the firms in their sample the answer was no. The characteristics of technical progressiveness appeared to be shared by firms in both countries, and from this they concluded that these factors are independent of culture.

The German culture encourages and values many of the characteristics of technical progressiveness. The dominant British culture tends to inhibit their development and to emphasise what might be termed the "stable/short term" view. Financing of investments tends to be a long-term, planned process in Germany whereas the pressure exerted by the City in the United Kingdom leads to much shorter investment horizons, which eventually become part of conventional management wisdom - a self-fulfilling prophecy. The traditionally low status of production in the United Kingdom is almost diametrically opposed to the German pattern, which ranks engineers on a par with doctors and lawyers. The German vocational education system has considerable industrial involvement and produces skilled manpower to meet the varying demands of technical change in a planned fashion, rather than in the "feast and famine" pattern characteristic of the United Kingdom.

Thus, if managers in the United Kingdom wish to be technically progressive, they must, to some extent, swim against the cultural tide. It is not really surprising that the small-firm model has proved so important to firms wishing to maintain technical progressiveness because it permits the creation of an informal sub-culture which can exist independently of the national one and which represents the dominant culture for the organisation. Such a model also has the advantage that it offers rapid response and feedback which helps to reinforce its effectiveness as a

model. Technical progressiveness engendered by the small firm approach breeds success.

In tne United Kingdom, the force of conflict is no longer between upper, middle and working classes, but between the "us and them"; the worker and the factory management - a function of Labour rule in the United Kingdom. With time, this might change. If the worker takes more pride in himself and in his environment he will come to realise that it is not purely "us and them", but that everyone is involved - the Thatcher reign has demonstrated this.

The contrast with the West German management culture is quite marked. Perhaps the most important of these is the absence of the concept of "professional" management. Managers are first and foremost concerned with getting the job done, rather than with the protection of their specialist position.

In Germany, the power in top management is situated with the chairman, who is considered to have the final authority in decision making, although he may consider himself a primus inter pares. Next in power is the technical director. Firstly, he is believed to represent the very "heart" of the company, ie. production, and this belief shows the emphasis that is given to the engineering operation. Secondly, he is the executive manager of the department which outnumbers any other in manpower, capital and investments, and as such is accorded the largest share of negotiating power. The commercial director can only veto any move by his technical colleague when he is backed by the chairman himself.

6.3 The role of the government

There is little doubt that innovation policy is becoming an item of increasing significance for all governments. The role of technology as a determinant of international competitiveness and hence economic growth is clearly increasing in importance.

In a comparative study of the United Kingdom, Germany, Japan and France, Rubenstein et al.[1] concluded that, "*...there is a belief that the effects of market forces and competition on the research/development/innovation process outweigh by far the effect of government actions, and that the general government policies far outweigh the effects of specific innovation promotion policies*".

It was clear from the interviews of South African managers that government support was not viewed as essential to the successful operation of the innovation process, although for the purpose of applications for support it was usually necessary for the company to make a declaration to the effect that the project would not be able to proceed without government support.

Schumpeter[1] describes an imitation process which suggests a new twist to the conventional explanation that Britain's poor industrial performance is the result of a poor record of innovation. Rather than being good inventors who fail to innovate, it is possible that British firms are also good innovators - in the sense of being the first to acquire commercial revenues from a new technology - but fail to sustain and build upon this success when the imitators begin to gather. It is possible that there is a systematic

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1. Quoted from Bessant and Grunt (3)

weakness in British firms. It maybe the management, shop floor practice or even recruiting policy which renders it more difficult for firms to respond to imitative challenges from their competitors. This is a large and complex question, but before it can be answered, it is necessary to establish whether, in fact, innovating firms in the United Kingdom exhibit any tendency to perform less well than their competitors, during what Schumpeter called a period of post-innovation improvements.

Of course, the challenge to the innovating firm is to respond, but in doing so, it commits itself to a sequence of post-innovation improvements which are a necessary condition for it to retain or expand its market share.

In the United Kingdom, United States of America, France and West Germany, it was part of the conventional wisdom that economic growth was the concrete result of previous investment in scientific research. Whatever the relationships of science to economic performance, they were not deeply rooted in the British psyche. As people, the British are better at discovery and invention than at the application of their creativity to practical and commercial gain. To shift from the context of scientific discovery to that of commercial application, then, is to shift the analysis of British economic performance from technical invention to technological innovation. The Queen's Award Scheme rewarded British inventive skill in contrast to a rather disappointing performance in innovation.

6.4 Education

The following table is a summary by Bessant and Grunt

(3) of the educational situation between the United Kingdom and Germany.

Relationship of qualifications and organisation process

	UK	GERMANY
education and training	external	internal (eg. apprenticeship)
recognition of certificates	low	high
adjustment to job requirements	training on the job	promotion schemes, training.
criteria of promotion	performance by organisational virtues	certificates, performance (Leistung)
functional specialisation	separation of administrative and technical leadership	integration of administrative & technical leadership
cooperation	hierarchical	cooperative/ lateral
communication	hierarchical	professional (beruflich)
legitimacy	via status	functional authority

From the above table, one might well ask if the engineering education in Britain is complete? A question which is just as applicable to South Africa!

A particular deficiency in engineering education which frustrates the career development of the individual engineer, accounts in part for the sorry state of British manufacturing industry through inadequately trained engineering management, and leads to the poor status of the profession.

According to Walmsley (10), there are two errors in the British education. Firstly, students are taught the science of engineering in isolation from all its

other dimensions, and secondly they are taught to believe that they are immediately qualified for a job on completion of their technical training. Engineers get little time to become articulate at university. There is little opportunity in the crowded schedule for personnel or business skills. Does this not echo the situation in South Africa? Not at all surprising since the South African educational system has been based on that of the United Kingdom.

In conclusion, it is worth noting that the British influence on South Africa is not limited solely to education. South Africa's learned societies are conducted on similar lines to those in Britain. The British Trade Union organisation is duplicated in South Africa, whereas history shows that it would have been wiser to have modelled the local Trade Unions on the lines of those in the United States. In addition, similar snobbery exists in the engineering professions of Britain and South Africa. Technikons are viewed as "second rate Universities" whereas they offer excellent educational opportunities and are capable of training first class people. Their German equivalents are regarded as fertile seed-beds of technical skills. The shortage of technicians is most acute in South Africa and Britain. A University-trained engineer cannot work to his ultimate capacity if he does not enjoy technician support.

In Britain and South Africa engineers are, in general, notably absent from the boards of quoted companies. The routes to the boardroom are via Marketing or Finance. Unless a company is involved directly in the field of engineering, its managing director is invariably from a commercial or legal background.

Technology advance and innovation do not prosper under the conditions which have been noted here.

7 DISCUSSION

7.1 Planning

Change is the only thing that is permanent

Planning, as the term is commonly understood, is actually incompatible with an entrepreneurial society and economy. Innovation, almost by definition, has to be decentralised, ad hoc, autonomous, specific, and micro-economic.

The way in which new technology is introduced can have a significant effect on the success or failure of the innovation process.

Characteristics such as flexibility, speed of response and good communications are of central importance in determining innovation success.

A company must invest sufficiently in the planning stage for any technical change (or for that matter any project) to be a success.

Most of the companies interviewed, when asked to look back on projects tackled, commented that in hindsight not enough planning was done. They said that as the project got underway, pressure to produce results and in many cases, hardware, meant that problems were not properly addressed and although solutions initially seemed to work, later in the project's development the "sore" reoccurred.

The author feels that one of the barriers to the implementation of new technology is poor planning. Planners today are competent; what is being addressed are those areas which are normally ignored, because

traditional business methods have told us that they are insignificant and an order to comply is sufficient.

In the smaller companies interviewed (with exceptions), innovations were implemented in the same ad hoc way that the innovation was perceived. Good products were the result, but they were not readily accepted by the market for it was not yet ready for it.

Flexibility should be high throughout the life of the new technology. In the early stages of its development and implementation, changes are cheap to effect when compared with those that have to be made when the choices in innovation are restricted.

When planning for the implementation of new technologies, the company's mission, goals and culture must be addressed. In fact, these could be good selling points when convincing top management to accept your proposal. Other factors that need to be considered are company size, industrial sector, organisational structure and types of production process. The principal impact on the company (in addition to providing the structure in which change takes place) is that which might be called "the logic of optimal production". That is, for a given process, investment in new technology will be made on the basis of that technology which contributes most to bringing the actual process closer to optimal conditions. The priorities here might include savings in energy, materials, labour, improvements in quality, consistency and reliability. They are also likely to vary over time.

Insensitive factors that affect the company's ability to change are the environmental factors. This in-

cludes

- economic climate
- state of the market
- activity of competitors (including their innovation policies)
- tate of the labour market (structure, availabili- tc.)
- rnment policies (to promote technical change ontrol activities, eg. emission controls, health and safety legislation.)

Brain-storming might be a method to generate items to be accommodated during the implementation phase. All departments that might become involved during the implementation phase should take part in the brain-storming sessions.

It is politically advantageous to involve the unions at an early stage in order to avoid difficulties. It is helpful to mobilise support and input from quarters usually not directly involved in decision making.

The innovation process is essentially a "technology push" phenomenon. A clear understanding of customer requirements is at least as important as technology in stimulating technological innovation. Continuous coupling of technological development with the market place must be done to ensure success during implementation. The marketing department can play a major role and therefore should be included in any brain-storming session.

At the level of planning for the individual, there are a number of issues relating to responses to new technology and to change in working arrangements. Unless planned for, these can produce attitudes of hostility and suspicion towards the changes and this in turn

leads to industrial relations problems. It is unlikely that a man will welcome a change which may well result in his being made redundant or which reduces the skill component of his work.

Learning curves are also associated with change. This is demonstrated by the fact that technologies of innovation do not happen overnight. It is something that takes a finite amount of time to be accepted and mature. The time needed for acceptance and maturity can, to an extent, be reduced by increased financial funding.

Another issue which is likely to become increasingly important with complex technologies is that of interfacing skills; ie. the skills associated with joining together different elements of the development and production systems.

The project should trade on the local base of knowledge and experience to enhance the quality of the final product. This approach also helps avoid post commissioning problems.

A useful tool to use when planning the implementation of a change, is to list the opposing forces within the company or environment and determine their effect and strength.

Once this is done, then a strategy is determined which will be appropriate to overcoming the resistances highlighted using the above method. *Negotiate* with those who are going to lose something of value and offer incentives. *Educate* those who will resist due to misunderstandings or lack of trust. Use a *participative* strategy with those who view the changes in a different light. Sell the change in such a way that they perceive themselves to be part of the idea. If

the resistance comes from people who have a low tolerance for change, ie. who will fear that they will not cope, then force the change through and support and reinforce the resultant behaviours.

No plan is complete without specifying the monitoring system. Monitoring should be meticulous so that unexpected events are identified quickly and are addressed intelligently.

7.2 People - The Natural Resource

The same person rarely makes both a good administrator and an effective innovator

Without the support of the individual and the access to the knowledge which a person has gained in the organisation, no innovation or change can take place.

Therefore, concern and development of the staff must be an essential part of the management's job. It must facilitate the self-development of all subordinates. Staff must view development as being that of self-development and must accept responsibility for their own development.

No two individuals are the same. They differ in many ways eg., in work and lifestyle values, personal and work needs, interests, family situations, stress tolerances, the will to manage, self-defined limits, capacities and speeds for learning, and levels of ambition. The organisation cannot presume that all employees are alike or will react in the same way to offered "opportunities".

Hence, no two managers will fit into the same job in the same way. When one moves a person to another job,

the job must be adapted to employ the strengths of that person. It will give management an opportunity to alter the job description, if required. The fundamental being introduced here is that one should fit the job to the person and not the person to the job.

The required manpower complement of a company does not happen accidentally. In all cases it should be planned. The manpower plan should take into consideration the boom and the recession times of the company. It should try to level out the manpower requirements for these oscillating periods. Not only will this process give stability to the company, but it will also boost morale and stability in the work-force.

The *Peter Principle* is twenty years old, but in some cases it is still valid. There are many ways of recognising an employee's achievements. Explore them rather than promote him into incompetency.

The aspect of *cross-training* is one in which a person is trained to do more than one job in the company. It is particularly evident in the staff of the smaller companies interviewed. It is a concept that could be used to great effect in all companies. The Unions might initially challenge the wage for the cross-trained individual. One should then point out that training is to the advantage of the individual and that it adds to his job security.

Training is seen as a secondary function, as a means of oiling the wheels of technical change. Firstly, it provides individual motivation and development at the most basic level. People like being trained, because it is an expression of the fact that the firm does care about them. The training process may also achieve greater involvement and participation in the technology change.

Development occurs largely on the job. This is by far the most effective way to train personnel, but at the same time it can be disruptive and time-consuming for the supervisor. It is also the most costly in terms of time and organisational resources. However, the practising of new skills and the receiving of feedback is vital to the long-term retention and commitment to the new job/skill. Therefore this type of training will require commitment from senior management and the release of involved staff.

Different jobs require different skills. Following this principle requires a good diagnosis both of the nature of the jobs and tasks to be performed and of individuals' training and development needs.

The job must contain challenge and/or stretch which constitute some of the essentials needed to maintain job satisfaction and interest. The challenge experienced must be continual and gradual. Sudden changes create uncertainty and insecurity. Gradual changes help to maintain interest.

A step-by-step approach will have a greater chance of success than a large, highly sophisticated change. Whatever the change is, one cannot neglect the human factor. The rate of acceptance of new technologies depends on the interpersonal skills and individual readiness of the worker to the change. It is far easier, and usually more effective, to prepare him for several, well-spaced incremental changes than for one large one.

Periodic recharging (holidays) eases stress and consolidates learning. The body, mind and emotions need periodic rest and recuperation. It is therefore essential for a person to take a break during the

learning of new skills on a daily basis as well as a regular holiday from work (on a yearly basis).

Successful development programmes require monitoring. They do not just happen by themselves. One should follow up a few weeks after the completion, if development programmes are required to consolidate the learning process.

Individuals' careers need frequent evaluation in order to ensure that their development occurs as quickly and smoothly as possible with a minimum of personal and organisational side effects. Just as the needs of the organisation change, so do those of the individual.

Organisations should base promotions as much on assessed potential as on observed performance. Just because a person has been in a job for a long time, or is able to do a job well, does not mean that the person should be promoted. The employee's desire and potential to perform in at least the next-higher position should be just as important in the promotion decision.

One way of dealing with the promotion of technical or specialist staff in companies where promotion is principally based on the management scale, is to introduce a dual promotion scale. One leg of the scale is for the traditional management route where the company's current criteria and remuneration apply. The other leg of the scale is for the technical person or specialist. These people can be promoted into the top levels of the company, where they receive comparable remuneration or market -related remuneration. Their status has been raised and they become more proud of their position and company. Their level in the company does not relate to their management responsibilities, although their general responsibili-

ties and authority have been raised. In other words, a high level specialist may be reporting to a lower level manager.

This dual path has had the effect that technically orientated people can stay in the technical field and still reach the upper echelons of the company. This will have a tremendous spin-off in keeping technically trained people in their technical fields.

When it is time to reward an implemented new technology, one should remember that although it was probably the idea of a single person, it took a team to implement it.

Education is a means of showing a person that the company cares. It is self-development and growth of the individual which is to the advantage of the company. Ongoing education, both inside the company and outside, is a must. It stimulates the individual and is a fertile area for new ideas. Companies should encourage their staff to participate in their specialist professional institutes. Through these institutes, the horizons of the individuals are broadened. The cross-fertilisation of ideas bolster the innovation potential of the person.

The effects of the above points will cause reduced employee turnover and absenteeism, improved commitment to the employer, better management decisions, more innovation, better teamwork, and improved morale among workers. This is due to the concern, by the company, for the individual.

7.3 Award for Meritorious Defiance

A mistake is at least evidence that someone tried to do something

Entrepreneurs are driven by a vision which they believe is so important that they are willing to dedicate their lives to it, even when it starts to give trouble. Entrepreneurs often get themselves into trouble by saying exactly what they think, because they don't seem to be good at compromising.

Entrepreneurs are often in trouble because they act when they are supposed to wait. They tend to act beyond the territory of their own job description and function.

Hewlett-Packard have an "*Award for Meritorious Defiance*". This award is presented for recognition of "*contempt and defiance above and beyond the call of engineering duty*". However, the essential reward for an entrepreneur is freedom.

How can one succeed at entrepreneuring? One should

- Do anything needed to move one's idea forward.
- Consider that it is easier to ask for forgiveness than for permission.
- Come to work each day willing to be fired. If one is already dead, then one can think clearly and have a good chance of surviving the battle. Entrepreneurs have to have the courage to do what is right instead of what they know will please the people in the hierarchy, who are trying to stop them.

7.4 Resistance to change

During the interviews, in almost every case, the first major resistance to change was cited as a result of poor communication. In those cases where other reasons were offered, it transpired after discussion with the interviewee, that lack of trust in management and lack of understanding were the underlying factors. These are manifestations of poor communication.

Other reasons cited for resistance to change were

- close to retirement
- not willing to learn new job (Old dogs, new tricks)
- losing control of job to machines
- "not invented here" syndrome

All the above problems can be solved through communication.

Consider a unilateral declaration of change. It is fast and relatively simple to implement for the management. The change is presented to the work-force as a fait accompli. The result of such an action is possible hostility and active resistance, either at the outset or at a later stage. From the technical side, the change chosen depends on original choice and there is little flexibility for modifications at a later stage.

The unknown is sure to lead to resistance. Only job and self security will lead to the acceptance and support of the change by the work-force. This is achieved through communication.

The reasons for resistance cited above can be collectively described as habits. We have a lot of old habits that no longer fit into today's business environment. Organisations, like people, are creatures of habit. For organisations, the habits are existing

norms, systems, procedures, written and unwritten rules - "the way things are done here". Habits kill innovation and breed a contented work-force. One should encourage the work-force to question methods and to offer suggestions. In addition, one should run an incentive scheme for new implementable ideas.

Suppliers are also seen as resisting change. In the South African context, the industry is not large enough to support, in many cases, more than one supplier. The supplier has a process or line that has been running without problems for a few years. He is reluctant to change it. The fundamental reason for this is that he does not fully understand the process and hence the effects of any changes.

Clients are cited as resisting change. It has been found that the client does not have an understanding of the design of the products used by him, nor does he really understand the environment in which the products are to be used. The client is portraying an image of being supreme and will not humble himself by admitting that he lacks the knowledge.

For each innovation, the market equilibrium is constrained by a long-run demand curve, but this equilibrium constraint is only relevant after a period of transition to overcome market resistance. A major growth impulse is provided by any innovation which can generate scope for a sequence of secondary improvement innovations (incremental change) extending the market, lowering production costs and overcoming specific bottlenecks.

Hedgers are people who are not committed to the change nor are they against it. They wait to see what everyone else is going to do. They watch to see how the tide is running before they commit themselves. Man-

agement should identify them and give then specific direction. Show them that management is for the change and then get them involved.

To overcome resistance to the implementing of new technologies, one must plan. The affected groups must be identified and the planning targeted towards them. Each group will need a specific plan. Those with a high tolerance for change must be treated differently from those who lack understanding and trust.

Communicating is time-consuming and must never be considered as an easy task. It has to be targeted to the specific audience. If done honestly and sincerely, it is an action seen by the staff as being one of consideration and concern for them. One communicates to change an impression in a person.

7.5 Communication

The key to change is the proper management of information.

The vital factors associated with the successful deployment of new technology seem to be independent of whether or not the firm is unionised (16), of the composition of the labour force and of the prevailing market conditions. What is necessary is a level of trust between management and work-force (which can most effectively be promoted through communication) and an ability on the part of the firm to demonstrate that investment in new technology ensures that the firm will have a continued future.

The general complaint by the unions of not being informed of potential changes in most cases is valid. However, it is up to the unions to show management

that they are mature enough to receive such information.

Persuading company staff to accept a change is a marketing exercise. This is a costly exercise in terms of time and organisational resources but failure to gain the acceptance by the staff could be more costly. Innovation is "sold" to the work-force via presentations, training and other aids. The work-force still has no direct involvement and is essentially passive in the process. Its direct involvement and responsibility is still necessary to ensure continued commitment. It must become a part owner of the change.

Communication also involves the dissemination of technical and scientific information around the company. Periodic gatherings where the scientists and engineers present to foremen, middle and senior staff information on the projects on which they are currently working should be encouraged. This need not be restricted to what is going on in the company, but also developments outside the company. This forum results in the pooling of resources/ideas within the company for the advancement of all projects. It provides for the cross fertilisation of ideas from other project teams. It can be extended to include the presentation of problems in projects.

The 1980's and 1990's will be known as the era of the information explosion. So much information has become readily available. The handling of this information is important for the company and the innovators. The centralising, referencing and disseminating of the information is vital for the company. This is too large a task for the individual to do. There should be a company librarian to sort through the information, and distribute it via abstracts to interested

persons - in much the same way that the CSIR has done with its Centre for Information Services.

It is human to gossip. Rumours start when there is limited information. In a confined work-force such as in a company, rumours travel fast. They breed discontent and disillusionment. The surest way of combating this is regular communication with the work-force.

7.6 Management

Manage change
rather than have change manag you

Team Work is the name of the game. One should reshape the organisation so that people work as members of a team. They will the have the flexibility to respond to external change and to manage internal change. Teamwork engenders trust and eliminates empire building. Organisational power politics become non issues, for the emphasis is placed on team results.

One of the main advantages of the matrix system of project management is that team work is engendered. The project team draws members from across the functional disciplines and broadens the base from which ideas and expertise are obtained.

Team work overcomes the horizontal differentiation of a company (7.12 Company Culture) and makes it very difficult for departmental managers to build empires. This assumes that top management is more interested in the project results than in the results of individual departments.

Company team work should be considered by management. Later, large and small companies are discussed (7.9

Small vs Large). There is an opportunity for management to set up joint developments with companies of different sizes.

Close contact between the innovating firms and the users of the innovation is frequently identified as an important element making for successful innovation. The sooner management gets the user involved in the development of the new technology, the easier it will be for the user to take possession of it. With mutual trust and cooperation, management will find that incremental post-innovation will develop more naturally.

In companies with deep hierarchical structures, it is found that top management is isolated from the new technologies and other developments taking place in their companies. These companies show characteristics of "slow to move" when it comes to innovating. Shallow structured companies are the converse. Their management can talk about the new technology being developed in the company. The company is fast to react when it comes to change and less resistance is noticed.

Management should look at the German attitude. There, management manages the job and not the position. In many instances this is the opposite of what happens in South Africa. The management of position is often seen as empire building.

Management should explore the different attitudes of the labour force and turn these into opportunities. They should train people for the new jobs created by the technological change and give explanatory lectures, bearing in mind that the fears and requirements of the different levels of people in the company require different approaches. The work-force that is

to initiate the technological change needs support in the form of a commitment from management. Without continued support, the technology change will grind to a halt. Management must be seen to support actively the change.

Management plays a very important role in getting people to initiate change. Many management theorists contend that innovation occurs when people are encouraged to take risks without fear of being punished and with the promise of rewards for success. Research, however, suggests that achievers are driven more by the likelihood of success itself than the consequences of failure or success.

Top level people (in the traditional company, this is management) can catalyse change by helping and encouraging others to be change agents. By getting other people to take ownership of the new technology, they increase the number of people committed to the change.

Why does management see the entrepreneur, the champion of change, as an added burden? The entrepreneur tends to have exceptional behaviour. He clashes with others in the organisation. The entrepreneur is like a foreign object introduced into a body. The body's immune system will try to reject it, in order to defend the existing behaviour. The challenge facing most companies will be met, not by the introduction of a foreign object, but by reconditioning the body to meet changed conditions.

How often has one heard the "us vs them" attitude? It was very prevalent in the United Kingdom. This attitude is not conducive to change. Until management can get the work-force to work as a team with the company, no significant change will be implemented.

In Germany, the Technical Director is often the second in charge. The German companies recognise the importance of technical and manufacturing departments to the company. Due respect is given to professional technical staff.

The change process must start with leadership, not management. Leadership is not limited to the top hierarchy of the organisation. Everyone who understands the purpose of transformation can occupy the leadership position. It is important for the top management of the organisation to create a clear vision of purpose that others can understand and follow.

With a dual promotion scale in force, it need not be a top manager who takes this role. It can be one of the top technical or specialist persons. This person must develop an environment which facilitates the creative and innovative process, demands excellence, breaks the habits of mediocrity and allows for relationships to be created that stimulate the change process.

7.7 Holistic Approach

Holism is team work. It is a philosophy used to approach challenges in the same way that Systems Engineering is used to tackle large turn-key projects. It represents a top-down design and management approach. It considers the task, firstly, from the view point of it being a whole entity, and then, secondly, the detail required to maintain the prime task.

Technologies and volume of work required for some of the new developments are too large for a single person to cope with. It is therefore prudent that a team approach be used.

The new product development process emerges from the constant interaction of a hand-picked multidisciplinary team whose members work together from start to finish. Rather than moving in defined, highly structured stages, the process is born out of the team members' interplay. A group of engineers may start to design the product (Concept Phase) before all the results of the feasibility tests (Feasibility Phase) have been obtained. Or, the team may be forced to reconsider a decision as a result of later information. The team does not stop, but engages iterative experimentation. This goes on in even the development process (Full Scale Engineering Development Phase).

"Necessity is the mother of invention". Creativity is similar. It is born by pushing people against the wall and pressuring them . Management must begin the development process by setting a broad goal or a general strategic direction. The project team must be given the freedom in which to operate. The mere suggestion that the team is not structured causes built-in instability which is conducive to a creative environment.

A project team takes on a self-organising character as it is driven to a state of "zero information", where prior knowledge does not apply. The project team begins to operate like a start-up company. It takes initiatives and risks, and develops an independent agenda. At some point, the team begins to create its own concept.

The project team must have freedom to use its resources as it deems fit. Management must give it the autonomy to operate.

A project team consists of members with varying func-

tional specialisation, thought processes and behaviour patterns. Such diversity fosters new ideas and concepts.

While selecting a diverse team is crucial, it is not until the members start to interact that cross-fertilisation actually takes place. When the whole team has been brought together, one person's information becomes another's. If everyone understands the other person's position, then each will be more willing to accommodate the other.

At some point,the individual and the whole team become inseparable. The individual's rhythm and that of the group's begin to overlap. This overlapping becomes the driving force that moves the team forward.

The quickness of the pulse varies in different phases of development. The beat seems to be most vigorous in the early phase and tapers off towards the end. The phase-to-phase method of development can slow or even halt the entire development process. Under the holistic approach, the phases overlap . This enables the project development to absorb the slower or faster moving sub-projects without demoralising the respective sub-teams.

Under the holistic approach, the individual is seen as a whole. Learning is encouraged not only in the direction required for the company, but to develop the individual as well. This accumulation of experience and learning in other fields motivates the individual and could, one day, be to the benefit of the company.

The drive to accumulate knowledge across levels and departments is only one aspect of learning. There must be a drive from each staff member to transfer his/her learning to others outside his/her group.

This transfer of learning must take place on a regular basis.

Subtle control is exercised in the project team in several ways

- Selecting the right people for the project team while monitoring shifts in group dynamics and adding or dropping members when necessary
- Creating an open work environment
- Encouraging engineers to go out into the field and listen to what customers and dealers have to say
- Establishing an evaluation and reward system based on group performance
- Managing the differences in rhythm throughout the development phase
- Tolerating and anticipating mistakes. One learns more from mistakes than from successes.
- Encouraging suppliers to become self-organising. Involving them during the design phase is a step in the right direction.

7.8 Empire Building

Empire building is a symptom of incompetency and one of the contributing factors is the Peter Principle. The person who has the management and technical skills does not have to build an empire. He naturally attracts followers. An empire builder is a person who does not want to be confronted with a problem, so he surrounds himself with people who act as barriers. The purpose of the department becomes obscure and he makes the work of others difficult. He will try to prevent the hiring from outside to solve the problems so that the problem remains unsolved and his department has something to do. When having to recruit, he will chose people who are shy or are "yes men" and who

come from a very traditional background. While he has the support of his staff, it is probably benefiting the company. When his staff stop supporting him, he will be found out, which is probably too late for the company.

A factor which is as detrimental as empire building is the "Top/Senior Management Clique". This is where one senior manager cannot see fault in another senior manager. They protect and support each other unequivocally. Although it is important to present a unified front to the rest of the company, one must not fall into the trap of carrying a person who is actually of no use to the company. One should train him or get rid of him. It will be of benefit to him and to the company.

Communication and team work between departments is one way to reduce and break down empire building. Rotation of individuals to other departments, without their support staff, will expose and prevent empire building. Each person should be managed by means of productivity and quality. Departmental objectives must not merely support the next level boss. They should be self-standing and measured not only through the next level manager, but also through other departments.

7.9 Small vs Large

Small firms traditionally have advantages of flexibility and rapid response to change but the disadvantages of limited resources. Firms can adopt a strategy which uses the advantages without being inhibited to any great extent by resource constraints.

Small firms have a distinct advantage when it comes to

an innovating organisational climate. This is almost self-evident, but relates to the overall atmosphere within the firm - morale, motivation and the sense of common purpose. This engenders a willingness to be flexible in the innovation process which is often absent in larger firms where there is less of a commitment to the unit and where conflicts of several different interest groups may dominate the negotiation process and reduce the team effort.

There was one structural feature which does seem to be shared amongst the majority of companies interviewed - the small firm orientation. At first sight they do appear to have a number of advantages - small hierarchies, rapid responses, good communication along lines, high flexibility, well developed general skills and shared responsibility amongst management, - which might be expected to help the operation of the innovation process. However, most literature, particularly from the economics point of view, holds that it is still large firms which are dominant in innovation - principally because of their greater resources. Certainly, small firms face this problem of lack of intensity, which might be expected to inhibit their ability to be successful at manufacturing innovation. The evidence is highly variable, with supporters both for the "*small is beautiful*" and the "*the big is best*" viewpoints. Rothwell[1] suggests there is some truth in both arguments and small and large firms are interdependent as far as innovation is concerned - what he terms "dynamic complementarity". This is important because it implies an element of deliberate choice regarding structure and procedures rather than an evolutionary organisational form.

The aspect of companies within companies has been put

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1. Quoted from Bessant and Grunt (3)

into good effect by a number of South African companies. There has, however been one detrimental aspect. One of the companies interviewed divided its project department up into several business units based on product families. This generated fierce competition between them which has become detrimental to the overall company goals. The cause of this is not due to the business units, but due to the way each unit is evaluated by the divisional head.

In today's climate and especially the South African situation, large and small companies should consider joint ventures and sharing of the innovation process. Large companies are better prepared to assess market needs using their existing marketing departments, with both formal market research and feedback from existing customers. Once a need for an innovation has been assessed, the large company could then screen small entrepreneurial concerns which may have the skilled personnel to develop the innovation for the market need. The independent entrepreneur can concentrate on areas in which his skills lie, namely organising the innovation team and developing the idea from a technical viewpoint. Corporate personnel can concentrate on areas in which they are more highly skilled, namely the managerial/administration side of the innovation process, such as raising finance for the venture, marketing the innovation and planning the overall strategy for manufacturing and marketing the idea.

7.10 The Financial System

Any investment in a project within the firm must form part of an overall strategy which takes into account the direction and expected development of the business. Decisions are made on the basis of some expected return which will exceed the cost of the capital

invested. Consequently, the choice of sources of finance will be strongly influenced by this factor. There are a number of options to choose from but clearly the most preferable will be from internal sources. However the extent to which this is possible depends on the number and range of commitments which the firm already has - and its profitability. At times of recession and particularly for the smaller firm, this may be low and the options for internal financing may be limited.

For larger firms, there is the additional problem of dividends to shareholders which represent part of the profits. These might otherwise have been channelled into investment.

Perhaps the largest barrier to innovation is that of resources. An extension of this is that the innovator himself can be a barrier, if the concepts are not thought through. There could be an alternative way to achieve the same goal with less risk.

The financial staff of the company always claim that they are open to suggestions with respect to investment in internal projects. What is required is a well motivated request. The financial director has an overall view of the company's financial liabilities and can easily determine whether it is too thinly spread. Along with senior management, the innovation projects must be prioritised in accordance with the company goals and mission, resources and technical capability and marketability.

A motivation for funds at the beginning of the innovation must consider the needs several years ahead. It is no use to start a new technology if it cannot be financially supported in a year or two.

An aspect of the budget often omitted by the project manager is that of implementation costs. This includes training of staff from other departments and the user, marketing the change and allowing for the learning curve.

The financial department is a support department to that of the project team. Having a representative at progress meetings will help the project manager in obtaining approval of his request.

Two barriers cited by several of the interviewees are that of cheap labour and import protection. It is felt that although cheap labour is an advantage in breaking into a market, it was not conducive to further innovation in order to stay in the market. Import protection helps initially, but results in reduced competition which stagnates innovation.

Technical advancements take years. Thus, lending institutions are reluctant to wait so long for a possible return on their investment. Larger companies are able to spread the risk and time factor over several products, whereas small companies cannot. In Germany, there is a strong link between the banks and industry. This link has existed for several years. The close cooperation has benefited the company by the banks assessment of the market and trends, and the bank has benefited because it has been able to closely monitor its investment and offer financial advice. Thus the bank has been able to reduce the risk associated with small companies.

In essence, the smaller the risks involved in the change, the more likely one is to obtain finance for the project.

7.1 Technical Progressiveness

It will be useful to review the innovative behaviour of management in terms of a general model suggested by Rogers and Shoemaker[1] who see the process involving the following stages

- awareness
- interest
- trial
- evaluation
- adoption
- implementation

i) **Awareness**

When considering the awareness of an organisation, one looks at how it searches for new opportunities, what sources it uses and from whence the opportunities come. Once a source or idea has been identified, how the company makes use of resources for the exploitation of the opportunity, particularly the internal resources of the company.

To what extent are technological gate-keepers and innovation promoters identified and used? Are these individuals allowed to offer an input to the opportunity or is it a decreed matter from top management?

To what extent does the company monitor its operations? This is seen, not only in terms of its operations, but related to the above pattern of active search and use of resources in a continuing nature.

Is the company involved in a generalist or spe-

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1. Quoted from Bessant and Grunt (3)

cialist activity? In terms of Rogers and Shoemaker, the company should be principally involved in generalist activities.

The ultimate in company awareness is the degree of technical competence amongst management.

ii) **EVALUATION**

When evaluating a company, one looks at flexibility with respect to investments. The openness associated with the readiness to consider many different types of proposals for change is an indication of technical progressiveness. Are the individuals prepared to take risks? What is the level of internal technical competence; the access to external resources?

How formal and rigid is the planning?

iii) **ADOPTION**

To what extent did management (down to the worker) adopt the change? The process of adoption includes consultation and the involvement of management. This is done in keeping with the view that innovation is a shared responsibility.

What is the technical and managerial competence of the staff to handle the change?

Most important of all, was there top management commitment? Whilst innovation is seen as a shared responsibility across the organisation the motive power comes from the top.

iv) **IMPLEMENTATION**

Was there early communication with respect to the change? What strategies were formulated for its implementation? Did top management become involved? Once the change or implementation started, what monitoring arrangements were formulated?

What was the company climate like? Did it foster innovation? Was there the necessary flexibility within the organisation to adopt the change? Was there planning in terms of manpower and training?

The characteristics of a technically progressive company have been obtained from Carter & Williams[1], Rothwell[1], Bessant[1].

- **HIGH QUALITY OF INCOMING COMMUNICATION.**
  This is achieved by having a wide network of contacts or sources outside the company. Within the company, one needs people who are skilled and experienced in many different fields. They should be capable of interpreting the incoming information.

- **A DELIBERATE SURVEY OF POTENTIAL IDEAS.**
  Here the company peruses both its internal and external environments, looking for ideas and opportunities for innovation.

- **A WILLINGNESS TO SHARE KNOWLEDGE.**
  This relates to the "openness" of a company, where visits, discussions and general informal exchange of ideas and experience is accommodated. Does the company participate in professional institute meetings?

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1. Quoted from Bessant and Grunt (3)

- **A WILLINGNESS TO TAKE NEW KNOWLEDGE ON LICENCE AND TO ENTER JOINT VENTURES.**
  For many of the companies it is essential that they use multiple sources of technology. Few had their own R & D departments. They preferred to cast their nets widely, using joint ventures where resource constraints are involved and licensed where this is an easier way to access technology than developing it in-house. These companies should also be willing to license and share their own technology.

- **A READINESS TO LOOK OUTSIDE THE FIRM.**
  In Carter and Williams' work[1] they used a firm's readiness to look outside as a measure of how far the company sets its standards of performance and technology by what it sees in its competitors. On this basis the sample of companies the author interviewed performed well, despite their small size and resource constraints, often scoring highly because of their attempts to be technological leaders in their specific sectors.

- **EFFECTIVE INTERNAL COMMUNICATION AND COORDINATION.**
  Effective internal communication is of prime importance. In recognition of this, companies have tried to maintain a small company orientation. Some of the qualities would be
  - effective teamwork when new developments are being planned
  - clear specification and understanding of responsibilities, authority and objectives of the individuals and groups within the company which enables them to work together effectively

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1. Quoted from Bessant and Grunt (3)

opment, production and sales which does not hold up projects or lead to their being shelved
- decision-making is informed and rapid at all levels.

- **HIGH STATUS OF SCIENCE AND TECHNOLOGY IN THE FIRM.** This is mainly a reflection of two points - that technically progressive companies value this kind of background and skill, and that there is a high proportion present in the company management - particularly in decision-making positions at high level. In the companies interviewed by the author, it was generally true that engineers and technologists were not regarded on a par with financial and marketing managers of the company.

- **A CONSCIOUSNESS OF COSTS AND PROFITS IN R & D.** Companies should be aware of the economic and competitive position of the company and the constraints this places on their activity.

- **RAPID REPLACEMENT OF MACHINES.** This relates not only to a desire among technically progressive companies to keep abreast of new technologies, but also to their policies to replace machinery regularly rather than running it over a long period, which gives depreciation advantages but makes the eventual cost of replacement prohibitive.

- **A SOUND POLICY OF RECRUITMENT FOR MANAGEMENT.** This refers to the regular intake of trained and experienced personnel. In larger companies this might be achieved by recruiting a high proportion of graduates. In smaller companies, this is more evident by the attention paid to intermediate level training and apprenticeship. Has the company done an age analysis of management and is there

a follow-up plan?

- **AN ABILITY TO ATTRACT TALENTED PERSONNEL.**
  Although financial reward is important, it is clear that in a seller's market for scarce skills, factors like motivation and job satisfaction will be of considerable importance.

- **A WILLINGNESS TO ARRANGE FOR THE EFFECTIVE TRAINING OF STAFF.**
  The training system needs to be developed to balance the requirements of innovation. Technically progressive companies give this a high priority, even under difficult economic constraints.

- **USE OF MANAGEMENT TECHNIQUES.**
  There is some association between technical progressiveness and the use of techniques like production planning and control.

- **IDENTIFYING THE OUTCOME OF INVESTMENT DECISIONS.**
  Associated with the above techniques are those used within the planning and decision-making framework to assess proposals for investment. As with the other techniques, the important feature is knowing when and how to use them but not relying upon them in a mechanical fashion. Used in conjunction with judgment and experience, they enhance the company's control over its activities without inhibiting them.

- **HIGH QUALITY IN THE CHIEF EXECUTIVE(S).**
  This refers to the need to provide a technically progressive lead from the top and depends on the presence of high calibre people with experience and qualification. They should have the respect of the people who follow.

- **ADEQUATE PROVISION FOR INTERMEDIATE MANAGERS.**
  This refers to the amount of delegation and the number of hierarchical levels. In technically progressive companies there is a sharing of tasks and responsibilities such that senior management can concentrate on strategic issues whilst intermediate management looks after the day-to-day operations. There is a close integration between them.

- **GOOD QUALITY IN INTERMEDIATE MANAGEMENT.**
  The most progressive companies are found to have, for example, production managers who comprehend the technology of the process for which they are responsible and who can, and do, initiate technical changes. The unprogressive companies, by contrast, tend to have in similar positions people who work to rule-of-thumb methods and who are convinced of the eternal validity of the processes with which they are familiar.

- **THE ABILITY TO BRING THE BEST OUT OF MANAGERS.**
  This refers to the leadership pattern and to the overall climate which encourages initiative and participation. This kind of climate is often associated with smaller companies and may be another factor to account for the popularity of this model.

- **USE OF SCIENTISTS AND TECHNOLOGISTS ON THE BOARD OF DIRECTORS.**
  The company encourages their technical experts to have an input to the middle and long-term strategies of the company.

- **A READINESS TO LOOK AHEAD.**
  There is some evidence that technically progressive companies look further ahead. Certainly

they are able to balance the short term, day-to-day demands of running the business with a long-term view.

- **A HIGH RATE OF EXPANSION.**
  A progressive company typically shows a high rate of expansion in a particular sector of the company, followed by a period of consolidation.

- **INGENUITY IN OVERCOMING MATERIAL AND EQUIPMENT SHORTAGES.**
  The ability to respond flexibly and make the best of often difficult or constrained circumstances.

- **AN EFFECTIVE MARKETING POLICY.**
  It is often the case that technical progressiveness goes hand in hand with a progressive marketing approach.

- **GOOD TECHNICAL SERVICE TO CUSTOMERS.**
  This factor is indicative of the overall view which technically progressive companies have of their product. Their concern and support does not stop at the end of production. There is a follow through, a systems responsibility - the feed-back loop.

7.12 Company Culture

When formulating the strategy for a new technology development, consideration must be taken of the organisational structure, management process, human resources and company culture. Company culture can been divided up into four sections, power, personal, role and task cultures.

In this section, two of these cultures are discussed

for they were the most prevalent in the companies interviewed, namely role and task culture.

Role culture (17) is characterised by rules and it focuses on procedures, rigid job descriptions, position power, logic, nationality and bureaucracy. It offers individuals security and predictability through high structure, "progress" up a rigid corporate ladder, and limited risk and innovation.

Task culture (17) is characterised by focusing on getting the job done, is team orientated, adaptive and flexible. Decision-making is concentrated in the group and individuals at all levels. Philosophy and vision are more important than rules and procedures. It offers security through innovation and team work, reward for team and personal contribution, flexibility and involvement in decision-making, and higher levels of accountability.

The large companies interviewed followed the role culture route whereas the small companies were task culture oriented. In the company in which the development department had been divided up into business units, an attempt was made to create task cultures in these units. However, the interfacing of these units with the rest of the company proved their downfall. Instead of making the coordinating manager for the units the interface person, each business unit head was the interface person.

In any company, different cultures can occur simultaneously as independent events that, in combination, create the organisational product or service. Within a business unit or department there will only be one type of culture although the unit may be in the throes of changing culture type.

For any project, whether innovating or implementing, cognisance of the culture has to be taken before assembling the project team.

Role culture does have positive effects. It brings control and stability to large companies. Through coordination and communication, particularly in a crisis, the organisation is capable of great achievement.

Role culture does have many disadvantages when considered in terms of an innovating environment. Management is by fear. Different echelons of management tend to indulge in police action rather than management. The high vertical differentiation divorces the top management from what is actually going on in the company.

Problems become "hot potatoes" as various departments withdraw into their shells by hiding behind regulations and procedures. A lack of voluntary team approach prevails.

Horizontal differentiation was not without its problems. In the company with the business unit divisions, specialisation resulted in the business units becoming more committed to their own goals and norms than that of the company's. In doing so, they became more competitive with one another and sought to undermine the activities of their rivals, thereby becoming a liability to the company as a whole through excessive politicking.

A role culture is not conducive to innovation. It harbours conformists. If one toed the line and did not "rock the boat" one could fumble around without interference. The structure makes demands on manag-

ers' time in the form of committees, meetings and other non-innovating activities.

Task culture is characterised with "how best can one get the job done". Greater demand is made of the individual. Each member of the team has to show commitment and drive. Every member is allowed full latitude to be creative and innovative. Each team focuses on the task at hand rather than the building of departmental empires. Teams are autonomous as long as they remain more or less within the bounds of their plans.

A task culture allows the innovative and creative individuals to grow to their full potential without the constraints of organisational hierarchy. The structure is uncomplicated and is free from the impediments of a multi-level and multi-functional organisation. The structure is adaptive and can be formed for specific purposes.

7.13 Unions

Let us never negotiate out of fear.
But let us never fear to negotiate.

Supposedly for the good of the worker, Unions in South Africa have actively campaigned the "us vs them" attitude rather than one of cooperation. Unions are fraught with generalisations with respect to businesses practices and how employees are being treated.

It must be pointed out that this discussion on Unions is also structured on generalisations. Several attempts were made to obtain interviews with union officials without success.

The maturity of the unions is questionable. They seem to be following the trends of the British unions some two decades ago. History has shown that a more constructive path would be to follow the German trade unions (work councils). The attitude of "all for today and tomorrow will look after itself" is inexcusable.

In the author's experience, shop stewards were more forward thinking. Perhaps this is because they are less politically motivated. Their general request was to be kept informed of what management was planning. They wanted to be able to express their opinions and give the worker a longer planning horizon. They felt that although they were far down in the company's hierarchy, they did at times have good suggestions and alternatives to make. They felt, contrary to the feelings of their superiors, that a company future meant that they had a future.

Impressions from articles written by spokesmen from the unions is that they are more interested in political gains than the future security and wellbeing of their members. The National Union of Metalworkers (18) told its ISCOR members to buy as many of the special offer shares to staff as they could and then to sell as soon as trading opened on the stock market. Although this advice will probably generate an immediate profit for the worker, it has two other implications. The first is that long-term security for the worker is not an issue for the union. Secondly, the union does not want a cooperative deal between workers and management and wants to maintain the "us vs them" situation. The more congenial situation, where the worker is part of the company and its future, appears not to be to the union's liking. A worker must be paid irrespective of his output. He is owed a job. The unions do not seem to want to take on the respon-

sibility of running a company and making it profitable.

The only written statement found by a union with respect to innovation and technical change came from COSATU (19), the Congress of South African Trade Unions. It says, "*Believing: that all able-bodied men and women have a right to work;.. and further noting..that the introduction of new technology for profiteering purposes is making the whole unemployment situation even worse. This is further aggravated by pressure from employers for higher productivity;.. Congress therefore resolves to: fight as one united force to defend all jobs threatened by retrenchments; fight the closing of the factories; and fight for participation in and control over - right from the planning stage - the implementation of any new technology. And fight all attempts by employers to make workers work harder and attempts to rationalise production, because in the present system this always leads to unemployment.*"

If the climate of the industrial relationships is cooperative and there is consultation and involvement, then there is likely to be considerable flexibility in the process of negotiating technical change and a good chance of getting a good fit between innovation and organisation. If on the other hand there are problems then the change environment is likely to be considerably reduced because inflexibility on either side will constrain the environment. This emphasises the importance of the negotiating machinery. In practice the German experience with the Betriebsrat (work council) lends support to this view. Experience of the companies interviewed was that such negotiation machinery does not have to be formally defined - although this helps to provide a "safety net". The essence of the negotiations, which in most cases clearly worked well,

was that it relied on informal systems, personal relationships and mutual trust and confidence.

7.14 High Technology

Knowledge is what remains after we have forgotten everything we learnt at school

High technology is only one area of innovation and entrepreneurship. The great bulk of innovations lies in other areas. In terms of job creation, high technology is the maker of tomorrow rather than the maker of today. In the United States of America, high technology created a similar number of jobs to that lost due to changes in of America's economy. Most of the jobs created during the same period were through new ventures that were not high technology but middle or no technology.

Buying technology may cause a "skills gap" - ie. a mismatch between the technology and the company's ability and resources to support and use it.

Faced with the challenge of providing new skills for new technology, there appears to be three options open to most companies - buy, rent or train. Buy skills in the labour market. Rent or contract skills in short supply. Of the three options, training is likely to be the most effective in the long term, although it clearly represents a continuing and possibly high cost to the company.

Accumulated knowledge and experience can often act as a barrier to change, limiting an organisation's perceptions of promising directions of technical advance and restricting its ability to read changes in the environment. The past inheritance of specialised

human capital within an established technology regime and its component design configurations is rightly identified as a barrier to those radical changes which might devalue knowledge, accumulated through many years of patient effort. It is for these reasons that fundamental innovations come from new companies and it is suggested that *learning by forgetting* may be as important as learning by experience in ensuring the long-run survival of a company.

Innovations are successful when someone becomes the passionate champion of a new idea and acts with great courage to push it through the system despite the "Not Invented Here" syndrome.

7.15 Government support

Habits of flexibility, of continuous learning and of acceptance of change as normal and as opportunities, needs to be encouraged - for institutions as well as for individuals.

There is little doubt that innovation policy is becoming an item of increasing significance for all governments. The role of technology as a determinant of international competitiveness and hence economic growth is clearly increasing in importance.

In a comparative study of the United Kingdom, Germany, Japan nd France, Rubenstein et al.[1] concluded that, "*... government action to stimulate innovation is perceived as comparatively irrelevant ... there is a belief that the effects of free market forces and competition on the research/development/innovation process outweigh by far the effect of government*

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1. Quoted from Boissant and Grunt (3)

outweigh the effects of specific innovation promotion policies." This still holds good today and was echoed by most of the companies interviewed.

The government-supported research organisations are appreciated by the companies, but none of them had been able to make any significant use of these organisations. A lot of the research done by these organisations was too high-tech for them. The effect on everyday industry was limited.

7.16 TECHNOLOGY AS A COMPETITIVE WEAPON

Increasing R & D investments alone do not ensure that a company will successfully exploit technology as a competitive weapon.

Companies that exploit technology will have three conditions in common (20)

- TOP MANAGEMENT ORIENTATION. They will have a technical education and work experience in their company.
- PROJECT SELECTION CRITERIA. Managers allocate funds among projects that will support and maintain their technological leadership in specific areas.
- SYSTEMS AND STRUCTURE. The decision-making system and structure of the company reinforces the priority given to technical matters.

The majority of top managers in the companies that rely heavily on technology have strong technical backgrounds. Most of them have degrees in either science or engineering. The interviews by the author showed that top management involvement is extremely important to the development of a successful technology strategy. The companies that rely less on technolo-

gy find they are hampered by poor communication between technical and business managers.

There are, however, pitfalls associated with a technically strong top management. These companies have had difficulty in avoiding two pitfalls. The first is the emphasis on technology at the expense of other areas. The second is managers' over-involvement in technical decisions. Two possible solutions are, firstly, the dual promotion path as previously mentioned, and secondly the providing of technical staff with management skills and managerial staff with technical skills.

A company where scientists and engineers communicate only with other research organisations runs the risk of isolating its technical efforts from business needs. On the other hand, a company that encourages its scientists and engineers to be market orientated runs the risk of focusing on only short-term priorities and yesterday's problems.

Managers appear to base decisions to start projects on five criteria

- Supporting business goals
- Maintaining and building technological leadership
- Solving a customer's problem
- Developing a window on technology
- Pursuing a technical advance.

In the companies where technology is a high priority, the planning systems incorporate the technology plan as an integral part of the business plan. Further, the chief technical officer sits in on important business and strategy meetings.

The pay, promotion, and hiring process are also important communicators of the priority which management

attaches to technology. Companies should put a high priority on bringing in new technical blood, regardless of the state of the business. The companies should also operate a dual promotion ladder, one for the management staff and a separate one for the technical staff. The criteria for the two ladders will also be different. One frequently finds that the manager responsible for shepherding a technical innovation into routine use is much better equipped by education and experience to guide that innovation's development than to manage its implementation.

7.17 Post innovation

In interpreting technical change as related sequences of innovations, it is useful to shift the focus of attention from technology, as an artifact, to technology as knowledge.

Innovation is a dynamic process occurring over many years. A firm cannot afford to rest on its laurels gained from earlier technological achievements.

The challenge to the innovating firm is to respond, but in doing so, it commits itself to a sequence of *post-innovation improvements* which are a necessary condition for it to retain or expand its market share.

Post-innovation improvements will

- Enable application in additional segments of the same market. Once the effort has been spent to implement an innovative change or new line, it seems pointless for everything to stop there. The information and experience that has been gained can be used in other areas or be utilised for further development or improvement. It is often better to carry out incremental improvements to an

better to carry out incremental improvements to an existing line than to do a major change.

- Meet or anticipate changing requirements of existing customers. Unless one matches the changing requirements of a client, even if the client himself does not realise that his requirements are changing, or one does not maintain the "competitive" edge, all the effort that one has spent to reach the present lead is for naught.

- Allow application in a new market. Once the company has adopted the technology, it seems logical to exploit it to the full. This will include other markets which can absorb the technology.

- Incorporate lessons learned during use or manufacture. This is always a fine point from which to develop or "renew" other product lines.

- Incorporate external improvements in a technology. Monitoring what has been done elsewhere can help to improve or extend an existing or potential product.

8 CONCLUSION

One can give advice,
but one cannot give the wisdom to profit by it

In today's fast-pace, fiercely competitive world of new commercial developments, speed and flexibility are essential. Companies are increasingly realising that the old sequential approach to developing new products simply will not get the job done. Instead, A *HOLISTIC* method is required.

This holistic approach has six characteristics: built-in instability, self-organising project teams, overlapping development phases, "multilevel", subtle control, and organisational transfer of learning. Just as important, the new approach can act as a change agent: it is a vehicle for introducing creative, marketing-oriented ideas and processes into an old, rigid organisation.

Those who manage technological change must often serve both as technical developers and implementers. It appears common that one organisation develops the technology and then hands it to users, who are less technically skilled to develop, but are knowledgeable about their own areas of application.

A pictorial representation of technology representation, is that before the batten (technology) changes hands, the runners (developers and users) should have been running in parallel for a long time. The implementation manager has to integrate the perspectives and the needs of both developers and users.

Adapting a marketing perspective encourages implementation managers to seek user involvement in the early

identification and improvement of the fit between a product and the user needs. Preparation of the user organisation to receive the innovation, and the shifting of "ownership" of the innovation to the users needs to be addressed in the planning phase.

Many implementation efforts fail because someone under-estimates the scope of importance of such preparation. Indeed, organisations are full of managers who believe that an innovation's technical superiority and strategic importance will guarantee acceptance. Therefore, they pour abundant resources into the purchase or development of the technology, but very little into its implementation.

The higher the organisational level at which managers define a problem or a need, the greater the probability of successful implementation. At the same time, however, the closer the definition and solution of problems or needs are to end-users, the greater the probability of success.

How, then, can an implementation manager foster general acceptance of an innovation from such a range of constituencies? Leonard-Barton & Kraus (21) believe that the executive must view the new technology from the perspective of each group and accordingly, to each, plan an approach.

Overselling a change presents a problem to the implementation manager who then has to fight the perception that his project is way behind schedule and that the product delivered less than promised. Failure to sell the change in the beginning usually results in insufficient resources being allocated. It is therefore imperative that the implementation manager, from the outset, stresses that the change is a new development with unknowns. In addition to this, regular technical

performance reporting must be done.

If an innovation is to succeed, the implementation team must include

- A sponsor, usually a fairly high-placed person in the organisation, who can make sure that the project receives financial and manpower resources and who is wise about the politics of the organisation
- A champion, who is a salesperson, diplomat, and problem solver for the innovation
- A project manager, who manages conflicting priorities and moulds the group through communication skills.

Since these are roles and not people, more than one person can fulfil a given function, and one individual can take on more than a single role.

Clear identification of customer-need, together with a top person in authority, are the two most frequently occurring factors enabling a firm to succeed.

It also appears that each firm must be committed to a specific technology grouping and must operate in a specific market and in a regulated and general economic environment. The details of which technology grouping is eventually chosen by a firm is determined by its selection of environment.

Initially, innovation was considered as a somewhat momentous, discrete event made possible by a prior invention and drawn into economic significance by a process of diffusion. However, innovations are rarely fully developed when they are first introduced and their full economic significance depends upon the continued development of the original innovation during a period following its introduction to the market-place.

Georghiou et al (22) say that there cannot be a study of innovation which is not simultaneously a study of a particular organisation.

A firm always exists in a situation of limited information. It does not have free access to all knowledge relevant either to its technology or to its markets, and so the perception of a firm will be influenced by its history in both of these areas.

What is less immediately apparent is that the same technology may be advanced by organisations not in direct competition, ie. by firms whose markets are protected by some boundary such as tariff protection, transport costs or government purchasing policy or by natural monopolies such as public utilities, which may be free from the pressures of competition.

Amongst the most significant inter-company differences to which one would draw attention, are: differences in the efficiency with which a given process is managed, differences in the ability to manage growth, differences in product characteristics and differences in access to capital markets to supplement funds from internal sources. Inter-company difference can be related to the differential capacity of individuals within companies to obtain and process information, and points to an awareness of key individuals within companies.

Factors which distinguish companies in their innovative activities include flexibility of organisational structure, adherence to reactive or pro-active innovation strategies, the quality of technical and scientific manpower, the scale of funding for R & D and the coupling of innovating activities with a company's marketing and product activities.

In understanding the pressures which apply to innovative activity, it is useful to begin with the distinction between the availability of the means to innovate and the distribution of incentives to innovate.

Learning is company specific. This enhances the market position of the already-advantaged company and may erect formidable barriers to the entrance of new companies.

What we need in South Africa is an entrepreneurial society in which innovation and entrepreneurship are normal, steady and continuous. Innovation and entrepreneurship have to become an integral life-sustaining activity in our organisations, our economy and our society.

Good companies exhibit a strong entrepreneurial approach to a problem. It is this characteristic that attracted highly skilled personnel to join the company rather than larger companies with greater resources and higher salary scales.

A dual promotional path should be considered by the company. The enhancement of the status of Engineering and the Sciences should be done by those involved in these disciplines.

Innovation and new technology implementation needs team work and strong leadership. More effort should be put into the planning stages. Environments and culture should be considered when implementation strategies are developed.

Communication must always be the top priority of all management. Mutual trust and a sense of involvement is essential for employee wellbeing.

Joint ventures between large and small companies should be investigated so that the strong points of each can be utilised.

The dividing of change into small packets is a way of reducing risk which should make financial investment more attractive and reduce resistance to the change.

Companies should carry out self evaluation to determine whether they are technically progressive. An appraisal of their sources of innovation and rules for the exploitation of technology should be routinely carried out.

In general, the author concluded that the small South African companies fared well when it came to managing and implementing new technologies. The medium and large companies were slow to react. They are restricted due to their past traditions.

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APPENDIX TO

MANAGING AND IMPLEMENTING

TECHNICAL INNOVATIONS

A survey of a few Innovating South African Companies.

CONTENTS

1 REASONS FOR THE SURVEY

There were three reasons for conducting the survey

- To obtain an unbiased view
- To canvass local opinion
- to source local ideas.

Any project championed by a person is subject to that person's interpretation of his experience and environment with respect to the topic.

By discussing the topic with other people in industry, a point of view which is more akin to the South African situation may be obtained.

Since the dissertation is meant to be of a practical nature, opinions from the local environment have to be considered. Opinions from other countries could be used to guide or learn from but they are not always applicable.

The saying "a boer maak 'n plan" is very relevant here. Although many ideas were previously obtained from literature, the one source that had not been broached was local opinion on the topic.

This survey was carried out in order to remedy this omission.

2 STRUCTURE OF THE SURVEY

The companies which were approached had to be involved with either development or the implementation of new technologies, ie. involved with change and the management of change.

A range of companies was selected and were approached to take part in the survey. Of the 10 companies contacted, 8 agreed to participate. The eight companies are listed below

Company A is a well established, (20 years) private precision machining engineering company.

Company B is a small to medium sized, young, privately constituted, company handling the technical development and management of new technology projects for other companies.

Company C is a fast growing, small /medium electrical engineering company, privately owned.

Company D is a metallurgical/mechanical engineering consultant, operating alone.

Company E is a large, public, general engineering company of (20 years) standing.

Company F is a small civil engineering consulting company.

Company G is a medium sized, technical research organisation attached to a University.

Company H is a large quasi-government company of some 13 years standing involved in both manufacture and new product development.

Within each company, an attempt was made to interview a top manager or technical person, and then someone from lower management or foreman level. In company H, however, representatives from the general manager level through 6 hierarchy levels downwards, and from

the financial, project management, manufacturing and the R & D departments were interviewed.

The reason for choosing people at different levels in the companies was to determine whether the impressions, attitudes and goals were the same at each level.

Once the individual people were identified, each of them was supplied with a questionnaire. They were requested to look at the questionnaire and to record their answers. The questionnaire was supplied to them before the interview for two reasons. Firstly, to stimulate thought on the subject and, secondly, to encourage them to do their own survey amongst their colleagues.

In most cases, before the interview, a tour of each company was carried out by the author, so that an impression of the company as a whole could be obtained.

At the interview, the interviewee gave his/her replies to the questionnaire either in writing or verbally. The replies were recorded by the author on tape. A check was made to determine whether the author had the right interpretation of the answers to the questions. At the same time, discussion was encouraged around the topic to probe for further thought and experience. The author recorded the salient points of the discussion. This part of the interview proved to be very illuminating.

At the end of the interview, the interviewee was asked to liken the company to a car and to give reasons for his/her choice of car.

The questions and a summary of the replies are given

in the next section (3 Questions and Replies).

3 QUESTIONS AND REPLIES

Accompanying the questions asked at the interviews is a summarised version of the replies. The 63 questions are listed here together with the summaries of the replies.

Q1) Does the company have a written mission and/or policy statement? If so, does this lend itself to innovation and technology change?

The company mission existed in most of the companies. Although it is a broad statement, it encompasses the goals and culture of the company. It is a living document which needs to be revised approximately every five years. The regularity of revision seems to depend on the changing environment. It is a document that needs to be kept alive otherwise the staff soon become used to it and forget that it is there. In two cases, the document mentioned innovation and new technologies. In both cases, the mission was regularly discussed.

Q2) Was the decision to implement new technologies meant, inter alia, to break down traditional demarcation lines or to reduce the power of organised labour?

The introduction of new technologies was seen to be necessary for the survival of the company and was not introduced to reduce the power of organised labour. In one case it was introduced to break down traditional work structures and to change the company from one which was following trends to one which was setting trends.

Q3) Is innovation or new technology vital to the survival of your company?

In all cases the answer was Yes. It was realised that if the companies did not keep up with changing technologies, they would fall behind and might never be able to catch up.

Q4) Is innovating cost effective?

It was recognised that one innovates because of cost or because of a changing market. Furthermore, it was seen that if managed correctly, innovation could be cost effective. The return on the investment depended on the project. Most were seen as capital outlays with a return in the long term. In the beginning it was perceived as a risk, but as the project developed a clearer view was obtained.

Q5) Why did the company feel it necessary to introduce new technology?

For the future survival of the company, not short term, but middle and long term. New technologies were used to solve problems and to meet the greater demands of clients. In one case, a company was forced to change due to the pressure applied by its suppliers.

Q6) How was the decision arrived at? At what level?

In small to medium companies, the need to innovate came from top management. In the large companies it came from lower down the hierarchy. Lower and middle management recognised the need and championed the need upwards.

Q7) Did the company appear to introduce new technology because; a) its competitors had already done it, b) it was genuinely convinced of the merits of new technology to the particular plant situation?

The smaller companies were genuinely convinced of the merits of new technology. Technology was seen not to be context free. It had to be adapted to the environment in which it was to be applied.

The larger companies felt that their main customers were saturated with conventional products and found their business to be shrinking rapidly. New technologies offered them a way to boost their sales by reducing costs and to enable them to explore new products. Both these factors opened up unexplored markets.

Q8) What is your payback period on investments with respect to new technologies?

This period varied from project to project and from company to company. Replies ranged from 18 months to 10 years. It appeared that the general payback period was from 3 to 5 years for people-related developments and from 5 to 7 years for plant-related developments. Some of the companies persuaded their clients to fund the development and implementation. In this, case payback was immediate for the company which was undertaking the development.

Q9) Do you participate in sponsoring tertiary education. If so, what?

All but one of the companies were involved in some way in tertiary education. The smaller companies spon-

sored research in specific fields of interest to the company. In some cases, they sponsored an individual and in others the university department.

There was a growing opinion that the sponsoring of individuals must be targeted primarily at the company's own staff. This was particularly so in the case of education at the Technikons and in Post Graduate study. The days of open bursaries for university study appeared to be over. The companies were offering grants for specific study directions and all grants were beginning to have strings attached.

One of the research companies was committed to sponsoring university education to the extent of 2% of its turnover (this was allocated to Post Graduate research).

It was obvious that the cost of education and the limited manpower available was becoming such that the universities were having to find out what industry needed. One large company had set up an annual meeting with a university to voice its opinions on the courses being offered and to inform the university of the company/industry's technology needs. The same company was involved actively with two Technikons, two universities and two "Science Parks". The contact people from the company were the departmental heads and senior managers. The academic institution representatives included the Rectors and Faculty Heads.

Q10) Does one need to manage technology or does it manage itself or fall in place?

In some instances, the initial stages of formulating the technologies were not planned, but once a technology had surfaced, it was managed.

The question that needed to be asked was, "Where am I now and where do I want to be?" This was considered to be the technology gap. Each technology had to be viewed in terms of its risks. What was the likelihood of the goal being met within cost, performance and schedule? Once this had been done, a risk factor was allocated to the technology. The technology is then managed according to the risk factor. The higher the risk, the more it was managed.

Q11) How important is a systematic approach to managing technology?

Management was seen not to be context free and to be specific to the technology. A systematic approach was recognised as being very important. However, in the initial stages of the innovation care was taken so as not to stifle the innovating process.

Q12) Is there a common corporate systematic approach to new technologies?

The replies were divided. All the larger companies did have a specifically laid out approach. This was revised once a year and the new guidelines did not vary much from those of the previous year.

The small companies allowed a free hand to be exercised in all directions. They left it up to the available skills and interests of their staff.

Q13) How do you cope with empire building managers? Is this applicable to your company?

Empire building did not seem to be a problem in the small companies. However, in the larger companies there were both denials and confirmations within the same departments, and between senior and middle management. Generally senior management denied the existence of empire building in their company, whereas middle and lower management confirmed its existence. All the consultants approached with this question said that empire building was present in the companies that they had to deal with and was one of the greatest hurdles that had to be contended with. It appeared to be a problem in both public and private companies - and to be burgeoning in the private sector.

Q14) Describe the implementation of computers into your company.

The research and small companies' opinions were that computers were part of the office furniture. Every engineer was issued with one along with his other technical equipment.

In all cases, it was the technical people who introduced the company to computers. In all cases it was the financial people who resisted them. This resistance did not prevent the ingress of computers. Computers came in to the companies "through the back door" via projects, ambiguous orders and sub contractors.

It was only when people realised that computers could help them to do their jobs more efficiently and quickly, that resistance faded. In one company, it took two years for the resistance from the financial department to be broken down.

The underlying resistance to computers was the result

of the learning process associated with them rather than with the computers themselves. The time taken to learn what a computer was all about and how to use it, with the aid of the thick, difficult-to-understand manuals, was the main reason quoted by senior management for their lack of computer skills.

In a company, one astute manager in the R & D department realised some 10 years ago that computers were a way to build a department around him (empire building). He created a modelling and simulation department with the use of computers. Access to this department was severely restricted. The result, 10 years later, was that a good deal of the modelling and simulation was being carried out by engineers and without the need for access to the restricted area. They had no need of this department. The department, by not allowing cross fertilisation with other departments and technical people, had lost its viability and had not kept up with the demands of the company or with the new technologies.

Q15) Are your technical staff able to work with/in a multidisciplinary team? Is this necessary?

In most cases it was felt that the technical staff could work within a multidisciplinary team. There were cases where an individual did not willing communicate with others or canvass ideas. The individual felt that he was less competent when approaching others and had to share the results.

It was recognised that practical problems are never neatly divided up into different disciplines. Communication and working within a multidisciplinary team was seen to be essential to innovation and technical problem solving. Management realised that the matrix

system forced this, whereas empire building prevented it. A hurdle was detected in the communication links between the technical and non-technical peopl.

Q16) What is the image of engineering in industry?

The answers were unavoidably biased, depending upon whether the respondent was an engineer or not. Most of the respondents were non-committal saying that the image of engineers was average. Engineering was not viewed as a sought-after career. Three respondents gave lengthy replies to this question. Extracts are quoted here.

First respondent. "South Africa is traditionally a technology colony. Therefore the engineer is the slightly better trained tradesman or artisan who can also organise and manage. He does not have a high status within the company. He contributes to decision making at a low level. His work is also low level. As soon as one develops a local industry which is based on local development, the engineer obtains a higher status, because he is the generator of new business. South Africa is in the process of converting from a colony to that of a developing country. This has been shown by recently advertised developments. Therefore the status of the engineer will, with time, drastically improve."

Second respondent. "The image of the engineer in industry is average. It is much better than it was 10 years ago. One of the major contributors to the poor image of engineers was the immigrant worker from Britain. If he worked on a gas line in his own country with a pipe wrench, he marketed himself as a pipe engineer. One found that the fitter and turner on the lathe called himself an engineer. That is the way

they saw it. They did not distinguish between a professional engineer and an ordinary engineer. SACPE, along with other professional institutes, has played a role in improving the image of the engineer in South Africa."

Third respondent. "In the outside world (outside that of engineering) the engineer is at the bottom of the scale of professionals. Medical Doctors are at the top with 10 points, Dentists at 9, a Lawyer is at 7, Businessmen at 6, Bottle Store owner at 5, Pharmacist at 4, Scientists at 1 and Engineers at 0."

The image at schools was that Engineering was a hard, dirty job that did not command a high salary or promotional prospects.

Q17) Who, in your company, is responsible for innovation and at what level is this person?

Answers varied and they depended on the company. The small and research type companies replied that everyone was involved and responsible for innovation. The larger companies replied that middle and upper management were responsible.

What appeared to be the case was that it was up to the senior management to provide the environment which encouraged the innovation process and which facilitated the implementation of new technology.

One company representative mentioned that he had found that the workers and foreman had been responsible for most of the innovations with respect to the plant and assembly lines.

Q18) Is there a market dimension (aspect or input) to innovation?

Respondents indicated that there had to be a potential market before the new technology would be considered. The engineer was best situated to develop the new technology for he was more aware of the market and its needs than the scientist.

There are two forces that drive technology, the first was the so-called technology force "because things are possible" that applications are sought after and the second was the market itself that asks whether things could be done in a particular way. The client often stipulates the extent to which innovation should be used in the new technology in his product.

Q19) Where do the leads for innovation or technical change come from?

The whole environment was seen as source. Each person answered according to his particular environment. Literature, advanced courses and seminars were seen as leads by those involved in the R & D departments. The marketing people replied that leads emanated from clients, technical publications and overseas contacts. Engineers said that leads came from the market primarily, from value engineering next and discussions, books and lateral thinking last. The production people thought that management was the source of leads.

Q20) Is there any difficulty in transferring technology from R & D to production?

Respondents mainly answered Yes. Too little time and

money was allocated to this function during the planning stages. The engineering way of doing things was seen to be different from that of the production line. Engineers made "one-offs" whereas the production line was geared to making large quantities.

In many cases it was felt that one way of approaching this problem was to put Engineers-in-Training into a production environment before design. Currently, it was recognised as the norm for them to be first employed in design.

Communication and technical ability appeared to provide the highest hurdles. One company involved representatives from production in the design and development team so that by the time the product was handed over to production, they already had technology and background related to the product.

Another company had a department called Process Development which facilitated the transferring of the technology to production.

Q21) Are there any barriers to innovation? If so how do they arise and how does one avoid them? Who/what are the largest stumbling blocks to innovation?

In the South African context, the largest stumbling block was recognised as tradition. People were seen to be scared to make changes. Changes involved thinking and risk taking; the secure way was to stick to the known things and old ways.

Knowledge was thought of as a barrier - when it was not updated on a regular basis. One of the consultants found that some graduate engineers whom he encountered, resisted change. Such people were found in

senior positions and were a very difficult barrier to surmount because they were afraid that their outdated knowledge might be exposed. This is why they wanted to keep new ideas out of the company.

Finance and the financial department were also seen as barriers to innovation. Generally, the financial person lacked commitment to the innovation team. The obtaining of finance for the development was difficult and had risks attached. The financial department did not like allocating finance to projects in which the risk could not be specifically defined or was perceived to be high. 20% of the money needed for new technology was thought to be for hardware and 80% for knowledge which one could not sell in order to recoup the company's money.

The "not-invented-here" syndrome and the "dead-wood-people" appeared as barriers to innovation. A method of motivating these people to accept the change and to perform with the new technology was to change their titled status. This gave them new credibility and perceived notice from management.

The social norms and acceptance was seen as a barrier. With a job description change or a title change, the individual changed his social identity and group. The re-acceptance into a new group was cause for rejection of change.

The short sightedness of Unions was cited as a major barrier. Unions believed that a change was made only for the benefit of the company and to the detriment of the worker.

The lack of planning was a barrier. Track records eased or hindered further acceptance of the development or change.

The financial department was seen to be a hindrance to change for they perceived that they were going to lose their control and limelight in the company.

Poor communication was seen by many to be a barrier. The lack of cross fertilisation of ideas and the failure to transfer information made the implementation and the generation of technology difficult.

Culture, both of the individual and the department, which did not accommodate change or new technologies, was mentioned as a barrier If the environment of the company, as set by the top management, was not conducive to new technology, then the path for its implementation would be difficult.

Q22) How many new projects can one implement at one time?

It was perceived that one new technical development could have several projects leading from it. The limitation to the number of new projects that a company can implement depended on the resources available. Each project needed a single person to take overall responsibility. It was generally felt that a person was capable of assuming the responsibility for (at the most) two projects at a time. It was realised that this depended on the size of the projects. Planning was also a limiting resource. The more meticulous the planning stage , the easier the project was to run and hence more time and resources were available for other projects.

Q23) How well does information flow within your company and is it conductive to innovation?

On the whole, information flowed poorly in the companies canvassed. The informal route was by far the most developed. Management did not manage the flow of information. Situations were cited where management subtly strangled attempts to communicate across the company. It was seen by empire building managers as a loss of importance and as a reduction in the need for their departments. Security and secrecy were cited as excuses for the lack of information.

The circulation of journals and other company obtained magazines was being carried out. Those on the circulation lists appeared to be arbitrarily chosen. New sources of information were politically circulated, usually to those people who could do least with it and were not likely to disseminate the information further.

The attendance at seminars was frequently limited to the department which received the notification. Information was used as a political tool and was wielded to facilitate position security and importance as well as to mask certain manager's inabilities.

A small company officially communicated verbally within the company. They felt that the misunderstanding was outweighed by speed and accuracy.

Different nationalities and racial boundaries were cited in production as problem areas.

One company commissioned a climate study within the company to identify, amongst others, areas where communication was inadequate. As far as the author was able to determine, no follow-up was carried out on the outcome of the study.

Q24) Who did management inform first?

In the large companies technologies and change were communicated via the hierarchy system which meant that by the time they got to the individuals who needed to use them, they had passed through several hands. It was important for management to know what was going on and what had been planned in the company, and, who to approach for the knowledge. But it was seen as not necessary for them to know the detail.

The approach which made sense was viewed in a medium sized company. Once a week the management of the company came together for an hour at the end of a day. At these gatherings, new projects, technologies, ideas and strategies, were discussed. The general manager started the ball rolling by introducing a person who had something to offer. Later, the gathering broke up into small informal groups for discussion. What appeared to be important was that the person doing the presentation (usually informally) was introduced by the general manager which gave him credibility.

Q25) Was there an extensive information/marketing campaign?

The unanimous answer was No. When it did occur, it was carried out amongst the departmental managers only and was not passed down to others. In turn, these managers were supposed to pass the information down to their department. As a rule this did not happen. The author felt that this was a form of position protection.

Q26) Is there any cross fertilisation between depart-

ments in your company?

No company categorically said Yes. There were various forms of cross fertilisation at senior management and at departmental head level. However, cross fertilisation did not take place at the level of the individual who needed the information or who needed to debate the ideas. Departmental heads lacked the detailed inside information of the projects in their departments and thus could not make constructive decisions as to who should have access to the information.

The matrix system was supported by people below departmental management level as a means of ensuring cross fertilisation across departmental boundaries. Departmental heads rejected this. Perhaps they saw it as a loss of power/control.

In a small company, where all the various departments were invested in one person, the owner, cross fertilisation was not a problem. The company had grown and control of departments was being given over to other people. Consequently, the transfer of ideas was beginning to suffer. Therefore, as clearer lines of delegation and well defined boundaries between departments were established, serious attention would have to be paid to this aspect.

One large company had lectures and presentations given to the executive management by their R & D department. The question arose as to whether this justified the existence of R & D and whether the information should not have been given to those in most need of it.

Q27) How important is it to separate the technical staff from the financial staff?

Although structurally separate, it was recognised that they should be in unison when it came to communication. The essence was seen to be team work. The financial person had to feel that he was a part of the project.

The larger the company was, the more powerful the financial department seems to have been.

Q28) Deregulation, privatisation, conglomerates. What are their effects on innovation or change in industry?

Conglomerates were seen to be neutral ie. neither good or bad. They were thought to stifle innovation.

Privatisation had an interesting effect in the economic sense. It meant that one made money on a different fundamental. The primary difference was that money was paid to another sector of the economy rather than back to the government. The profit that was made by the contractor was greater than that made by the state and thus productivity was promoted.

Q29) Are the technical staff that you employ adequately educated when you employ them?

On the whole, people employed lacked the experience and the ability to implement what they had learned. Engineers had little or no knowledge of project management or systems engineering. They lacked versatility and depth of knowledge. Some of the companies were tending to look for generalists for they were easier to employ and were not job-specific. They could be moved around the company depending on the demand whereas specialists could not. The trend appeared to be to make do with what the company had.

When interviewees were asked "Who is responsible for tertiary education?" the response was that it was primarily up to the individual, with the company facilitating. If the government was to be responsible for education, then taxes would have to be raised to pay for it. It should be left to capitalism. If there was a need, then people would get together and provide the service. The best universities in the Unite States of America were seen to be privately run. The state had its way of doing things which took time to change and might not be the best way. Private enterprise or the market forces could adjust faster.

Q30) At what level is new technology or innovation managed?

The most popular choice was that top management managed new technology. In some cases, middle management was allowed to assist.

All the consultants said that it should be managed at all levels. Their experience was that in many companies new technology was not deliberately managed. It was allowed to happen. This, they felt, accounted for the numerous failures.

Q31) What is the gestation period for new technologies?

Technology was considered not to alter on a day-to-day basis. The gestation period varied from a few months to tens of years. It depended on the size of the technology gap, on the level of the technology, on the funding, and on the maturity of the technology.

The market was seen as being able to absorb or to adjust small changes at one time. The technology had to diffuse through the technical pool of people before it would be accepted and passed on to the public. With increased funding, the time for implementation could be speeded up (by buying in people with the necessary skills and experience), but there was a finite amount of time for maturity and acceptance. It was felt that this could not be reduced.

Q32) Were there guarantees of no redundancy and have these been kept?

No guarantees were given where changes and new technologies were implemented. In most cases new jobs were created and there were no redundancies. In one case where there were retrenchments, the retrenchments were more due to excess fat within the company than due to the change.

There were a few isolated cases where the computer had made people redundant, but interviewees felt that if it were not for the implementation of the computer, more people might have been made redundant.

Q33) Was extensive retraining offered? If so, how was this carried out?

In most cases, where necessary it was offered to staff already employed in the company. In one instance it was not. This, in hindsight, was seen as a shortfall in the planning of the change. In this case, an effort by some of the individuals was made to upgrade their own knowledge.

Q34) Do staff who start the change see it through to the end or are they transferred during the implementation?

Continuity was seen as important for the success of the implementation. The project manager had the greatest chance to saw it through. The rest of the team usually only saw their work packages to completion and not the project.

Changes in priorities in the company meant the movement of staff. Hence, for the larger projects, the initiators did not see them through to the end. In this case, it was realised that the cost of the project increased due to the lack of continuity and that new people had to gain working knowledge of the project.

Q35) Do you think that your company lends itself to innovation or technical change?

It was recognised that environment and company culture interlinked to determine whether the company would be innovative or not. Most companies believed that they, to some degree, promoted innovation and facilitated change. One large company was honest enough to reveal that small groups within the company were involved in change and innovation, but the company as a whole was not. Its respondents did say that the company was becoming more aware of the need to accommodate change and that consideration of this fact was being taken when employing new staff and the moving around of departments.

Q36) Is there a control of technical information within the company?

The interviewees generally replied that in the upper company levels the answer was Yes. Information was frequently passed on the basis of "need to know". In most of the companies interviewed, it appeared that information was too strictly controlled. This did not facilitate innovation or the ready acceptance of change. The author felt that the fear of inadvertently passing on company classified information was prevalent in these cases.

Q37) To what extent are Engineers involved in the administration, finance, marketing and decision making of the company? Should this be changed?

In these departments engineers were not involved. According to management, engineers performed engineering tasks. According to engineers, they spent up to 80% of their time on administration.

The feeling was that engineers became managers too soon. They did not get enough time to become good engineers. Generally it was the only way for an engineer to earn a good salary, unless he became a consultant or owned his own business.

Q38) Is the government promoting innovation and technical change?

Companies generally felt that the answer was Yes. Both local innovation and new technologies were promoted. Whether it was enough was undecided. It was felt that the government should provide the incentive and the environment. The innovating and technical change should be left up to the companies. The need for support, such as that through the Industrial

Development Corporation could not be stressed enough.

Q39) Have you identified any project champions within your company?

To several of the companies, this was a new "buzz word". The smaller companies and the R & D companies were aware of the concept. They made, where possible, the project champion into the project leader. Through weekly informal talks, one company identified the person who was interested in certain projects and that person became the project leader. An R & D organisation stated that it was purely due to the project champion leading the project that the project was a success.

Q40) What do you understand by the term "Technological Gate Keepers"? Do you have any in the company and if so, how are they used?

This was seen as another "buzz word". Technical gate keepers were seen to be in great demand due to their experience or to their wide span of knowledge.

One company had identified internal and external technical gate keepers as different people. It was found that due to the company's structure, the experience and exposure of the individuals had been either internal or external. These people were used, on an informal basis, quite effectively.

In the large company, staff who had been with the company for many years had tended to become technical gate keepers in specific areas. This was not due to the researching of a specific area of interest, but rather to the spending of twenty years of their work-

ing life in that field.

The true technical gate keeper (a person who kept his eyes and ears open to the world around him and who was a source of constantly updated information) was very rare. Contrary to one company's belief that their technical services manager was a technical gate keeper, it was found by the author that he was a specialist, and not a technical gate keeper.

Q41) How does one monitor technical change or innovation?

Monitoring was subjective. It was done differently on different levels. The acknowledgement that there are different approaches makes a company. Everyone can make a contribution if handled correctly.

For the country, one monitored change in the export of products and know-how. For the company, teaching/learning processes, return on investment, market share, product lines and profitability are monitored. It could be seen through the client's trust in the company and their response to the company and its staff.

In the R & D section of the company one looked at new products, publications and technical reports. In the production area one looked at the cost of the product once it left the company, the resources taken to manufacture or assemble the product, the productivity and the quality.

Q42) What contact does the end user of the innovation or new technology have with the company prior, during and after the development?

Every company had a different answer. At one extreme, the clients were not trusted to keep the technology confidential and thus were not involved in the development. At the other extreme a company used client involvement as a marketing strategy.

The crux of the matter was whether the end user wanted to be involved. This seemed to be related to the risk factor involved with the technologies used and whether the end user would himself use the developed technology.

In companies that had high confidence in their development capabilities, the client had high contact but no influence in the decision-making of the project. It was argued that the client did not always have the knowledge to make the decisions.

In other cases, the technology was transparent to the end user. He was only interested in the end result, not how to get there. Such an example was the mining industry.

Other clients used intermediaries to monitor the technology and project progress. This was either because they w nted to remain anonymous or they did not have the necessarily skilled manpower to do the job. An example of this was the Defence Force.

Q43) How much is spent on R & D and on new development training?

Companies who had a definite policy with respect to budgeting for new technology divided their spending into two separate amounts, that for research and that for implementation.

Companies spent between 1% and 3% of turnover on new technologies or R & D, while between 4% and 11% of turnover was spent on its development or implementation.

One company did contract R & D work. All its training, R & D and implementation costs were borne by the contract with the client.

Q44) Does change increase the range of opportunities available to a firm?

Change and new technologies were used by the companies in their arsenals of abilities to market.

The author was told of a theory in economics which was referred to as "the theory of production possibilities frontier". Technology pushes this production possibilities frontier out and expands the capabilities, thereby extending ones capabilities. One seldom recoups one's investments with the first application of the technology. This is due to the learning curve.

Not always did technical change increase the range of opportunities. It could focus one's opportunities and hence reduce one's range. On the other hand, technical change could stimulate old markets and generate new ones.

Q45) What return on investment does one get on new technologies?

Apart from those companies who did contract R & D, the rest realised that returns on new developments were

not immediate. It was long-term and was of the order of ten times greater than that spent.

Although all the companies were positive of the returns obtainable with new technologies, there was, at times, caution.

Q46) Can new technologies be seen as a competitive weapon? Is it used as such?

Interviewees were positive that new technologies were to the *attackers' advantage*. Often a lot of money was pumped into a technology which had reached its old age without success. If the same amount of money were poured into a new technology success might have followed. The art of management was seen to be to know when to withdraw from a technology.

The success of new technologies in the market place was seen to depend on its maturity. The latest technology did not always satisfy the customer whereas mature technology would lead to cost effective designs and development.

Q47) What resistance does one encounter when implementing technology change? How does one overcome this?

It was felt that South Africans have been conservative and have resisted change. As with most situations, it was those who did not want to do something about the situation who shouted the loudest. Those who did were usually quiet.

A cliché which is becoming more applicable is "*'n Boer maak 'n plan*" (The nearest English equivalent is

"necessity innovates"). The ARMSCOR experience indicated that, given the right environment, we (South Africans) would innovate to the extent that we could compete on the international market, even in such specialised items as weapons.

The principle resistance was felt to be due to the people themselves, to their insecurity, to social affiliations and to personalities. Today's youth was seen to be far more adaptable to its changing environs.

Q48) Was there any worker support for and during the implementation of new technologies? From which workers and in what form?

Generally, amongst the qualified staff, there was support. This resulted from an ability to understand and comprehend the change. There was no fear for job security.

Amongst the work-force and the semi skilled staff there was support, only if an improvement in the job could be seen. To many it was seen as a threat. The company was viewed as having allowed the worker's technology to slip behind. Continuous upgrading of the individual's technical knowledge ought to have been made so that he could accommodate change readily.

Q49) Were changes in skills/work practices compensated by increasing remunerations?

New skills acquired by the person were generally compensated for in a salary package only when that skill was used by the company. This was true for the worker and not so often true for people in the middle

and upper echelons of the company.

In the companies where major changes had taken place, people who could not accommodate the change left the company. Others who could not be accommodated were retrenched. The remainder were rewarded when changes in skills, job or levels were made.

Q50) Was there any industrial action threatened or carried out during the period of introduction?

In those companies interviewed, no industrial action was threatened or carried out. This was due to the concerted effort made in communicating the facts to the workers.

Q51) Did workers perceive the new technology as causing a reduction in their skill level?

Interviewees felt that workers did not perceive new technology as a means of reducing their skill level. It did show that their current skills were not adequate. It highlighted the importance of keeping up to date with new technologies. Ill feeling was detected when an employee who wanted to learn a new skill was hindered by the company.

Q52) Was there any feeling of resentment about the way that management went about introducing the new technology?

Interviewees generally answered Yes. The workers felt that they were being left behind. New highly qualified graduates were brought in over their heads and they felt that their years of experience and their

loyal service were not appreciated. This was exacerbated when long service employees were retrenched.

The staff did have feelings and responsibilities. Management was expected to take these into consideration. Communication was recognised as being the best method.

Q53) Had the general interest level of employees involved with new technology been raised with respect to new machinery?

Those employees involved with the establishment of new technology were motivated by the technical challenges this represented. In other words, those who were able to be upgraded to meet the challenges of the new technology were inspired by the challenges.

New machinery was only a motivator when the operator could see an improvement in the quality or quantity of output, or if it made the job easier.

Skilled personnel, who were not threatened personally by the change, were inquisitive.

Q54) How did the attitude to new technology change since its installation?

Respondents felt that with familiarity of the technology, people became more positive. There were technologies that were terminated, but generally people could see that this was inevitable.

Q55) What did the workers miss about the old system of working?

Respondents replied that the workers missed the unthinking routine of their old work. Workers were initially uncertain how to handle the greater job freedom that the new technologies provided. In some cases the vagueness of the new job was unsettling. (Vagueness due to reduced number of procedures)

Q56) Had communications between management and workers improved perceptibly?

Interviewees generally answered Yes. Management had taken concrete steps to improve communications and had become more sensitive to the feelings and aspirations of the workers. Where there was initial lack of communication, management had become aware of the lack of trust that this had generated.

Q57) Describe the innovation process in the company.

Those companies who had embarked on the path of innovation, had found that it was an ongoing process which never ended.

In some of the companies it was informal, with an individual championing it. In other cases there were departments in the company which were given the responsibility of innovating. In these cases, they developed the innovation to the extent where it became an implementable task. The department where it was to be implemented was approached and internal training took place to enable them to accept the innovation.

Internal innovation and training seemed to have a longer lasting effect. However, managements' acceptance level of the innovation depended on the amount of

money they had to pay an outsider to the company, in order to obtain it.

Q58) Describe the implementation of new technology in the company.

It was felt that top management dictated. When asked why production people were not the initiators, it was found that they were more worried with their month-end performance figures.

In the smaller units (companies or business units) the person who was the most interested was allowed to carry out the implementation.

Q59) Have there been any people laid off due to new technologies being implemented?

The replies indicated that in most cases they were not laid off as a result of the technology itself. Where the technology was the cause, it was found that the individuals were either not willing or were incapable of being trained for the new technology.

Q60) Were there any new staff members employed due to the implementation of new technologies?

Replies showed that the answer was Yes. In all cases new staff were taken on, even after retrenchments. These people were mainly in the semi to highly skilled group. Staff were employed in the new areas opened by the technology and because they had specialised skills.

Q61) What are the main hurdles to innovation and technology change in the environment today?

Interviewees felt that the answer lay in the availability of resources for the implementation of the new technology. In particular, it was related to skilled staff and to the finance available for the venture.

Other hurdles included the Unions and their fear of redundant jobs. Also cited were sanctions, the brain drain, apathy and conservatism, attitudes, the learning curve, company procedures and reporting systems. It was difficult to persuade the worker that the benefits of the change were for him as well as for the company.

Q62) What are the main promoters of innovation and technology change in the environment today?

Companies felt that it was survival. Also quoted were need coupled with availability of technologies, the market and competition.

Q63) To what extent do financial planners have a say in innovation decision making?

Respondents replied that they obviously had a say as to what the company could afford. However, they tended to allocate to themselves the authority to dictate to technical people, whereas they should have operated as a resource area to the innovator.

In the small companies they did not have a direct say. Their job was to make money available for the innovation. In large companies the opposite appeared to exist. To what extent the financial planners had been

briefed about the different innovations on offer was not determined. However, in one case where a decision meeting was attended, it appeared that he who spoke the loudest obtained the support.

4 DISCUSSION

4.1 Communication

The most important factor that emerged from the survey was the importance of communication. To almost every problem, part of the solution was communication.

With every action, there must be a feed-back system to gauge how effective the action was. The same applies to communication. Without feed-back from the people one targets, one cannot gauge whether the meaning and purpose of a communication has been accepted correctly.

The author's experience was that where more than one person from a company was interviewed, different replies were given to the same questions. This occurred in all interviews. The interpretation and understanding of what was happening in the company differed from level to level.

Clear communication can only be achieved if there is a feed back-loop.

Communication plays a major role in innovation, change and new technologies. It is also one of the major problems because too little effort is spent on communication.

The impression that one loses control or status if one passes on too much information is only true for the empire builder. An empire builder's days in today's environment, are numbered. As the rate of change increases, the empire builder will be found out.

By sharing information, one increases the effective-

ness of the group. Individual performance is becoming expensive and not cost effective. Team work and team performance is what will be sought in the future.

More formal attention has to be given to the flow of information in the company. Cross fertilisation should be encouraged. It facilitates the crossing of formal departmental boundaries and stimulates the growth of ideas as well as pride in the company.

Cross fertilisation of ideas means that more people can be informally involved in a project. This is motivating for the individual. It helps to ensure that the probability of success for the project is kept high due to the many constructive inputs.

Cross fertilisation overcomes the effects of limited resources.

4.2 Unions

Unions in South Africa need to mature. Their short-term thinking is not to the benefit of the worker, company or country.

The mere fact that they are not dependable, promotes automation. Their lack of long-term strategies has an unsettling effect in industry.

Many words and phrases have been associated with the unions such as "job security, sensationalism, remuneration and politics". Whatever it might be, unions must consider their position in history and the respect they command in the world today. Their policies and outlook must be for the long-term wellbeing of their members. In order to achieve this, they must look after the country and company. Respect and trust

must be earned, not only from their members, but from industry and the country at large.

Unions must realise that by wanting more information about the company and its plans, they must be prepared to take on more responsibility towards the wellbeing of the company. This is the opposite of the image portrayed by the unions. They do not want responsibility nor to be part of the management of a company. They want to be free from all ties and commitments.

4.3 People

The largest constraint to change is people. There is not enough manpower with the skills, attitude or energy to drive change.

The skills necessary to manage people need to be developed. There were far too many comments about the companies' R & D department being used as a refuge for people. They should be dynamic and one of their goals should be the raising of the technical knowledge of the people in the company.

A trend amongst today's technically qualified staff is to be more discipline orientated rather than job orientated. It is perhaps a byproduct of the overall trend of specialisation or, in the negative sense, it highlights a shortcoming in today's education.

Innovation is probably THE unique area that will keep technical staff happy and motivated. It could be regarded as the "magic ingredient".

To overcome the shortage of skilled personnel, consideration should be given to the use of retiring or retired technical personnel on a consulting or con-

tract basis.

4.4 Education

There is an implied message from industry that it is unable to recruit technical people with the requisite knowledge. The graduate often does not realise that his certificate is a learner's licence. He must gain experience in the ways of industry. The application of knowledge is as important as possessing the knowledge.

Creative thinking is not emphasised enough. Whether it is due to the lack of experience or whether a tertiary education stifles creativity was not made clear to the author. It would be of value if courses such as Value and Reliability Engineering could form part of the college curriculum, in order to promote creativity.

Industry is of the opinion that Institutes of tertiary education should be approaching industry to find out what are the trends and needs for the future. These Institutes are in a better situation to interpret the trends and needs and produce a product that can be used by industry in the years to come.

4.5 Planning

One needs a base line against which to measure new technology. It is also necessary to monitor its progress. Long-term planning, by its very nature is fairly rigid and hence it is detrimental to the process of change and innovation. Several short-term plans are more manageable and flexible. A plan should include the time to research what has already been

achieved by others. Many "new" ideas are only old ideas which were introduced too soon.

Plans must include the implementation phase of a change. This is as important as the innovation itself.

Service departments such as planning, finance and procurement should be "personally" responsible for the wellbeing of the project. They should feel a type of ownership.

4.6 Strategy

Risks and uncertainty pose problems because many people are prepared to take risks but few are prepare to face uncertainty. Innovation represents uncertainty.

Innovation is a means to an end. Innovation, along with change, takes a finite amount of time, for which allowance must be made. Any change has to be implemented before it can be of benefit to the company. This implementation phase appears to have been very much neglected in the past.

The question of whether to buy-in or to develop new technologies in-house is dependent on resources and on the time available to the company. Buying-in technology often gives the marketing edge since it offers the advantage of being first in the market. However, a complete understanding of technology cannot be written down. It is invested in individuals.

Timing of the implementation is critical for the success of the change. Many projects have failed due to bad timing. The market/client must be ready and he

must be able to comprehend the technology. He must also cope with the costs and the cost of ownership.

The question as to whether innovation is cost effective can be answered by saying that companies cannot afford to neglect innovation. The Swiss watch industry provides an example. The Japanese used innovation and introduced the electronic watch. They captured a notable percentage of the watch market.

Ideally, technology change should be continuous. It should be presented in small packages which can be accommodated by the staff. It must be accepted by the client and it must be affordable to the company.

4.7 Attitudes

The image of engineering amongst school leavers needs to be changed. Engineering must appear to be more attractive in order to swell the numbers of Engineers. The engineers' image in industry has improved. So has the capability of engineers. There is still a long way to go.

Engineers are not the only people who are important to the future industrial growth of this country. However, they are key players.

The part played by the Engineer and the Scientist, in some companies, has to be defined. Scientists invent. Engineers innovate. There is a place for both.

Empire building was present to some extent in most of the companies interviewed which participated in this study. It was more prevalent in the larger companies. Empire building is detrimental to change and to innovation. It does not make good use of available re-

sources and it will cause partial stagnation of the department in which it occurs.

The author found that companies were paying lip service to innovation and technical change. These words had become "buzz words", used by managers. As far as the staff was concerned, very little was being done.

Although all of the companies were aware of the returns obtainable with new technologies, they were cautious (the halo effect).

Success is often advertised, but failures are not. One does not have to innovate to make money. It is not always a characteristic of innovation. However, profits are made through innovations and there are several companies who are able to prove it. Some prerequisites are essential.

South African companies are well positioned to make a significant contribution to the growth of industry in their own country and in Southern Africa. They need to make better use of available resources.

The author added, at the close of his interviews, one last question. "*If your company were to be a motor car, what type would it be and why?*" In only one company were two types of cars proposed. In all of the other companies, everyone named the same car for almost the same reasons. It would be unfair to the car manufacturers to mention the cars and the reasons for their choice. What is interesting is that, although different people on different levels in the companies differed in detail on how the company was run, they all agreed on the image of the company

- A luxury car that still needs running in

- Very high quality, fast moving, complex and no rigid system
- Customer service
- The present vehicle, slow and conservative, must be traded in
- A 1976 car, very good in its time, still going well but looks a bit shoddy - newer models available
- Good quality, very popular.

The author hopes that this brief outline of the benefits and difficulties of technical innovation will stimulate interest in the minds of other students, so that they will subsequently add their own contributions to the literature of this important topic. The rapid changes in South Africa's political, economic and industrial worlds will undoubtedly influence innovation and will provide a fertile research area for future scholars.