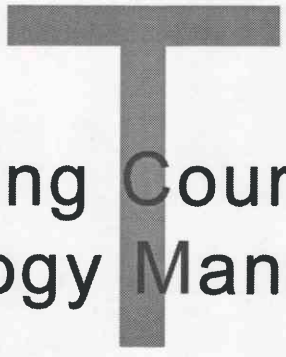
United Nations Industrial Development Organization
Vienna, Austria

International Centre for Science and High Technology
Trieste, Italy

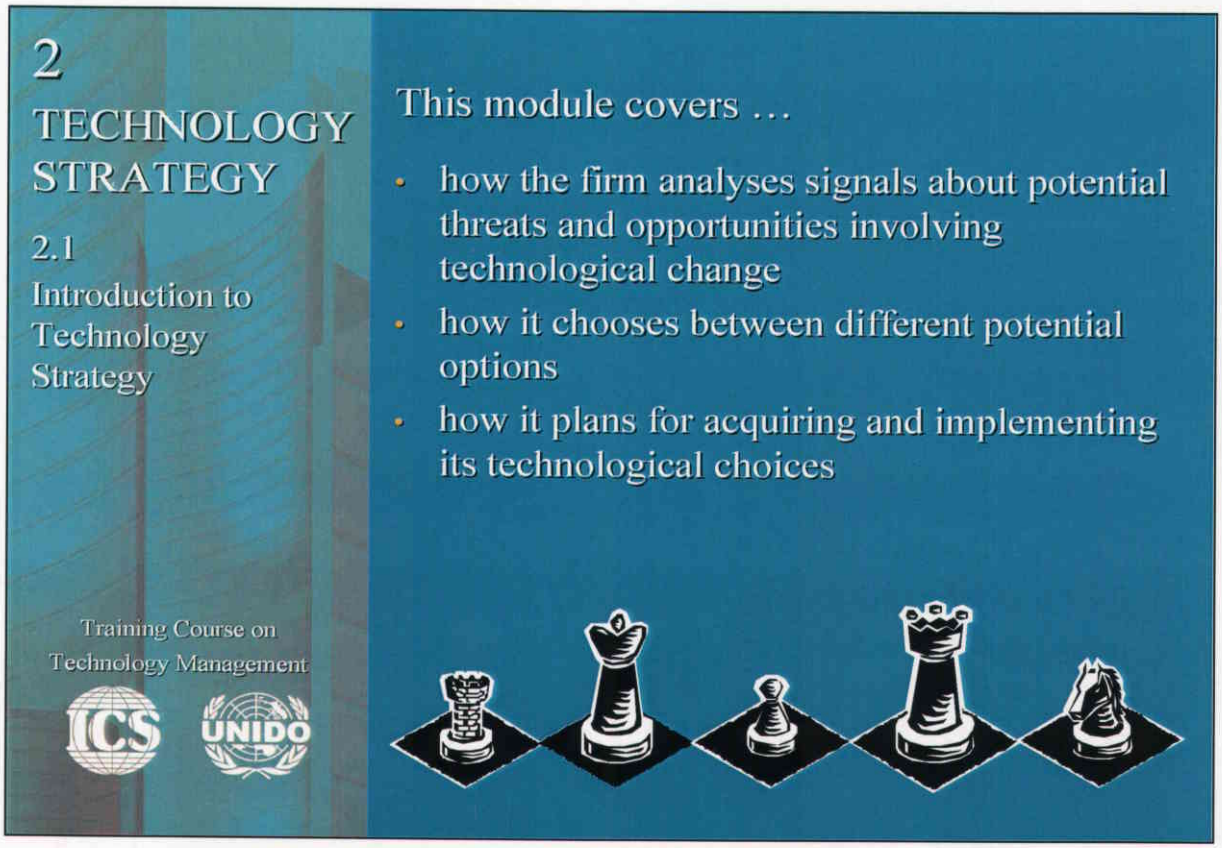
Module 2

TECHNOLOGY STRATEGY



Training Course on Technology Management

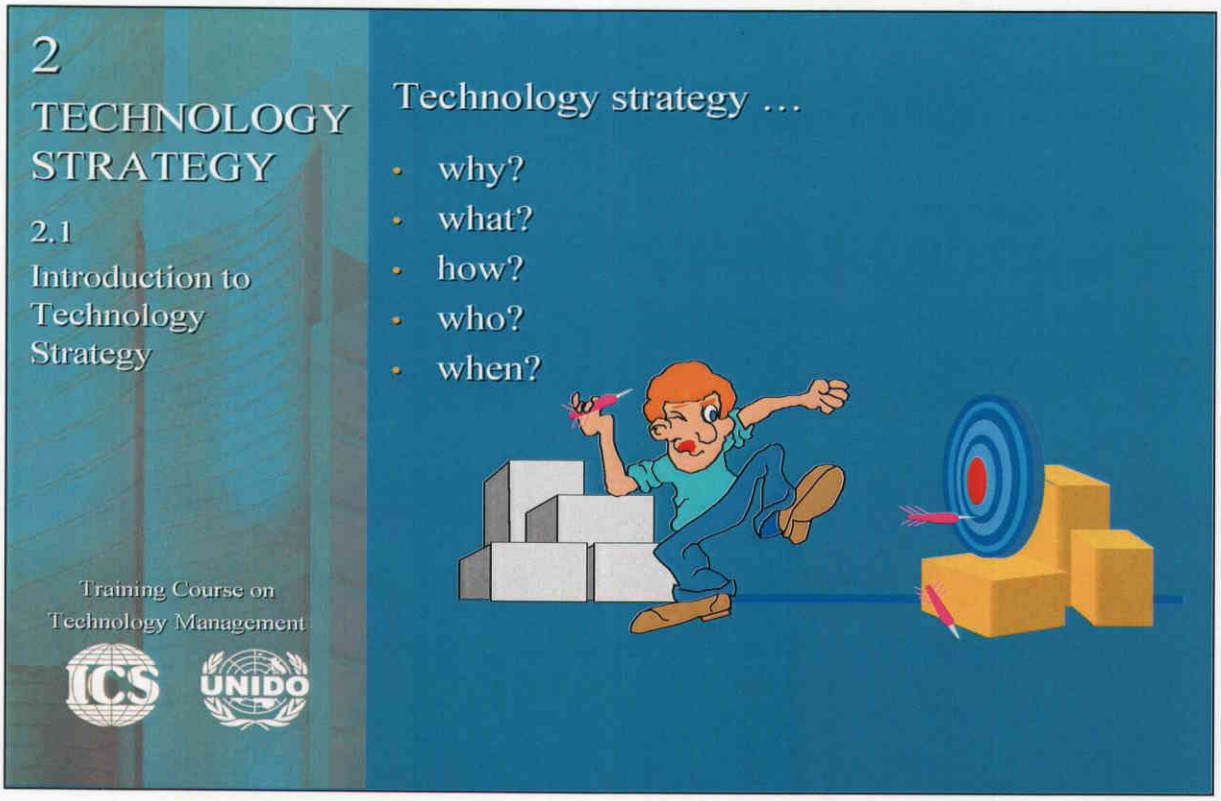
TABLE OF CONTENTS



This module is concerned with how the organization makes sense of the wide range of potential threats and opportunities in the environment. In particular it deals with :

- how the firm analyses signals about potential threats and opportunities involving technological change
- how it chooses between different potential options
- how it plans for the resourcing and implementation of those choices

In short, it explains how to develop a firm's technology strategy by addressing strategic analysis, strategic choice and strategic planning as they relate to technology.

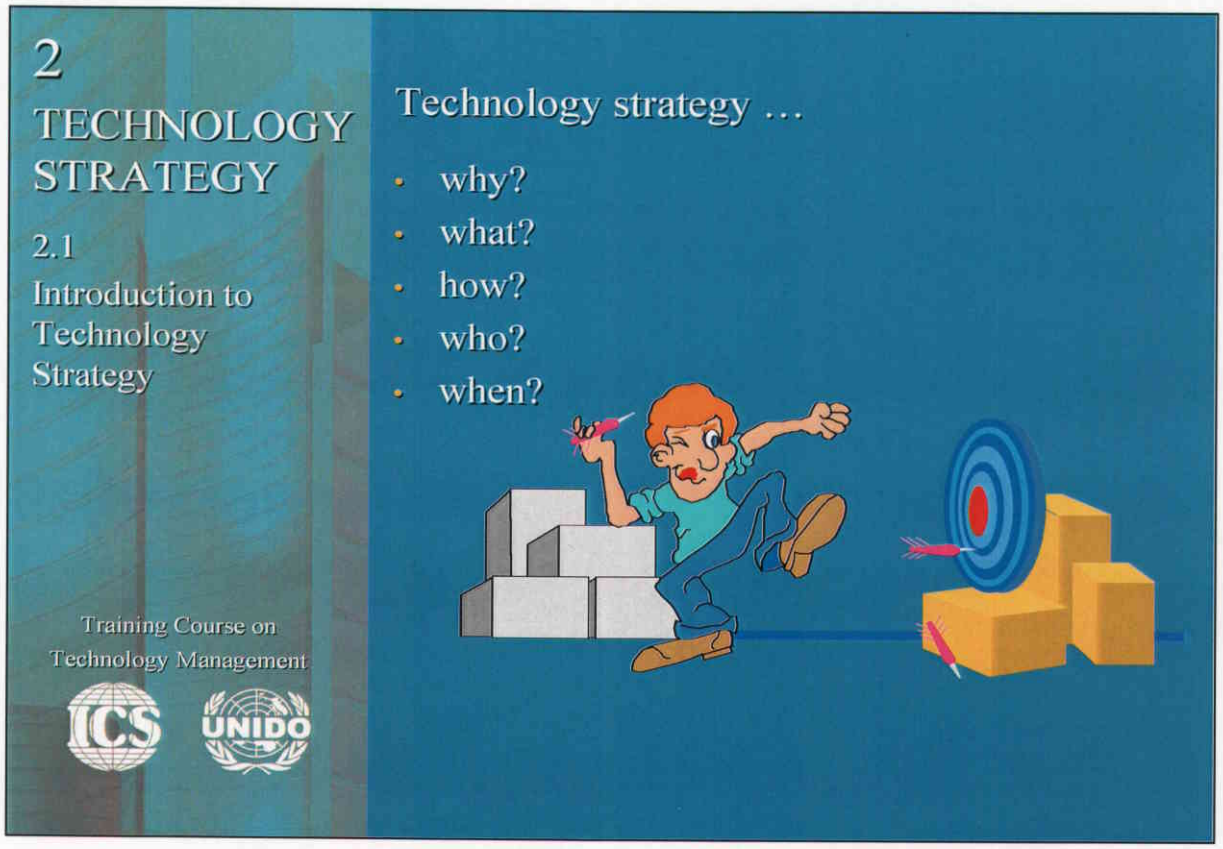


Strategy is essentially about making commitment decisions; firms have limited resources and deciding to follow one course of action means not being able to follow others. So making the right decisions here is critical. Research has shown that those firms which follow a focused and coherent strategy in technological change are much more likely to succeed in gaining and sustaining competitive advantage. And those which lack a strategy may be lucky in the short term but are unable to sustain their success.

The Redring Jug Kettle Case (Walker, Open University, 1986) is an example of technology strategy failure. Trying to make and market something new involves risks and these increase significantly if the firm has no prior experience. Walker et al discuss the case of the plastic jug kettle which has now become a common household appliance and forms part of a market worth around £500m per year. Redring, a subsidiary of General Electric, was the only company to move forward with what was for its time a radical innovation; their potential high market share was eroded not least because of difficulties in manufacturing and marketing the product. An engineering firm specializing in heat exchangers, they lacked the competence in plastics processing technology and in consumer product marketing; by the time they had climbed the learning curves needed to acquire these competencies, other players had entered the market and Redring's market position was reduced to a relatively small niche. Had Redring dong a better job of technology strategy, this innovation would have turned out much differently.

Examples of success in technology strategy include Cosworth and J&S Cash.

For example, the Cosworth company is a well-known producer of high performance engines for motor racing and performance car applications. They were seeking a source of aluminium castings which were cheap enough for volume use but of high enough precision and quality for their product. Having searched throughout the world they were unable to find anyone suitable. Either they took the low price route and used some form of die-casting which often lacked the precision and accuracy, or they went along the investment casting route which added significantly to the cost. Eventually they decided to go right back to basics and design their own manufacturing process. They set up a small pilot facility and employed a team of metallurgists and engineers with the task of coming up with an alternative approach that could meet the company's needs. After three years work and a very wide and systematic exploration of the problem the team came up with a process which combined conventional casting approaches with new materials (especially a high grade of sand) and other improvements. The breakthrough was, however, the use of an electromagnetic pump which forced molten metal into a shell in such a way as to eliminate the air which normally led to problems of porosity in the final product. This innovation came from well outside the foundry industry, from the nuclear power field where it had been used to circulate the liquid sodium coolant used in the fast breeder reactor program! The results were impressive; not only did Cosworth meet their own needs, they were also able to offer the service to other users of castings and to license the process to major manufacturers such as Ford and Daimler-Benz.

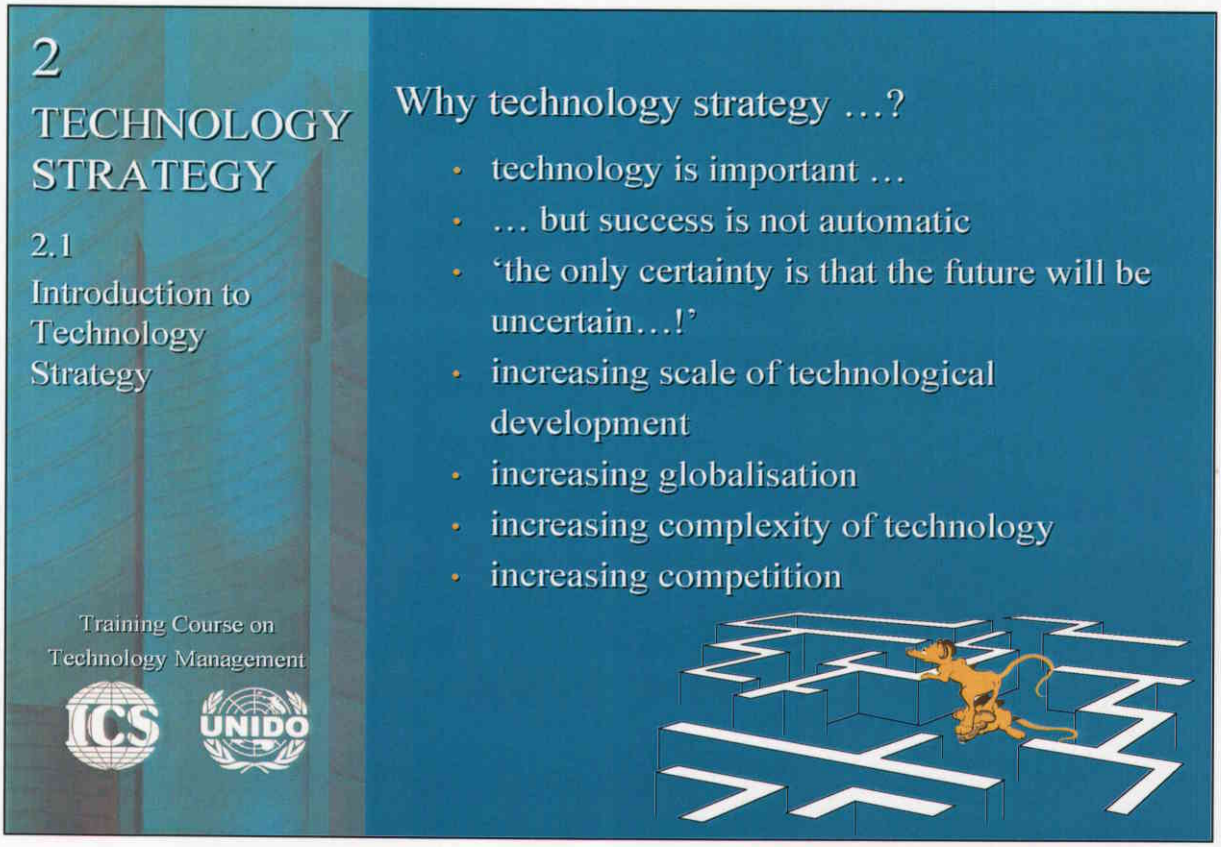


In another example, the small textile company J &J Cash was experiencing severe problems as a result of the inflexibility of their production equipment and design processes in the early 1980s. As narrow fabric weavers producing name tapes, labels and other woven goods, they represented too small a segment of the textile industry to attract the attention of the main equipment suppliers. The result was that although sophisticated electronically-controlled equipment was available for broadcloth weavers, nothing suitable was available for Cash's to adopt. Instead they were forced to generate their own. Over a decade they built up a mixture of internal competence (acquired through a lengthy and not always successful process of learning by doing and experimenting) and external linkages such that by the end of the period they had managed to develop and implement their own microelectronics controls for a wide range of looms and a sophisticated computer-aided design and manufacturing system. The benefits this brought were significant; from a position in which their basic product took at least six weeks to produce they can now process orders on the day they are received. They have opened up new markets and expanded the business through the new opportunities which greater technological capability has brought. They have also become suppliers of technological know-how to other small firms in a similar position. (Bessant 1985)

Technology makes a difference! Many studies have shown that technological change is a critical factor in shaping economic growth, and, as the examples on the previous page show, getting it right or wrong can have big impacts on the business. This is true at the level of the individual firm, at the sector level and even at national level.

For example, the success in the 1980s of Japanese semiconductor manufacturers was very much due to a collective national strategy agreed amongst the main electronics companies to develop and master the technologies necessary for high yield and consistent production of high volumes of mass market chips such as memories. Similarly, the Korean approach into the 1990s has followed this strategy and wrested much of the lead in high volume chips.

In the case of the car industry, the technological choices made by Japanese producers in the late 1970s and 1980s in both product and process technology provided a major competitive edge which meant that at one stage they could produce and deliver cars into Detroit, USA at $2000 cheaper than they could be made in the local factories! Studies of 'best practice' in vehicle manufacture suggested the gap between best and average plants was roughly 2:1 on a variety of dimensions including quality, labour productivity, inventory levels and time. Whilst the pattern of advantage has shifted around the world and begun to threaten Japanese dominance, the underlying transformation of the industry (which echoes the earlier one wrought by Henry Ford when he introduced the mass production system eighty years ago) is very much one which involved choices in technology strategy.

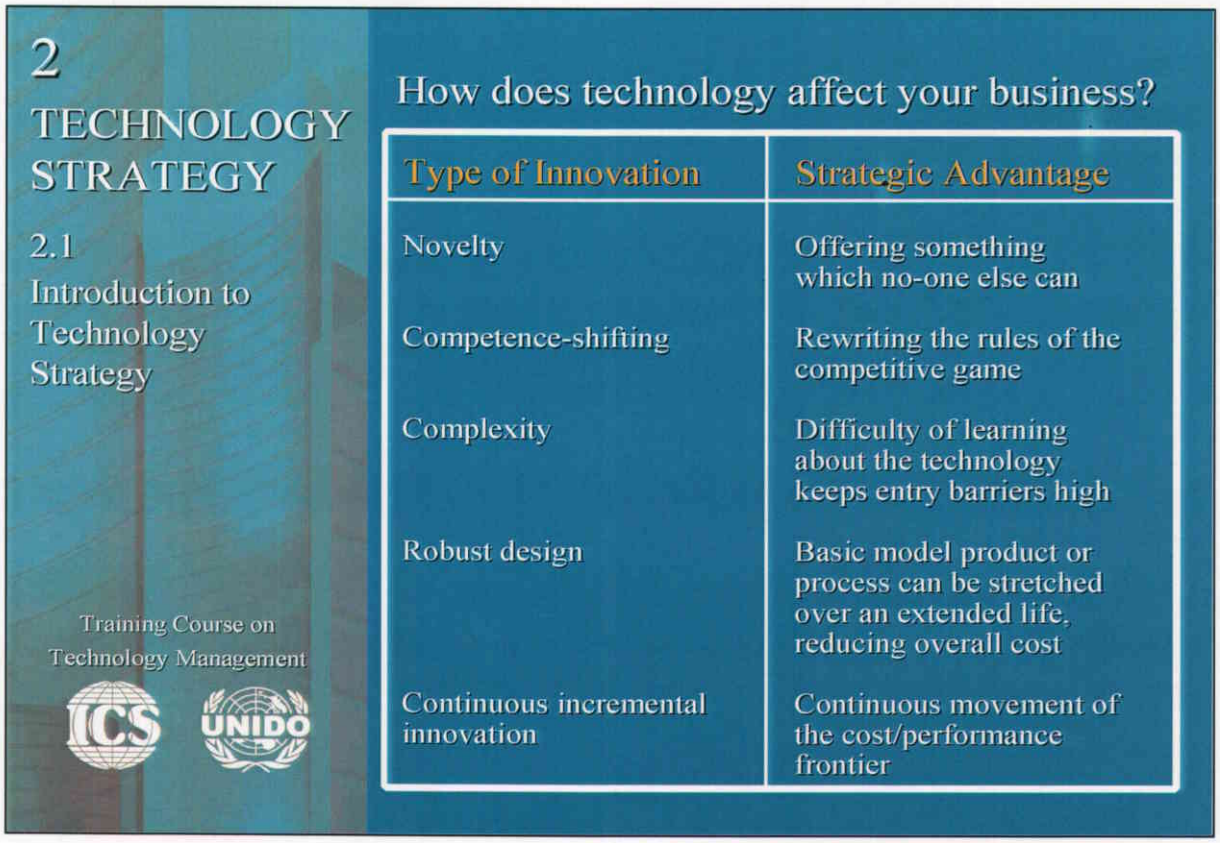


Similar patterns can be found across all industries including the service industries. In the UK, for example, the staid and quiet business of insurance was torn apart by a new approach, direct telephone selling, which fundamentally restructured the industry and spilled over into banking and other financial services. Behind the industry transformation was a clear technology strategy on the part of the original entrepreneur and his company.

Of course this message is even more important at the level of the individual firm. Without a clear strategy the risks of failure are high, but, equally, the benefits which come to firms which have a coherent strategy can be significant. For example:

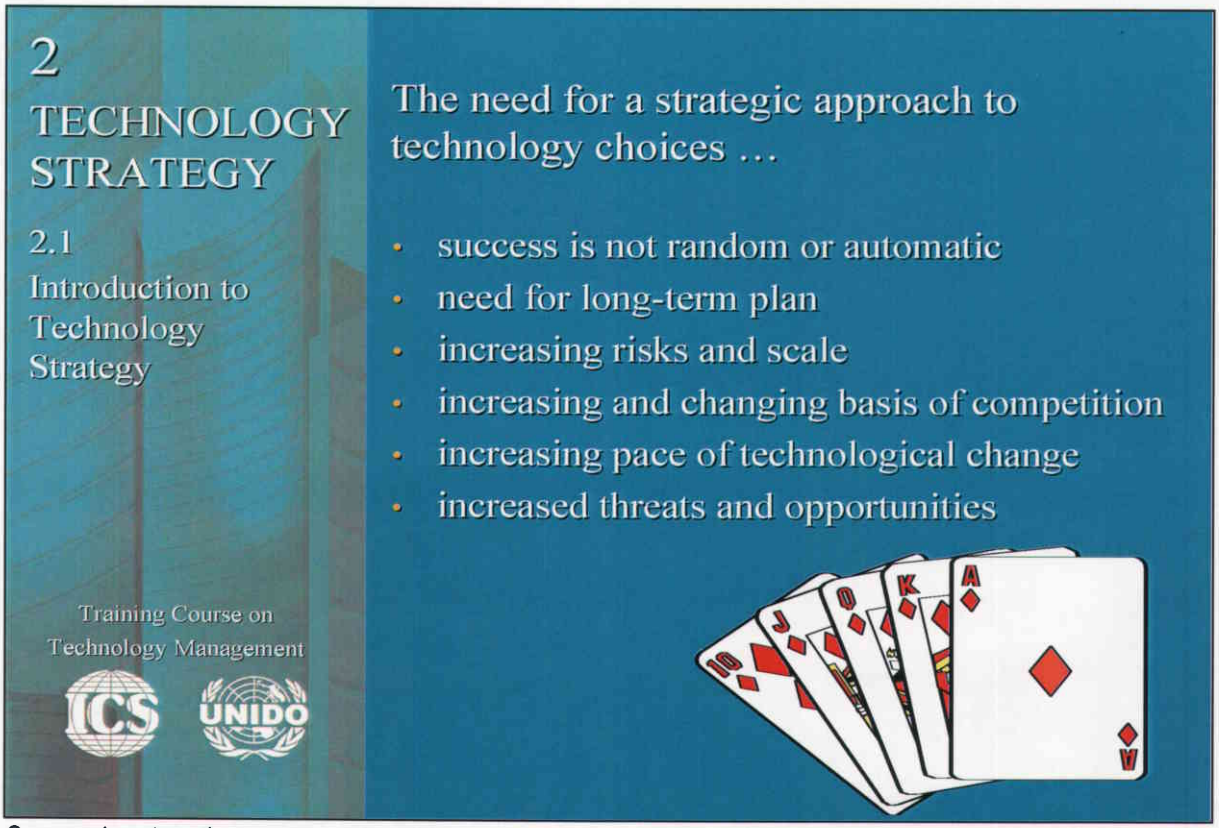
- Building lawn mowers does not, at first sight, seem to offer much scope for innovation. Yet the Flymo company (now one of the largest European suppliers in this market) has built its position over thirty years through exactly that - innovation in the design and manufacturing of its main products. It holds over 70 patents, with a further 100 in the pipeline, and has used its commitment to systematic and continuous innovation to build to sales of over £100m. More important, it has made a conscious (and so far successful) decision to use innovation to preserve its position in an increasingly price-competitive market. Its commitment, shared by the 700 people who work for the company, to focusing on customer needs and meeting them with high quality and well-designed products, has helped it fight off strong threats from low cost competitors.

- The city of Sheffield in the north of England is traditionally famous as the home of cutlery. Yet by the 1970s import competition had become so intense that the Sheffield cutlery industry had almost disappeared. One firm managed to reverse this trend; the Richardsons organization increased its sales from £1m in 1974 to £23m in 1989, moving from being a small 'commodity' producer of knife blades to become a major player in the industry. Its success derives particularly from the 'Laser' product range, introduced in 1980, which combined a new type of blade with a lifetime sharpness guarantee. A recent advertisement suggested the latest version, the 'Fusion Edge', lasts 11,000 times longer than traditional knives. Their success was not a 'one hit wonder', but the product of a commitment to innovation in products and processes, concentrating on building core competence in the key technological fields of metallurgy and manufacturing processes.



- Innovation of this kind is not only associated with large firms. In 1995, the UK firm of Stanhay Webb won the Queens Award for Technological Innovation for its work on the Singulaire multiline seed planter for the agricultural industry. The firm had maintained progress during the recession and grown to a turnover of £4.5m, with around two-thirds going in exports. The concept originated in 1983 was to develop a seed drill which could do what no other drill in the world was capable of doing - planting raw seed accurately in one, two or three lines. Twelve years later the product is now a world beater, selling in 30 countries.

- It is also not confined to manufactured products; examples of turnaround through innovation can be found in services and in the public and private sector. For example, the Karolinska Hospital in Stockholm has managed to make radical improvements in the speed, quality and effectiveness of its care services, such as cutting waiting lists by 75% and cancellations by 80%, through innovation.



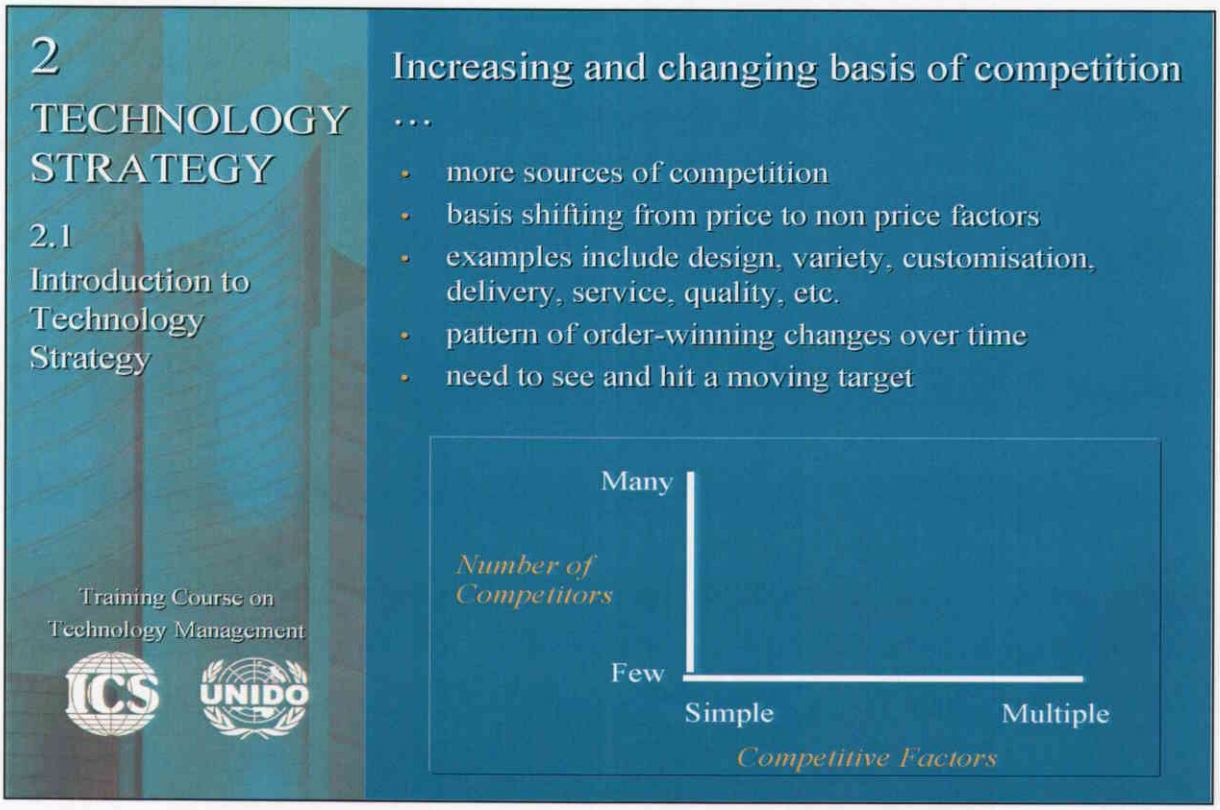
Success is not random or automatic. All the evidence tells us that technology strategy is about planned commitment rather than gambling. Simply jumping on the latest technological bandwagon just because it happens to be rolling is not a strategy, and there are plenty of examples to show how costly this can be. Equally, following a technology pathway which looks promising may not work if the firm has no prior experience or background in the field; for example, a metalworking firm suddenly trying to enter the biotechnology race because it is looking to diversify is not likely a good strategy.

During the 1980s considerable excitement surrounded the possibilities of using computer-controlled equipment to plan and execute the complete range of manufacturing tasks from design through to production. Growth rates amongst suppliers of AMT (advanced manufacturing technology) were often as high as 30% per year as manufacturers poured money into investment projects aiming at creating the automated factory, run by robots and deploying the latest in computer-integrated technology at every turn. For example, estimates suggest that by 1989 the UK was spending around £2bn per year, around 20% of all manufacturing investment, on AMT. But closer analysis of the experience of users suggested that the returns on this investment were often poor; in one survey respondents indicated they were achieving at best only 70% of the planned gains, whilst in other cases failure rates as high as 50% were reported.

Strategy involves a long-term plan to cope with uncertainty. Technological change is, by its nature, uncertain and it also involves a learning process. If a firm is going to compete on technology - whether in its products or processes - then it needs to accumulate what we call 'technological competence'. That is, it needs to learn and assimilate the knowledge (in formal and in tacit form) which makes it distinctively good at some aspect of technology.

Examples of competence include Sony's in miniaturization, Rolls Royce in aircraft engines, Samsung in semiconductor manufacturing and American Express in financial information systems. Competence is not necessarily something which only large firms can aspire to; many smaller firms have developed very useful niche strategies based on specific technological expertise. For example, the Sheffield firm of Richardsons have built up a world-class position in the manufacture of knives, whilst another UK firm, J&J Cash have developed a strong position in narrow fabric weaving of labels and badges.

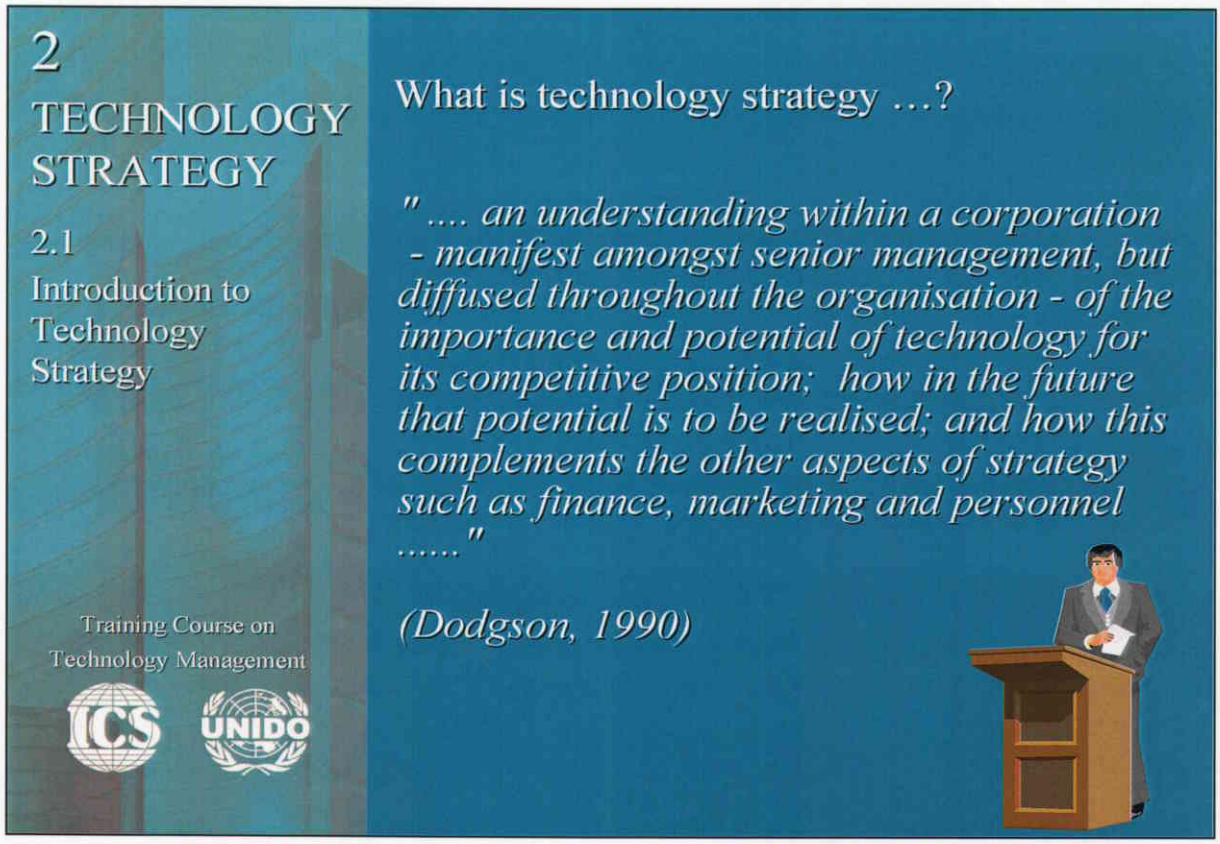
What we have learned from studies of technological competence is that it doesn't appear overnight - it has to be learned and absorbed. Even when firms buy other firms in order to acquire new competencies there is a lengthy period before the new competence is sufficiently absorbed. So building and deploying technological competence for competitive advantage is a long-term strategic concern; it is the managing, as a farmer does, of 'knowledge crops', developing and building up over time.



Not only is innovation uncertain, but the risks are getting bigger. Many of today's major projects have exceeded the capabilities of single firms to manage them and involve networks of players, and even those projects which are still within single firms have huge costs and time scales attached. For example, the pharmaceutical industry might typically spend over $1m every day in developing a new drug which might take two years to come to market, and may never reach that stage. A typical motor car now involves over 10,000 components, whilst even the humble washing machine now has sophisticated computer software controlling the mechanical functions.

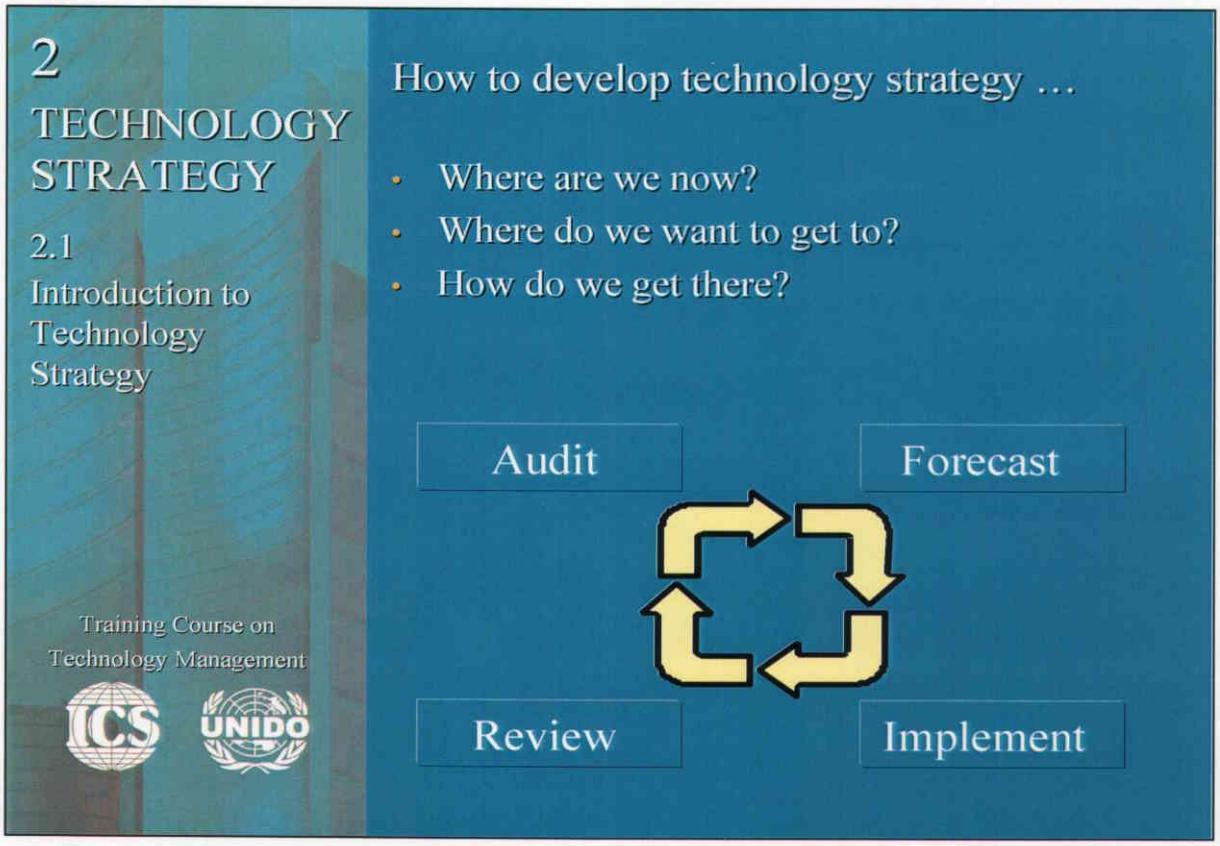
Of course, not every innovation is so high on the scale of risk and complexity, but the trend is certainly in this direction, and it means that firms need to look beyond the short term and take a strategic approach.

Two further forces pushing for a strategic approach to technological change are the increasing number of competitors (including more international players) and the changing basis of competition. No longer is it sufficient to offer products or services which compete on price alone; increasingly the emphasis is on nonprice factors like design, quality, delivery speed, service and customization. Nor is it possible to ignore these changes – even if you are not directly concerned with the export market, the risks of import competition are increasing all the time.

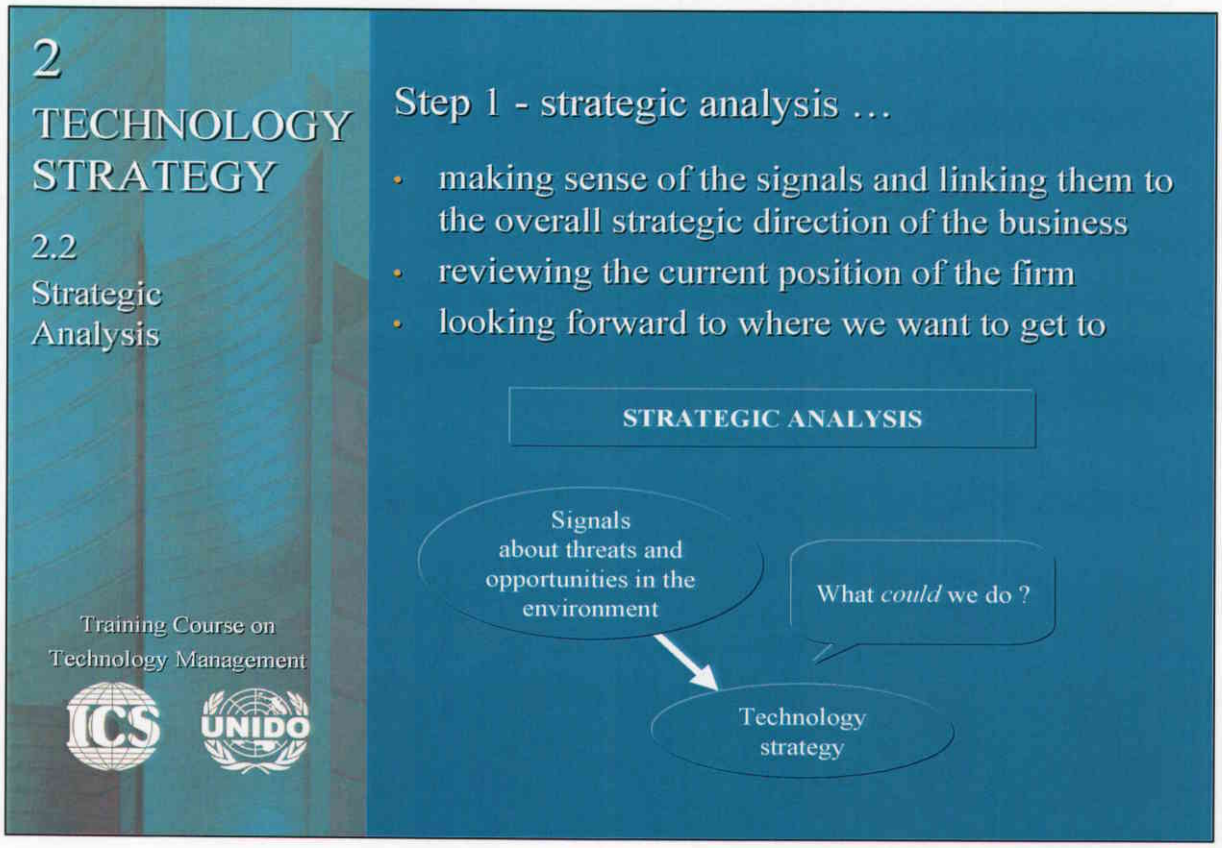


Technology strategy is primarily concerned with how an organization chooses and uses technology for strategic advantage. There are three aspects to this:

- strategic analysis - what could we do, and why?
- strategic choice - what are we going to do, and why?
- strategic planning - how are we going to implement our choices successfully?



Developing technology strategy involves trying to answer these questions as fully as possible; but it also involves learning from previous experience. It is a continuing cycle, in which the firm learns more and more about its environment, its own capabilities and how to develop these successfully over time.

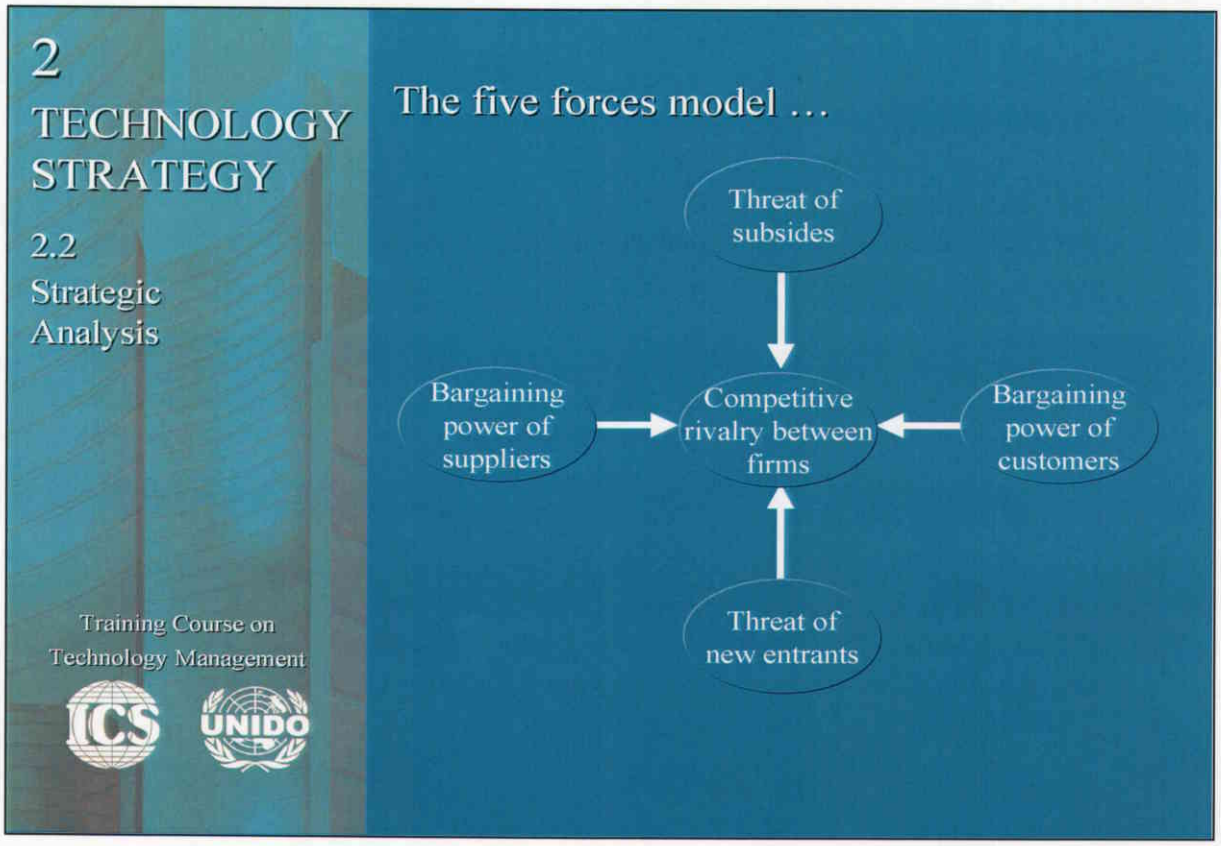


This stage is really about looking at 'what could we do and why?' It involves:

- making sense of the signals and linking them to the overall strategic direction of the business
- reviewing the current position of the firm
- looking forward to where we want to get to

Now we are „processing the signals". We want to understand the nature of the different challenges and opportunities and to pick up clear signals about the most urgent and significant options for change. Module 1 contained examples of tools and approaches to building up this picture, including various forecasting and scanning techniques. What we need to do at this stage is build a clear picture of the key issues which we need to consider. There are many techniques for doing this, but we will concentrate on three simple aids.

- the 'five forces model'
- competitiveness profiling
- value stream audit



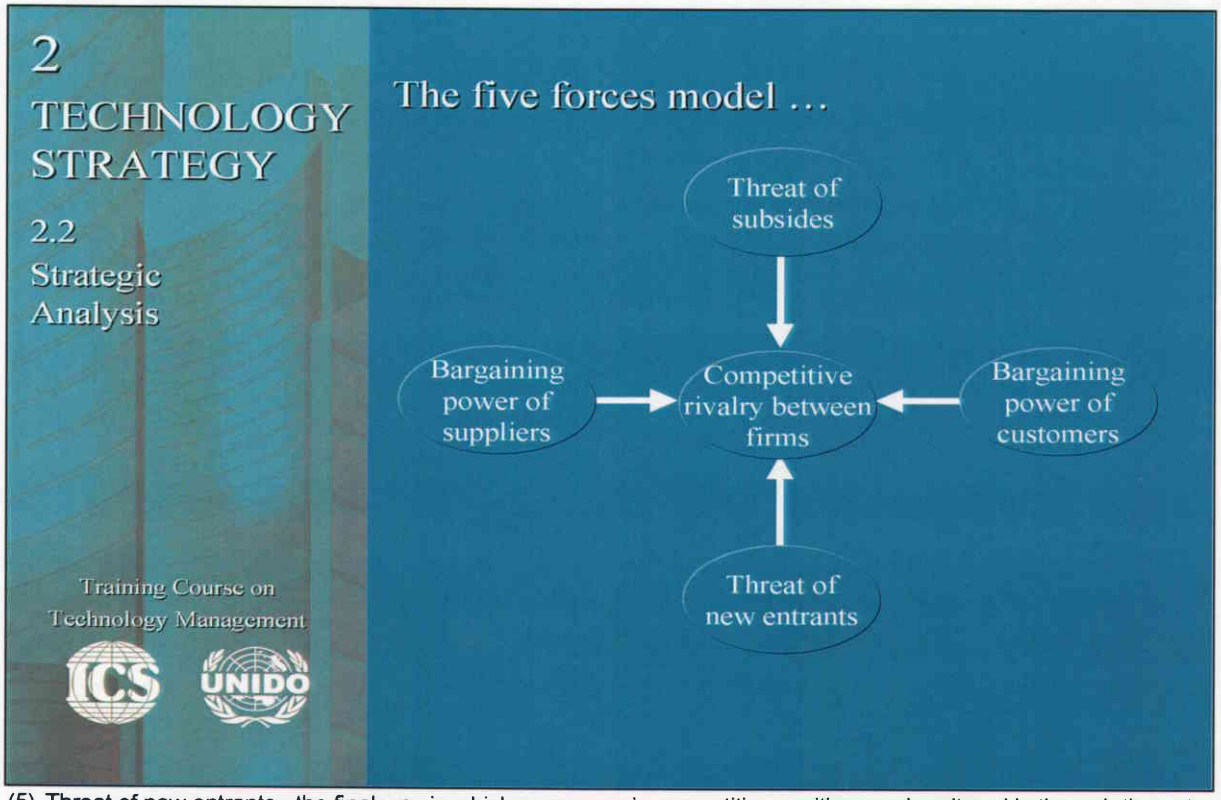
This is a simple map which represents the competitive strategic battlefield in terms of five forces which interact to shape the challenges for firms. Its main value is as a thought-provoking aid to discussion to help arrive at a shared understanding of the threats and opportunities facing the firm. Whilst it is a powerful and simple tool for analysis, it does not look in great detail about the choices or the ease or difficulty in following a particular course of action.

The five forces are:

(1) The competitive rivalry between firms themselves - the various players in a particular sector or niche who are trying to do the same things. They are constantly jockeying for position and trying new things out (product and process innovation) in order to develop a strategic edge and hence a stronger position in this space. But all of the firms in this space also have to confront not only what each other is doing but also:

(2) and (3)
Bargaining power of suppliers and customers - in some cases the suppliers are strong; for example, a major steel producer selling to a small metal fabricator, in which case the client firm has a weak position and its ability to compete will depend a lot on the major supplier. If, for example, the supplier raised prices, the firm would have little option but to carry that cost. Of course, the relationship is not always weak in this direction; the major automobile assemblers, for example, are in a very strong position in respect of the thousands of suppliers to them, and can use this to obtain inputs to their activities in ways which support their own strategies. The classic example of this is the Toyota Production System which developed a network of suppliers who would supply the right quality, quantity at a point just in time for Toyota to use in building its cars. This reflects weak bargaining power on the part of the suppliers in terms of our model.

(4) Threat of substitutes - a company's strategic position depends on the extent to which what it offers is unique and cannot be replaced by something else. For example, a firm specializing in typewriters would need to recognize the weakness of its position and move out of this product area and into something else; for example, word processing software or hardware. Equally a firm that has a product that cannot be easily substituted, either because it is unique or because it has some form of protection (e.g. a patent), is in a strong position.

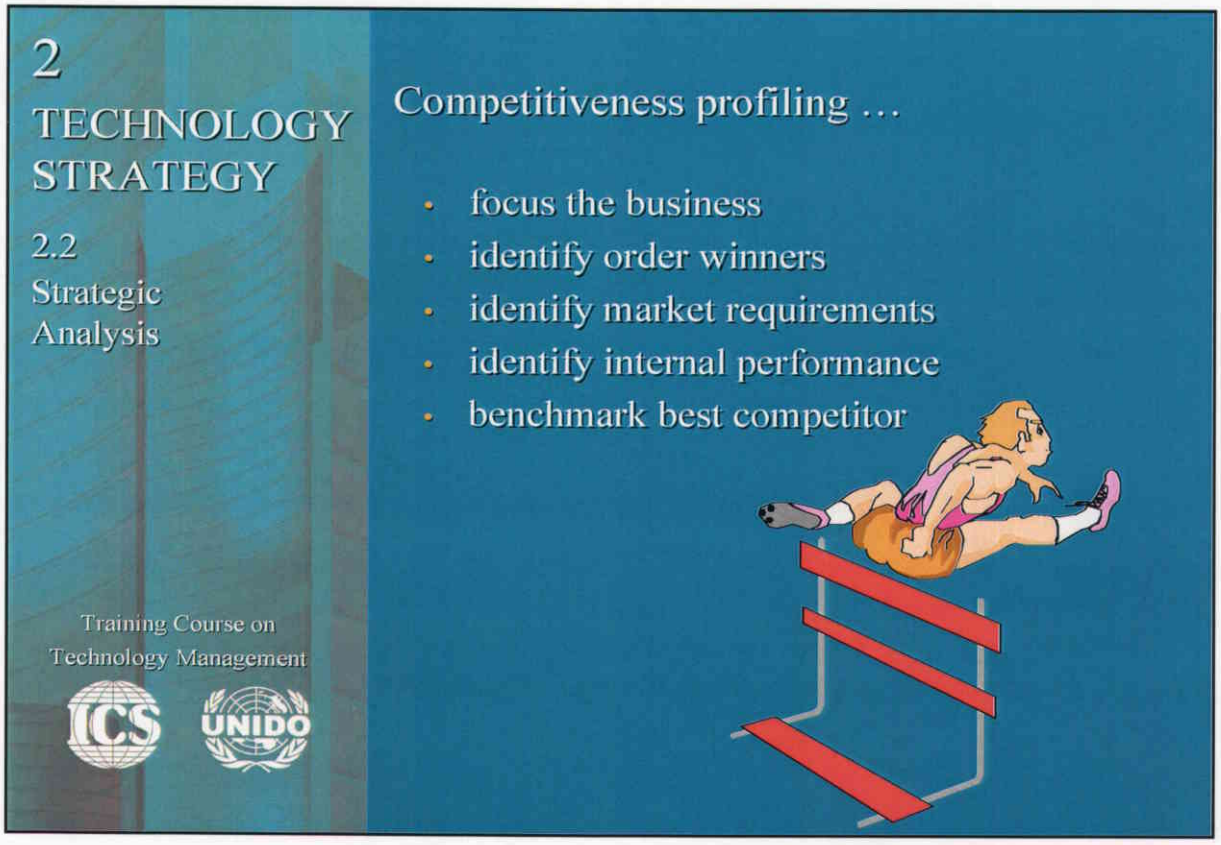


(5) Threat of new entrants - the final way in which a company's competitive position can be altered is through the entry of new competitors who may offer the same products or services at lower prices or with some other advantages. The extent to which there are high 'entry barriers', for example, high capital cost or difficult to acquire knowledge, is an indicator of strategic strength. Of course, both (4) and (5) are very susceptible to changes in the rules of the game; for example, a new technological could simultaneously open the door to substitutes and lower entry barriers to other players.

The main purpose of the model is to provide a structure for discussion and debate around the theme of strategy. Some particular ways in which it can based are:

(1) Competitive rivalry - look for niches where there are few firms as rivals and then benchmark against them. Or else look for growing markets in which more firms can still hold on and grow shares. Use it to focus on the competitor nature and number questions.
(2) Bargaining power of suppliers - use this to explore issues of balance and how to develop advantageous relationships. For example, if the supplier is exploiting its strong bargaining position (like the steel maker) then a strategic response on the customer firm's part might be to explore alternative sources of supply or even alternative materials or processes so as to reduce this dependence. Equally if the supplier power is weak, one strategy might be to exploit this weakness by tying the supplier into price reduction or other contract requirements which provide strategically advantageous inputs to the customer firm.

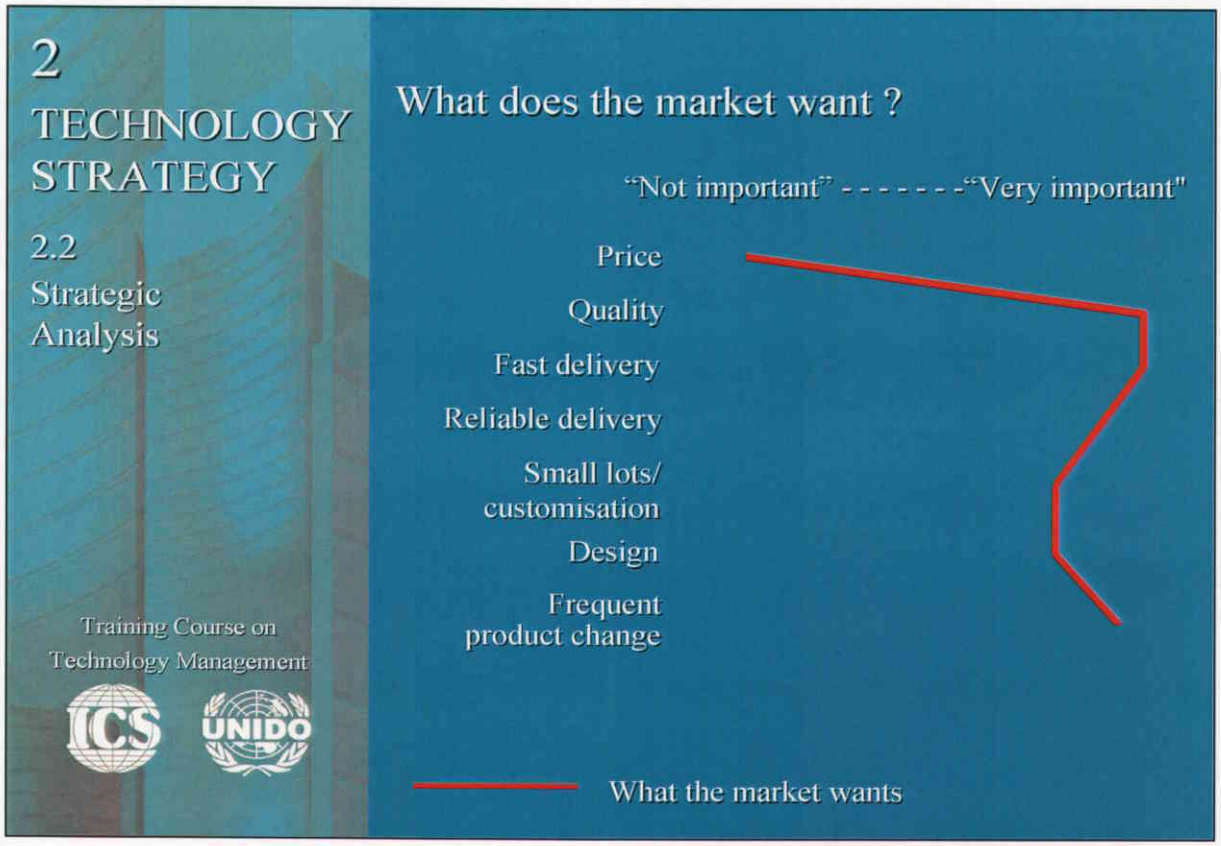
The danger in this is that it often becomes a seesaw of power relations. For example, in the car industry the historical pattern was one of adversarial relations, with an overall 'lose-lose' outcome. New thinking on supplier (and downstream relations towards customers) is concerned with developing cooperative relationships along the whole 'value stream'. Instead of optimizing one part of the chain at the expense of another this approach seeks to develop 'win-win' strategies. For example, in the car case discussed above firms are now trying to develop suppliers (even to the extent of providing cash, equipment, and engineering support) in order that those suppliers can provide them with uninterrupted supplies of the right quality, quantity and just in time. In the new VW plant in Brazil suppliers are actually based within the assembler's factory which carries the partnership model to new levels.
It is important to be aware that this model, though a powerful structure for discussion, has its limitations. For example, it provides a good framework for analysis but does not really consider issues around implementing changes to reposition for strategic advantage. It is also, because of its simplification of complex relationships, apparently linear in structure, whereas much competition is more in the form of networks and clusters.



A second powerful tool for strategic analysis involves creating a simple profile of how your products and processes match up to what the market wants and what your best competitors can offer. The step-by-step process is well-suited to discussion in groups and provides a powerful way of building a shared awareness of the strategic challenges facing the firm.

Step 1 involves reviewing and focusing the business. This recognizes that for all but the smallest firm, there may be a number of different product/market combinations with widely-differing strategic characteristics. Where one business might involve a relatively standard product and compete in a market based on price, another may involve producing to customer specifications, where competition is based on fast delivery, high quality and the ability to meet customer needs as closely as possible. Trying to configure a single factory to meet these different requirements is unlikely to be a successful approach, and an alternative model is to focus on particular families with common characteristics and concentrate development of parallel strategies for each of these.

For example, a firm making furniture might have three distinct product/market groups. The first is high volume furniture for general use which sells mainly on low price. The second is high quality, advanced design fashion furniture which sells at a higher price and can be customized to meet particular needs. And the third is for sale to a major retail store for resale under its own brand. Let us concentrate on the third of these.

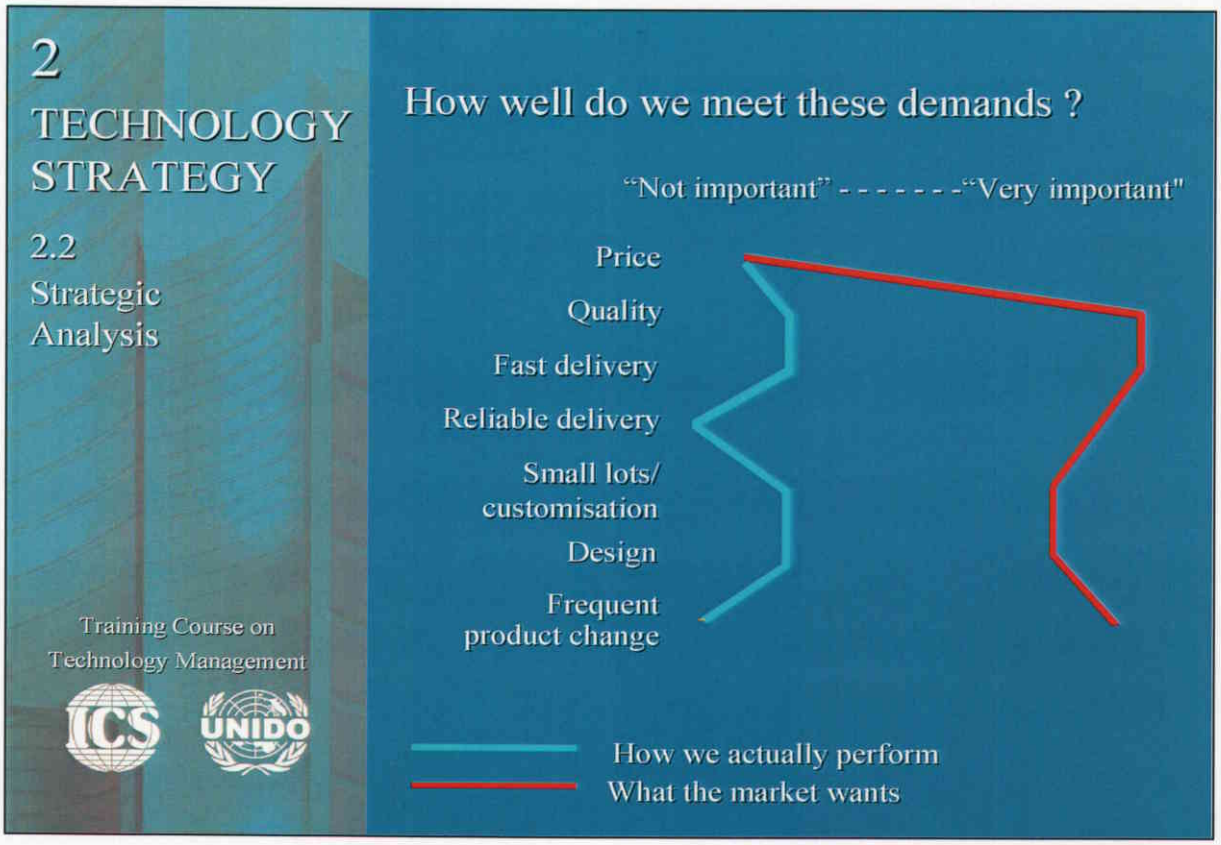


Step 2 involves identifying the market requirements for performance within these groupings; the concepts of 'order qualifiers' and 'order-winning' criteria are helpful here. This involves defining those factors which have to be present simply to be able to enter the particular competition (such as, for example, minimum levels of price or standards of quality performance), and those factors which win orders (such as faster delivery, better levels of customization, or high quality of service).

Then try to answer the question 'what level of performance does the market expect on each of these?'. Use a scoring scale from 1 to 5 where 1 is 'not important ' and 5 is 'very important'.

Essentially this stage involves building up a map of what the market requires and what competitors are achieving, as a means of setting clear targets towards which capability improvement must be directed.

For example, in the furniture case the retail store demands high quality, increasing variety, fast and reliable delivery and good prices. By contrast the mass market furniture sells mainly on price rather than design, and people will accept a trade-off on quality.



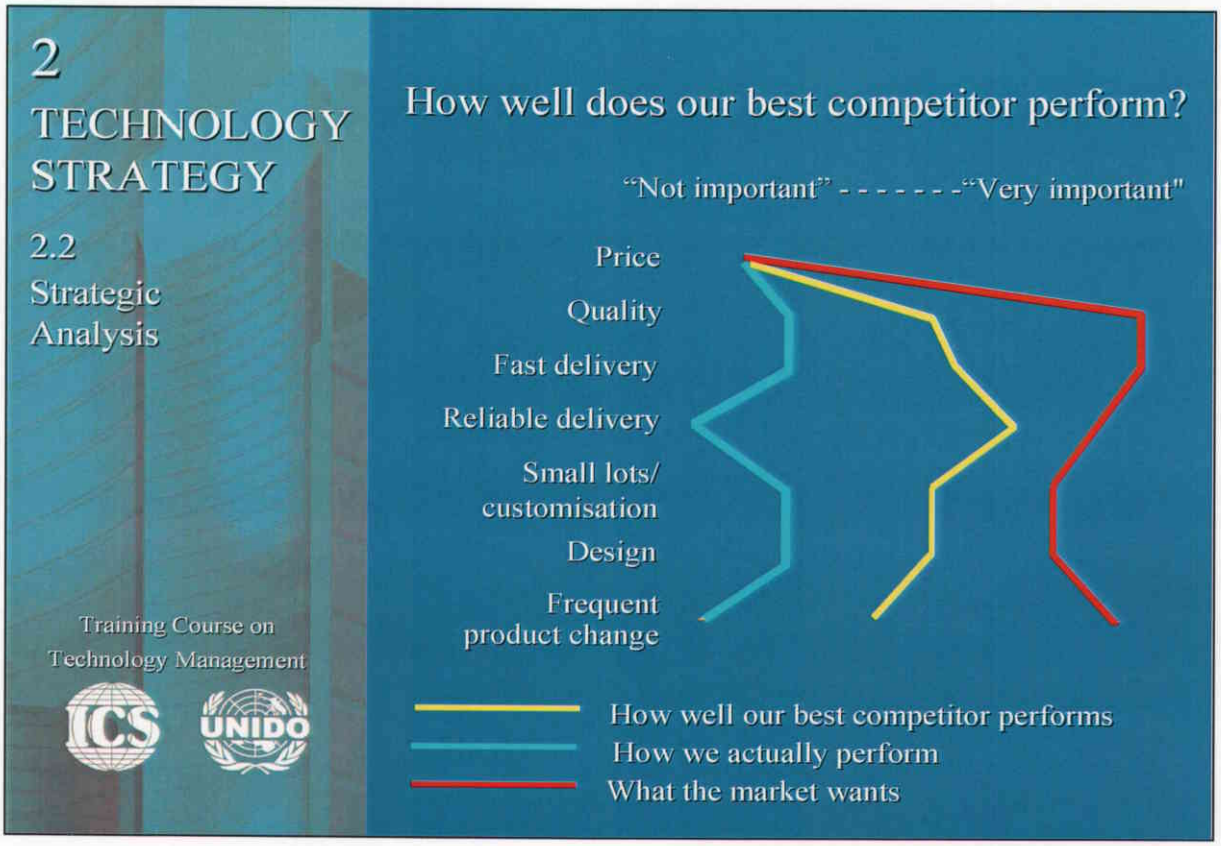
Step 3 involves answering (honestly) the question 'How well do we meet these demands?' – and in our example it is clear that there is a big gap which must be closed.

The problem becomes even more acute if we add a third question 'How well does our best competitor perform?' – and in our diagram it is clear they are better able to meet the needs of this particular customer than we are.

The challenge is simple – either we close the gap or we might as well exit from this market. So there is a clear target for strategic change. Of course the level of detail involved in constructing a simple sketch like this is low, but the process can be used to focus on a more detailed analysis using better information; for example, coming from a survey of customers or a benchmarking study of competitors. The purpose is the same – to help focus the analysis of the market on key strategic drivers and to identify where and what has to change.

Step 3 is concerned with reviewing the internal capability to meet these performance targets. This can be a review of strengths and weaknesses of individual elements or functions in the product or process, or a wider look at the appropriateness of the process itself, in the light of prevailing technological and market conditions (business process redesign). It is concerned with answering the question 'how far does our product or process help or hinder the achievement of the external performance targets?'

In the above case it may well be that the firm needs to look at new design technology to help close that gap. Or it could look at new production techniques to reduce its lot size and enable it to work with higher variety and smaller volumes, which would also speed up its deliveries. New equipment might be another option. But in each case these possible changes are now being considered in the context of a strategic framework, not as random inputs.



Step 4 involves exploring the range of innovations possible for effecting improvements in those areas identified in step 3. We might also want to stretch the model a little and ask questions like 'if we had a product that met or exceeded market needs, what would it look like?' or 'how much advantage would we get if we had a process which was faster/higher quality/ etc.?'

Step 5 reviews the potential choices and selects options based upon some set of priorities. These may be technological (for example, the urgency of need for replacement of worn-out equipment) or market related (for example, concentrating efforts on the most profitable or fastest growing products and markets at the expense of the more mature or declining combinations). The key here is to ensure that choices made are appropriate and do not represent the development of capability which does not match to market need. We will look at tools for helping strategic choice shortly.

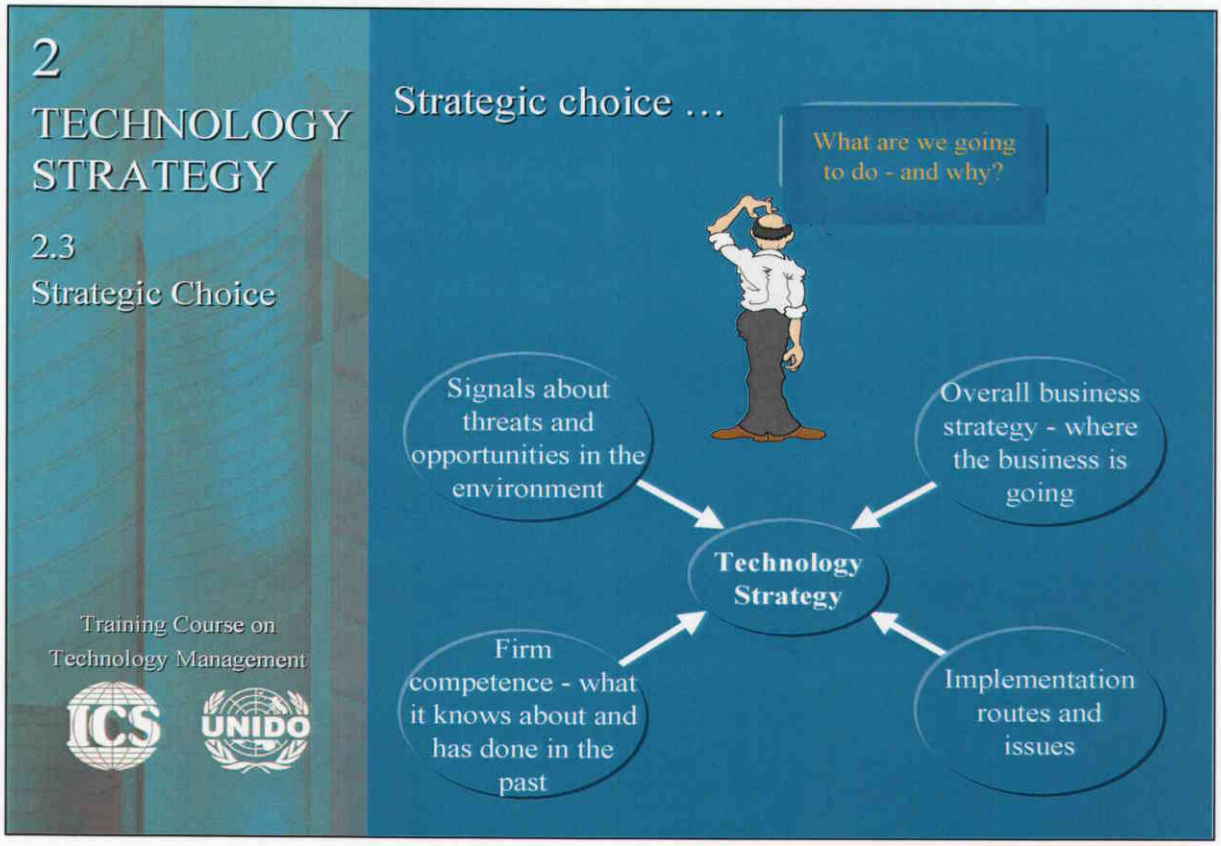
The value stream audit technique is designed to identify internal strengths and weaknesses – what is it about the firm which helps achieve the strategic goal of competitive advantage – and what gets in the way? It can be applied inside the firm or along its wider supply and distribution chain, but the principle is the same. The overall goal is giving the customer what they want - providing customer value, and the challenge is to find any and every place where value is not being added. It could be because of a poor machine or a duplicated process or lengthy queues or.....

The point is that such an analysis quickly focuses on where change is needed and throws up opportunities for change. It is based on the idea that the firm consists of a sequence of activities, each of which is designed to add some value to the product or service as it moves through. Eventually it finds its way to the customer. For example, at each stage shown, we hope that value is being added; but, of course, there are also costs of running the relevant activities, etc. And there is also an overhead which adds to the cost and supports the overall running of the business. But there is also, unfortunately, a component of waste associated with each activity and with the flow through the organization, which also adds cost and unnecessary time, space, etc. to the process. For example, if partly finished pieces have to wait in a queue before they can be processed this wastes time. If there is too much of a gap between machines or if the layout means parts have to travel a long way between activities, then there is wasted time and space. And so on.

Value stream analysis involves drawing up this kind of flow chart for your business and then asking, at each stage (including the stages between activities) whether cost/waste or value is being added. This often highlights unnecessary space, distance travelled, processing inefficiency, etc. It can be applied equally well to service activities - for example, the process of carrying out paper processing in sales or in developing insurance quotations or processing claims.

The technique does not need to stop at the boundaries of the firm; it can easily extend beyond the firm back into the supply chain and down into the distribution chain. Its potential there is to highlight where unnecessary losses arise in weaknesses in relationships between firms, and where strategic targets for improvements lie.

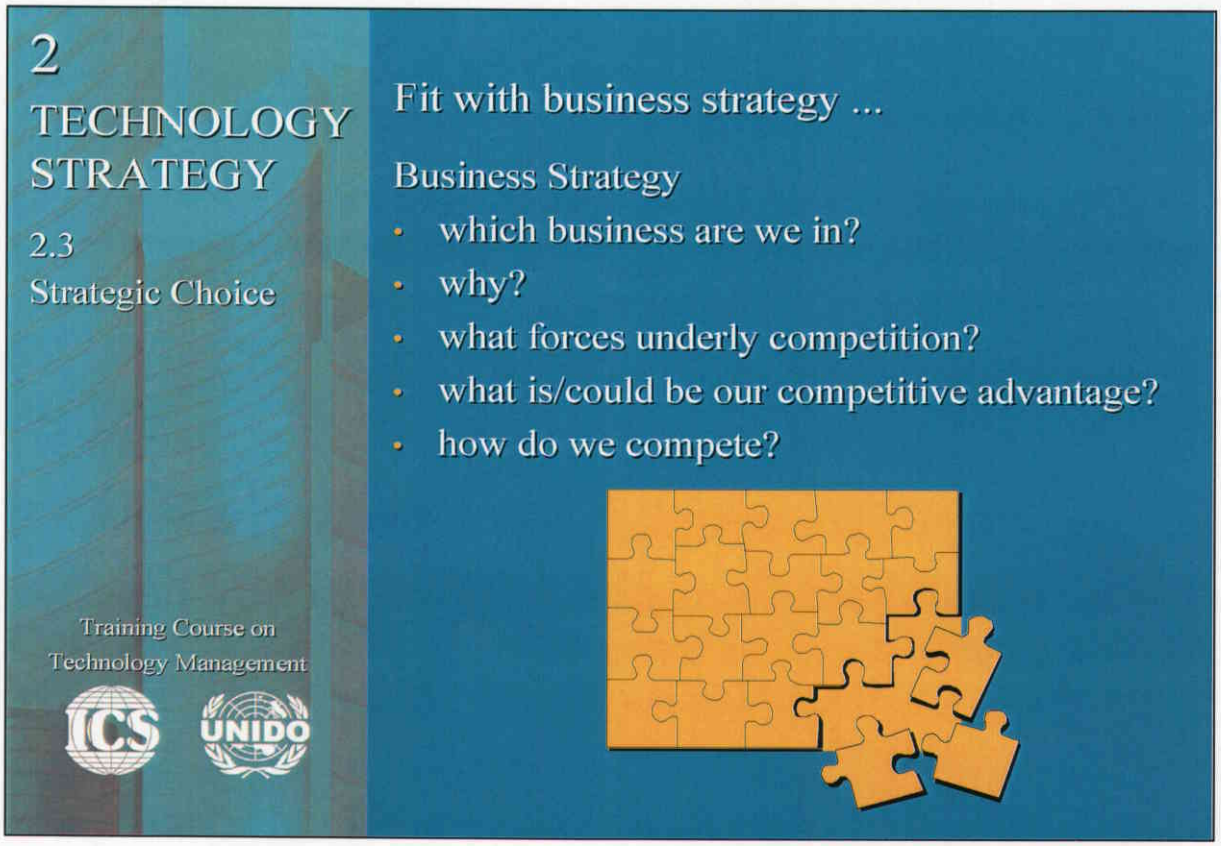
This approach is behind the current fashion for 'business process re-engineering' and it forms the underlying philosophy for 'lean thinking'. The concept of a lean enterprise or supply chain is just that - one which has minimal unnecessary 'fat' built in; and value stream analysis techniques are the key tool in developing such enterprises.



The results of these three mapping exercises should be a shared picture amongst the team of what direction changes are needed in as a result of SWOT – and the range of possible options for change. Now comes the tricky part - deciding which ones to go for. This is what we term 'strategic choice'.

This stage is concerned with identifying which opportunities will be chosen and why. We also need to consider in what order of priority. Three more pieces of information help us make this choice:

- fit with the overall business strategy – is this going to take us in the direction we want the business to go?
- fit with competence base – does this technological change build on or add to our existing competence?
- fit with implementation capability – are the challenges of actually doing it (inside and outside the firm) something we can manage?



One important factor in helping that decision is to make sure options being explored actually fit with what the firm is trying to do with its business. Research has repeatedly shown that firms that lack a strategy for innovation and simply 1 has, then we should be able to answer the following questions:

- Which business are we in, and why?
- Do we understand the various forces underlying competition in this business?
- Do we have a clear idea of where and how we can secure competitive advantage in this business?
- Do we share a clear view of how we are going to compete? As price leaders? As niche players offering some particular set of benefits? Or something else?

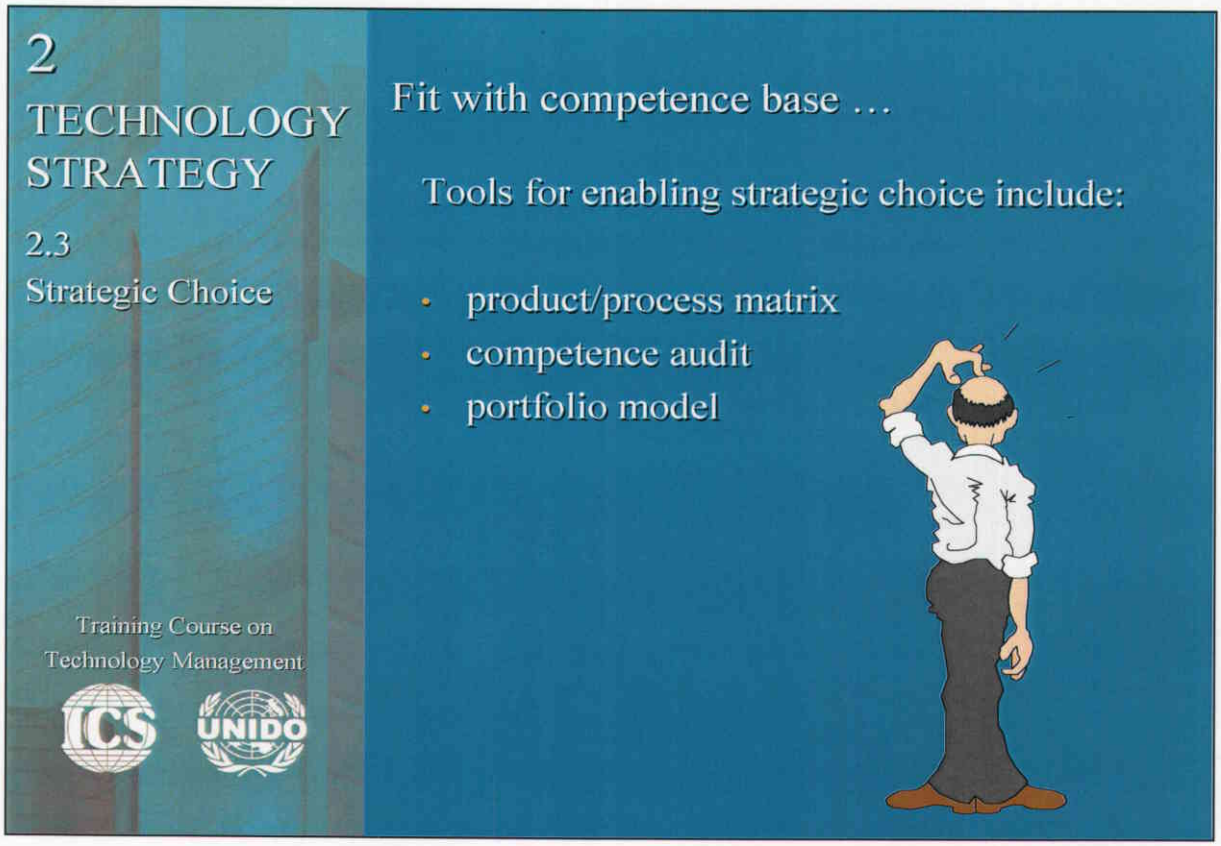
From the answers to these we should be able to answer the question as to whether the proposed innovation fits this broader framework. For example, if we have a business strategy which sees us as competing on price in supplying metal components to the car industry in Europe, then an innovation involving new manufacturing equipment to reduce the unit cost of manufacturing these would clearly fit well. Equally, investing in developing a new food product, even if there appeared to be an attractive new technology or market opportunity, would not fit with our plans.

Of course, we could decide to diversify out of car components and use the food product as a way of doing this, but we should only follow this road if we have thought it through carefully in terms of the risks and the opportunity costs.

One of the first questions which we can then answer is the approach we want to take to technological change. If we are big, have major R&D investments, a good legal department to protect our ideas and strong marketing to exploit new developments, then we could think about being an aggressive 'first-mover' in technology. But such leadership depends on having these building blocks in place. Equally we might prefer to be a 'fast follower', waiting until someone else makes the running with a new product or process and then counting on our ability to respond quickly and imitate them. To do this well we need very good antennae to pick up early warning about what they are going to do and good internal organization and resources so we can follow up quickly.

For a small firm there may be other options - specializing in a particular niche, for example. Or else they could link up with a major customer and follow a technological pathway which is largely dictated by the customer's technology strategy.

Whatever the choice we need to think about positioning and getting a good fit between what we try to do and the resource base we have to support it. Research shows that one of the most common causes of failure is when firms overreach themselves, trying to do things which they cannot support; for example, opening up a new market. Many different models for strategic positioning exist but the important message is to ensure that some thought is given to this!



The second question concerns the current technological base of the firm - its distinctive technological competence. By this we mean what it knows about terms of its product or service and how that is produced or delivered effectively. This knowledge may be embodied in particular products or equipment but is also present in the people and systems needed to make the processes work. The important thing here is to ensure that there is a good fit between what the firm currently knows about and the proposed changes it wants to make.

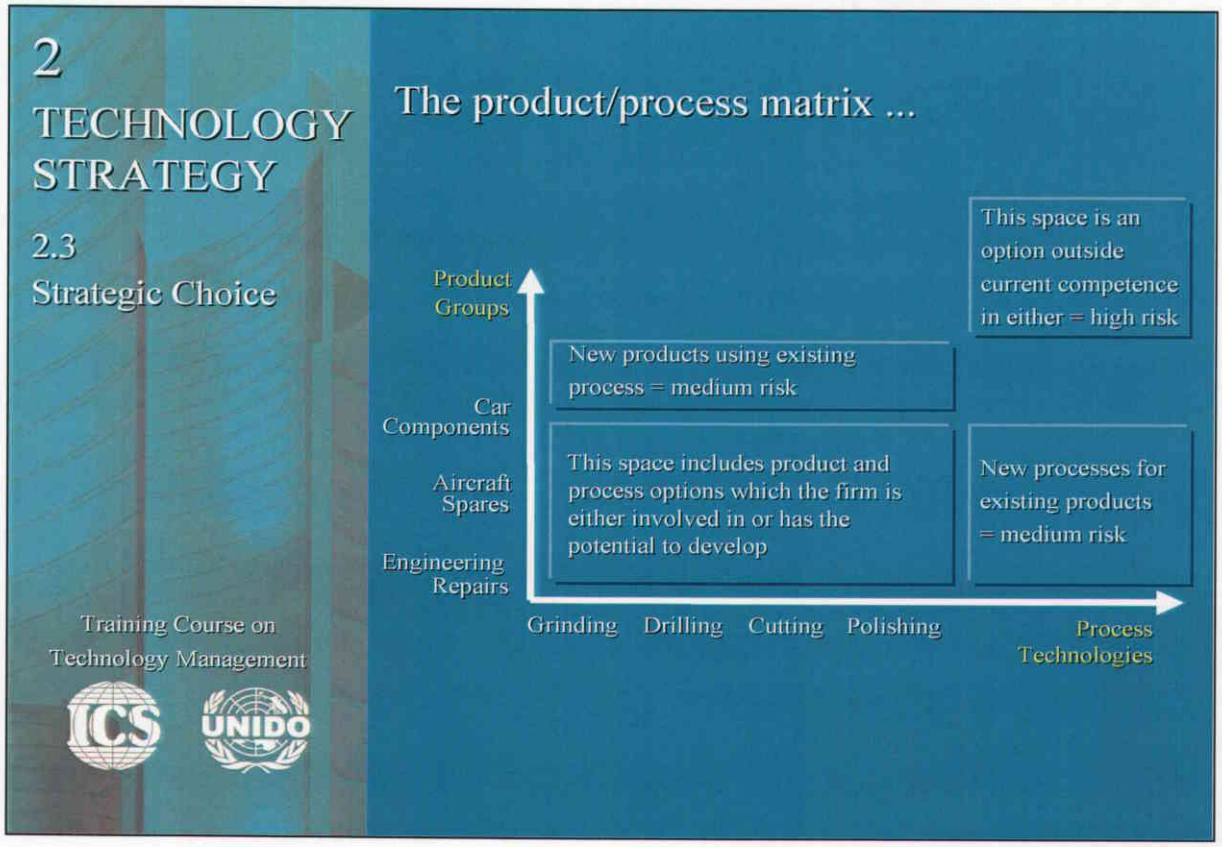
Competency need not be contained within the firm; it is also possible to build upon competencies held elsewhere. The requirement here is to develop the relationships needed to access the necessary complementary knowledge, equipment, resources, etc. Strategic advantage comes when a firm can mobilize a set of internal and external competencies which make it difficult for others to copy or enter the market (Teece, Pisano et al. 1992).

Experience tells us that innovations often succeed or fail because of the fit with competence base. As we saw earlier competence cannot be turned on and off like a switch but needs to be grown and developed over time; one result of this is that firms tend to follow particular pathways or trajectories based on their past history. A good rule of thumb is not to stray too far from this pathway.

Of course, there may be occasions when it is important to break with the pathway - when it becomes too crowded or when it reaches a dead end because of some new technology changing the rules of the game. But moving into new areas is higher in risk and the same principle of having to learn and absorb competence before it can be successfully deployed applies strongly.

How can we check that there is a good fit with what we plan to do and our current competence base? We need some form of map or audit framework and there are many approaches to this. Here are three which might help with the process:

1. The product/process matrix
2. The competence audit
3. The portfolio model



This is a simple tool for mapping whether or not proposed strategic choices lie in the firm's area of experience.

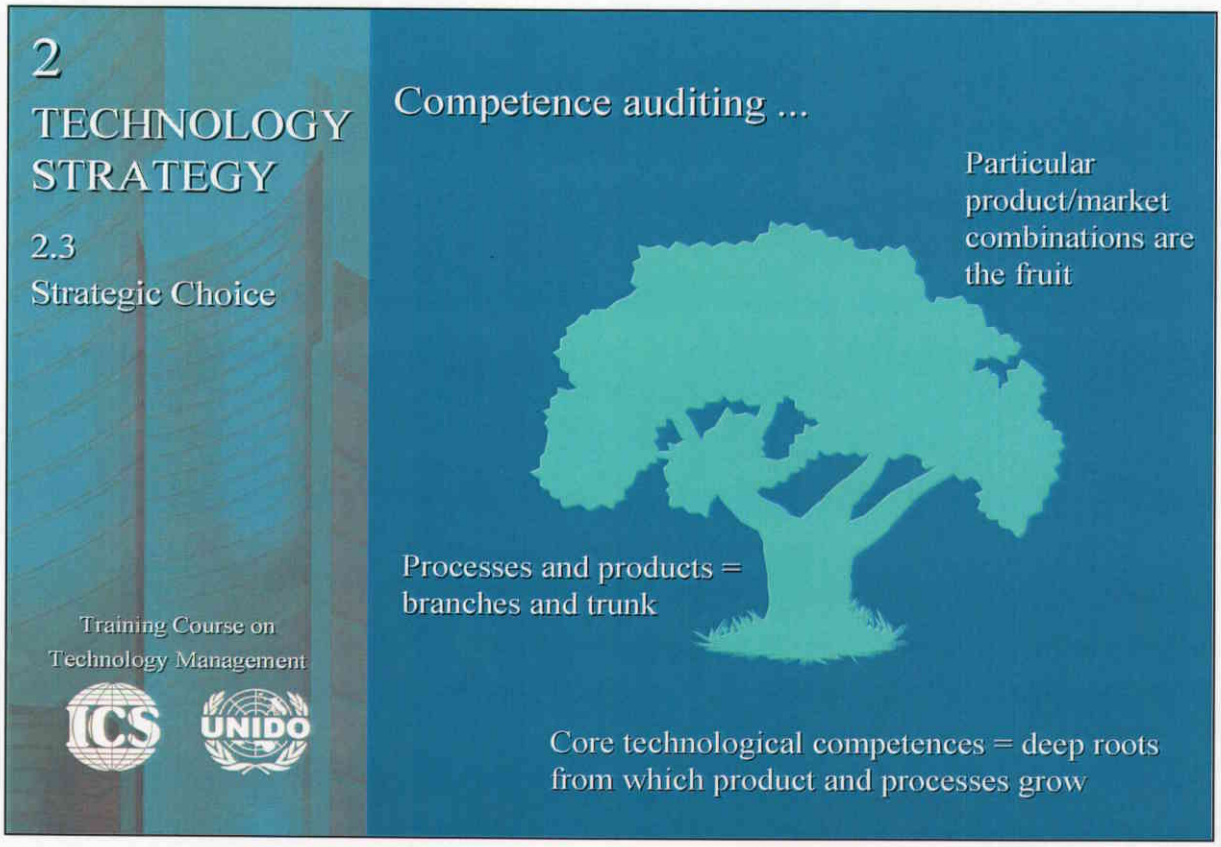
Step 1 involves plotting two axes, one for the product families which the firm currently make and one for the processes which it uses. This effectively defines the area within which the firm is operating in terms of its technological competence.

Step 2 involves asking whether the new proposal fits somewhere within this space or lies outside it; in other words, somewhere which will require the acquisition of new competence.

If it does, then it implies that the new development will require new combinations of existing knowledge and the challenge is one of internal learning. But if it lies outside current competence, then it will be necessary to think about how the gap will be closed, and whether it represents a high risk jump into completely new territory or an incremental advance in the firm's knowledge base.

Much innovation involves progress along one axis, keeping the other constant. For example, developing a new product family using processes with which the firm is familiar is relatively low in risk. Similarly employing a new process to make a well-understood product is relatively low risk. Where the change involves both product and process, the risks are high.

The basic principle can be applied in a number of ways. First the axes can be changed, for example, to explore the space around products and markets, or processes and materials. And the matrix can be extended to three, four or five dimensions, although by this time it becomes difficult to work with. But in each case the principle is the same, the axes represent 'knowledge space' within which the firm has experience and outside of which will involve higher risk learning of new competence. As with all tools of this kind its main purpose is to focus thinking and discussion to help firms 'look before they leap'.



The idea of technological competence is essentially about the deep knowledge base of the firm: what it knows about and is good at, on which it can build its growth. So we can take a metaphor of a tree, with this competence as the deep roots from which the tree can grow. Viewed in this way, we can see the trunk and branches as the processes and products which deliver growth from these roots, as the picture suggests.

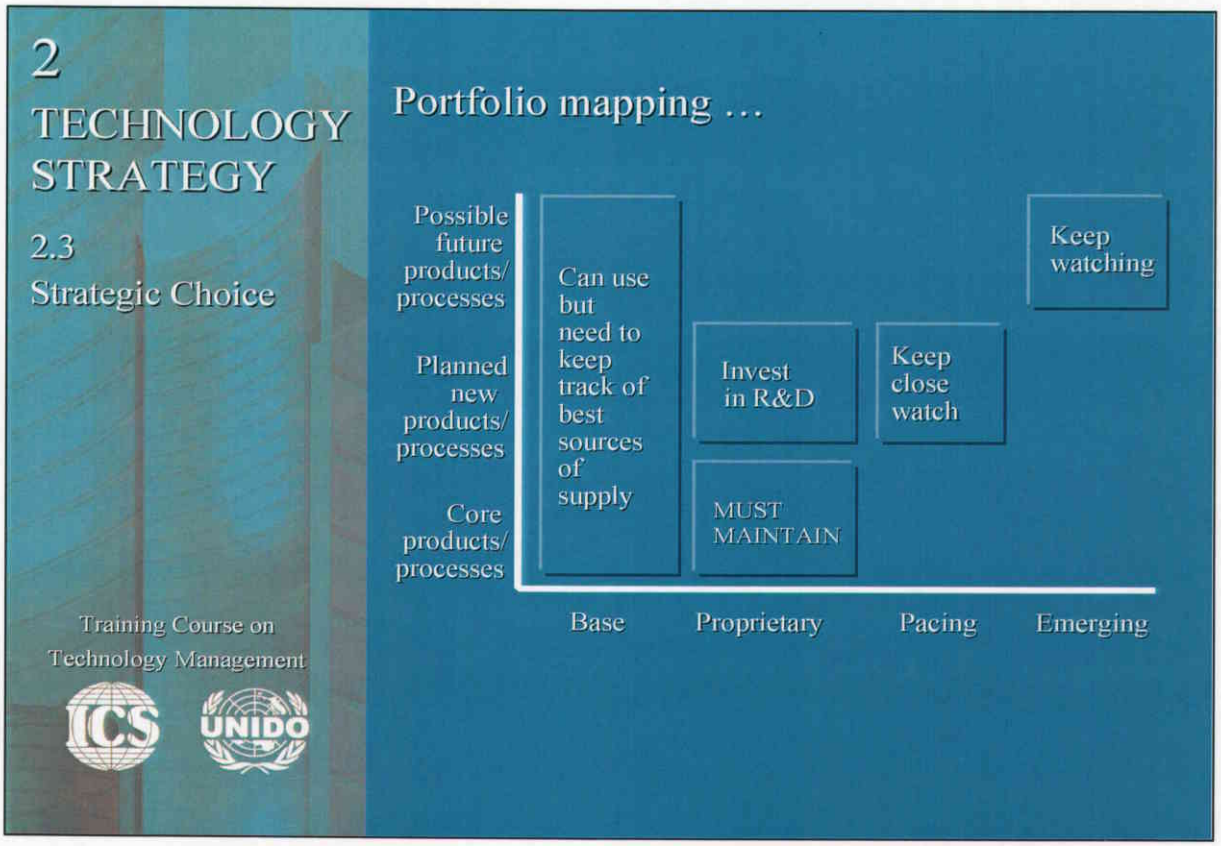
To use this as a mechanism for auditing competence and for positioning new technological choices, we can follow these steps. First, identify the roots: what is the core technological competence of the firm? What sorts of things does the firm know about/is able to do which others cannot, either because of patent or other protection or because it is difficult to do.

Then identify the ways in which this competence is currently deployed in particular, processes and product streams. (This is similar to the axes in the portfolio we have just been looking at).

Finally identify where there is currently something being offered in the marketplace. And look for spaces where new fruit could come out; that is, new combinations of existing product and process knowledge.

The tool can also help identify where there is fit with at least the knowledge base (even if the trunk and branches have yet to be built) and where there is no fit. In cases like this it may be necessary to grow a new tree and nurse it through to maturity; essentially a start-up approach to a new business development.

Once again the main purpose of this approach is to focus discussion amongst the management group responsible for thinking about technology strategy.



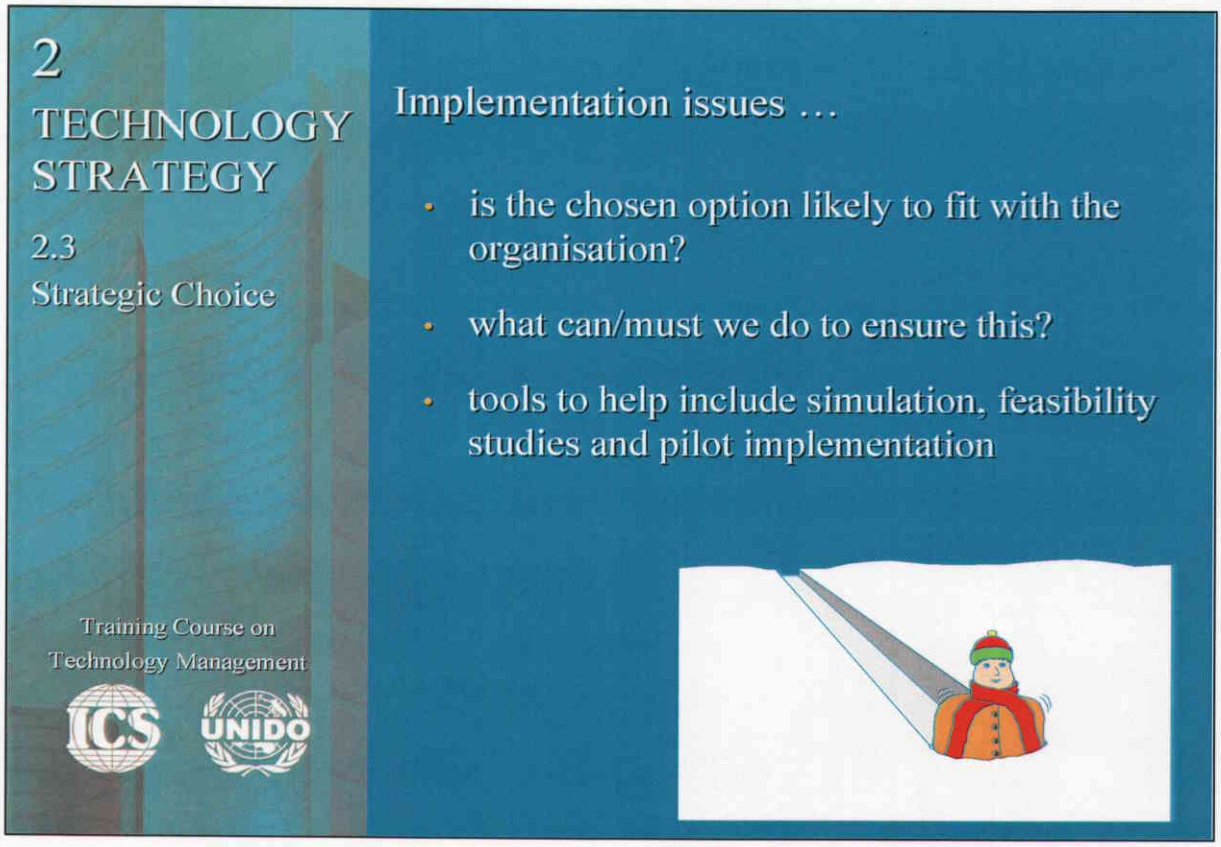
One useful tool for looking at potential new technologies is to map them on to a simple portfolio model. Typically we can classify new technologies into groups such as:

- **basic or generic technologies** - widely available, often not protected by patent and hard to defend as a source of strategic advantage

- **proprietary technologies** - those which the company owns and may have control over, via patents or other protection, or may have specialist knowledge or equipment which would make it hard for others to enter

- **pacing technologies** - the new set of technologies which are now making the running in defining the rules of the game in the marketplace, but may not yet be proprietary or generic. These might include things like the Internet and other communications tools today, and they need to be watched and looked at carefully since they could become sources of strategic advantage for someone.

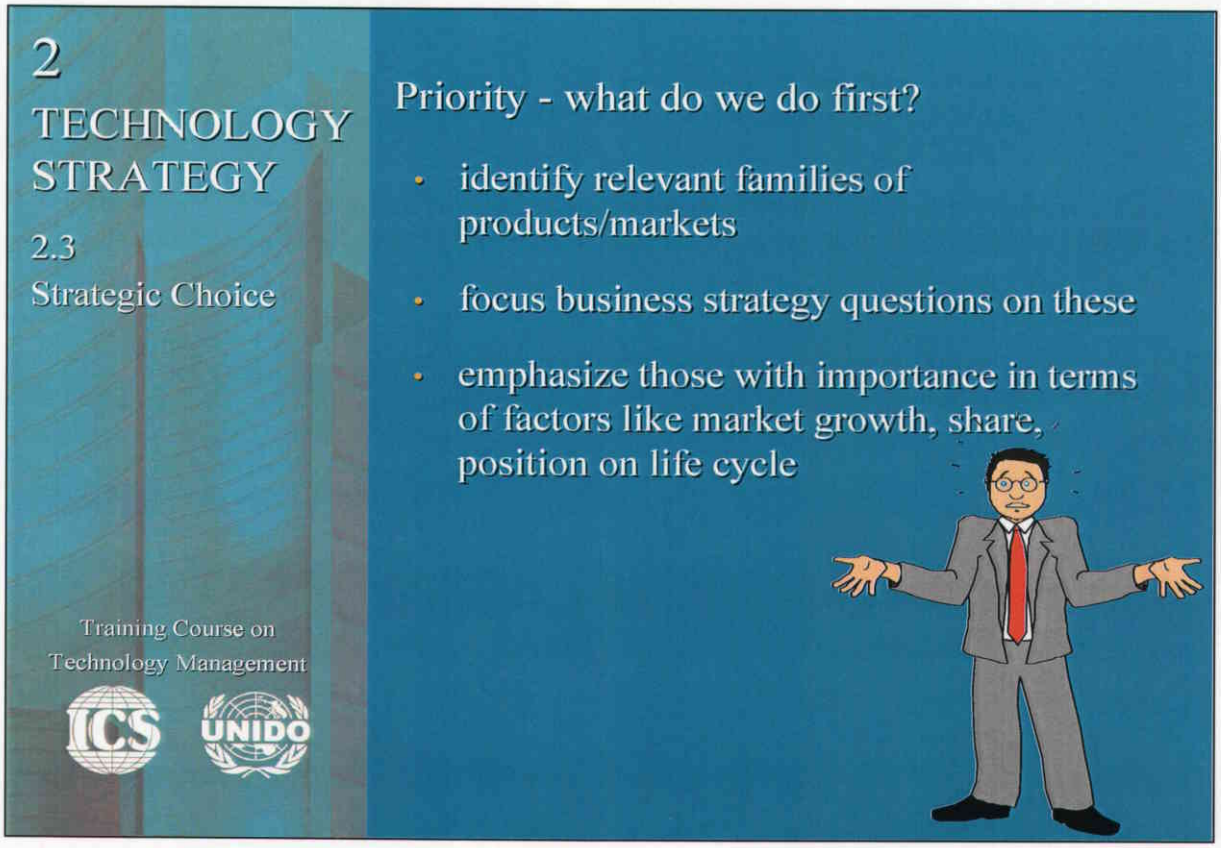
- **emerging technologies** - those which are still a long way from commercial exploitation but which may represent a major force if they come to fruition. For example, current work on 'nanotechnology', building machines and products on very small scale, might become a critical field in the next decade once the technological and market uncertainties become resolved. Technologies of this sort need watching and exploring as they become more significant. We can map these on to a simple portfolio and ask ourselves the extent to which they support or affect our current and likely future business. Other questions raised include positioning new technological possibilities in terms of how much they will cost to enter, how defensible will they be, how far from our core competence they are, etc.



The third piece of the puzzle which we need to consider in making our strategic choices concerns the feasibility of implementing the changes being considered. There is no point in choosing a particular option which is going to run into serious problems downstream - whether in the marketplace or inside the firm. For example, taking the decision to computerize the whole organization overnight may appear to make economic sense but is likely to cause considerable disruption and meet with resistance from the work force unless managed carefully. Similarly, failure to think through the likely adoption behaviour of particular markets may lead to a failure in launch of a new product - again, as many sad stories illustrate.

The point of considering these issues in the choice stage is not so much to reject the choice as to make sure that care is taken to plan for and cater for likely implementation problems within the chosen course of action. It is a bit like looking further on up the road to see obstacles before they come close and taking appropriate evasive action. For example, in the computerization example much of the potential resistance can be defused through a combination of communication and training. Equally, thinking through, and testing out ideas ahead of the market, can be an important aid to final launch.

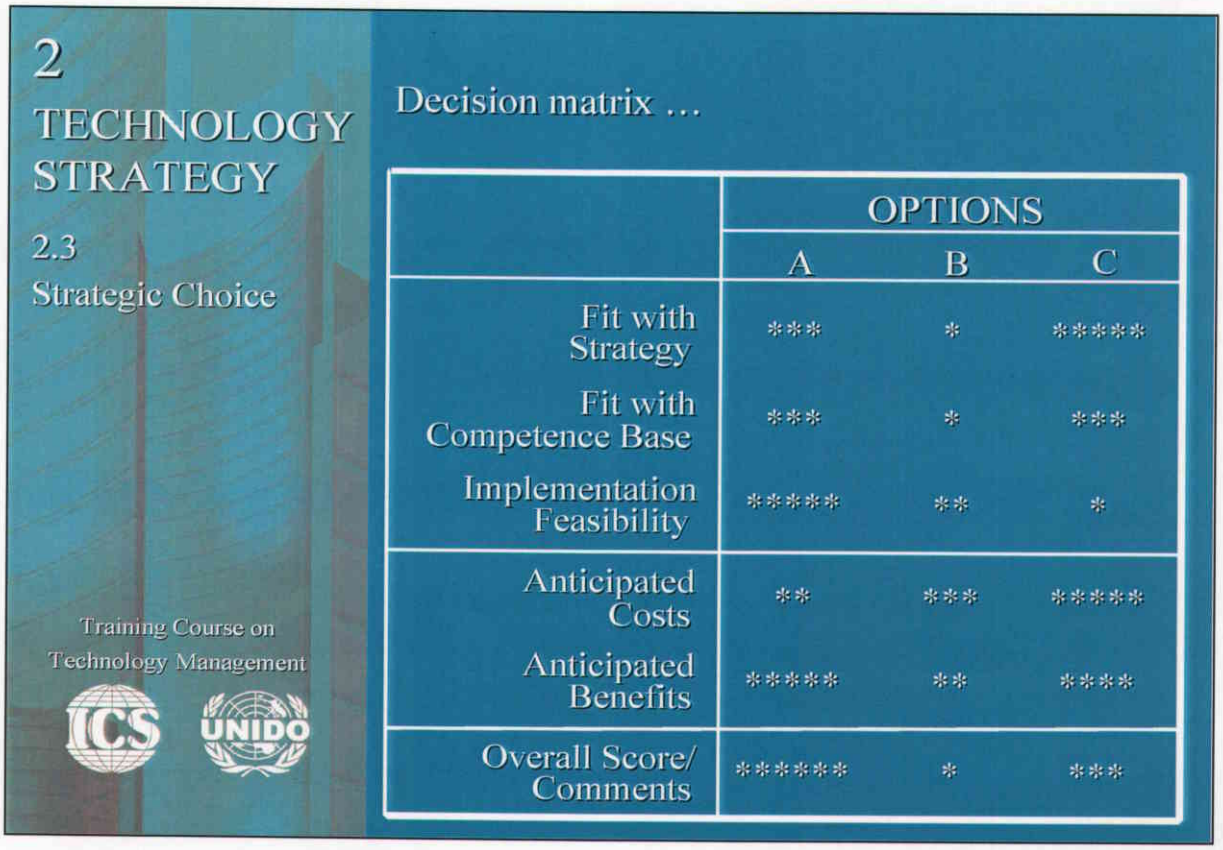
Tools here are again many and varied but examples include various kinds of simulation from simple imagined 'walkthroughs' to more structured scenario planning. A second important group of tools is associated with preplanning and feasibility study - gradually building up a picture of what is possible and what needs to happen to make it so. And a third group are concerned with pilot scale implementation, reducing the risk and providing the opportunity to learn and apply those lessons quickly.



To choose which options we need to have a sense of internal priorities and business focus. For example:

- identify relevant families of products/markets and focus business strategy questions on these (or potential ones if this is a new field)
- which are the most important families: growth / share / product life cycle questions

Screening techniques are another important internal selection mechanism. In many firms the choice is not necessarily of going for only one product concept but of selecting out likely runners for further exploration and development. Techniques for screening range from simple judgmental methods to complex mathematics. However it is important to recognize that even advanced and powerful screening tools will only work if the corporate will is present to implement the recommended decisions; in a recent study Cooper and Kleinschmidt found that the majority of firms studied (885) performed poorly at this stage, and often failed to kill off weak concepts.



A simple tool which can be used to help in this process of choice is a decision matrix. This provides a focus for looking at various options against a number of agreed criteria; once again, its main purpose is to help structure the discussion about strategy.

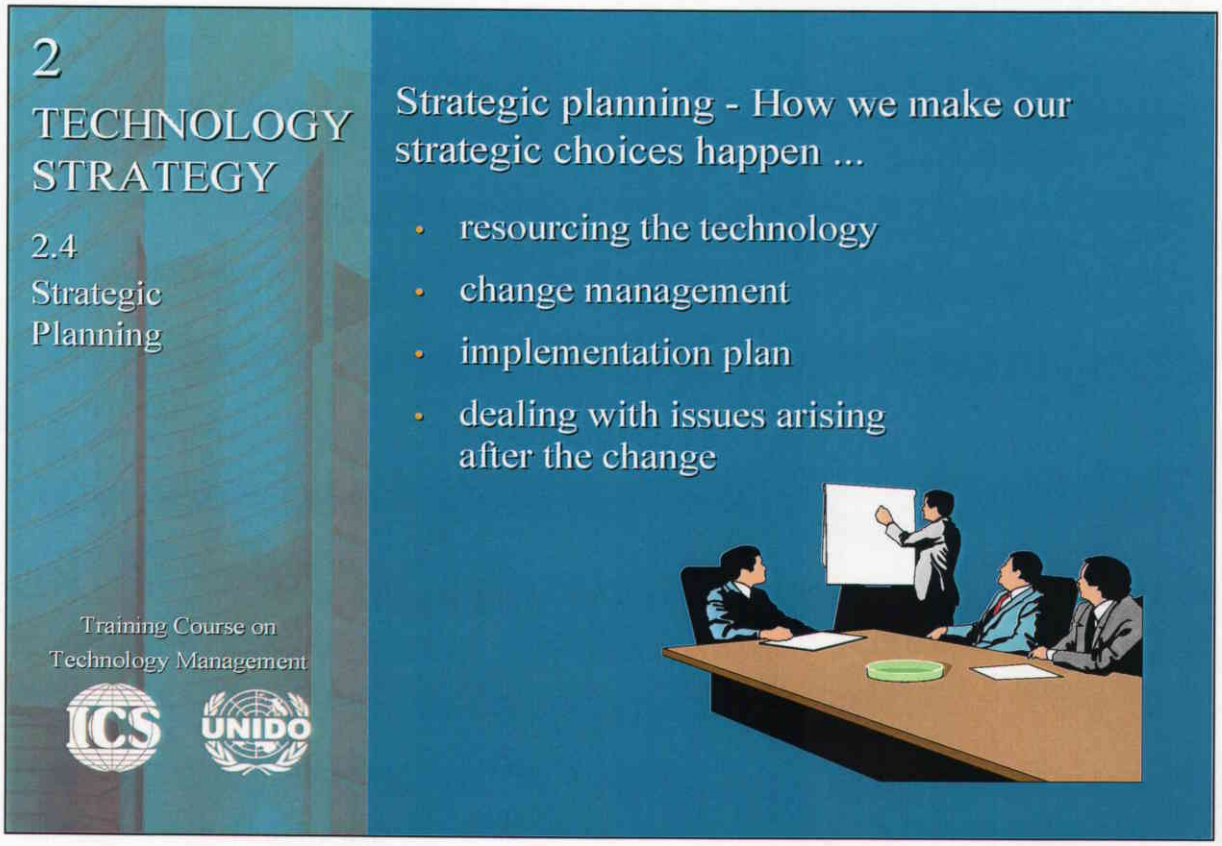
Step 1 is to list the options which are competing for strategic support.

Step 2 is to list the key checks we have already discussed. Does it fit our competence base? Does it fit our business strategy? And how feasible is its implementation? We can fill these cells in with simple scores or with detailed comments. If an option does not fit, it is dropped at this point.

Step 3 is to add some indication of the expected costs and benefits associated with the different projects. Again, options where the expected costs or benefits are not attractive are now dropped.

Step 4 is to add a total score column which tries to arrive at some priority based on the individual cells.

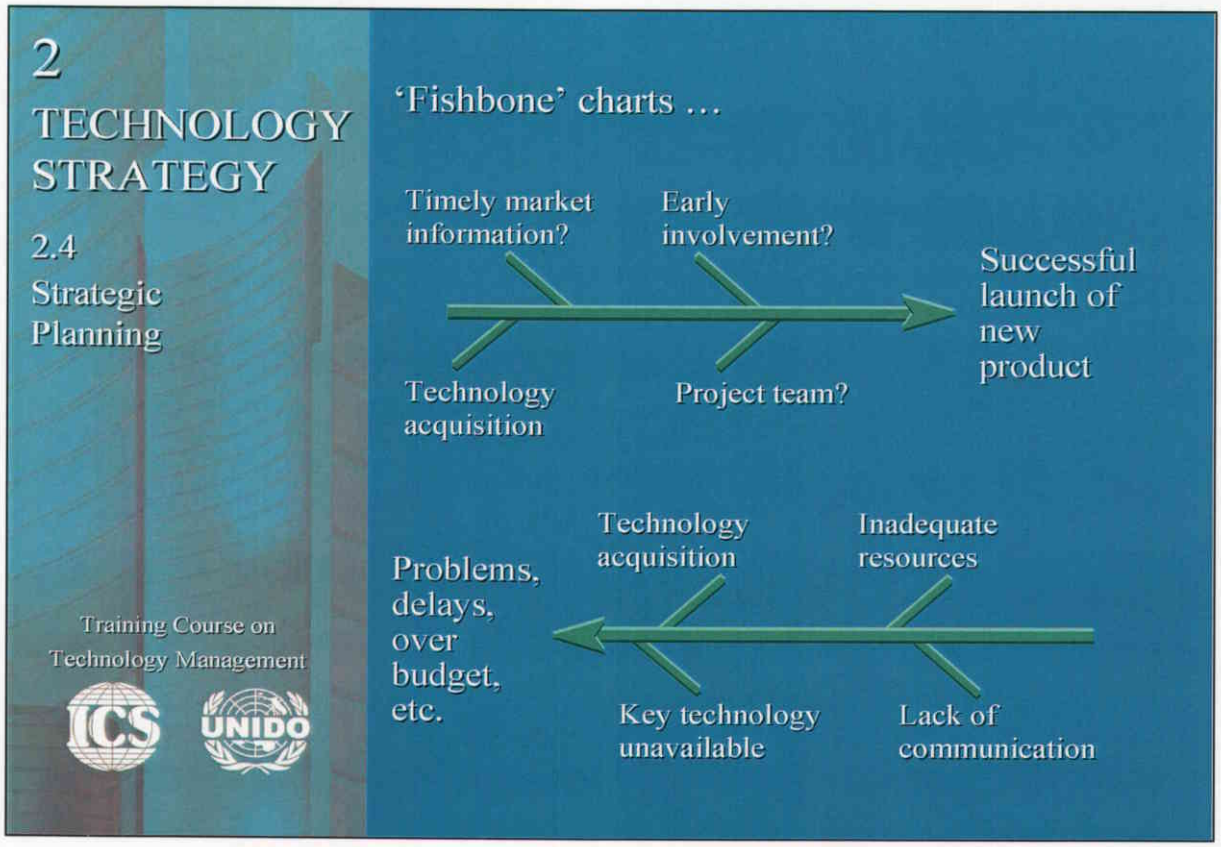
We can carry on adding cells, depending on the range of criteria we want to satisfy. Most decision matrices use a simple 'rough cut' version to knock out the low potential options and then gradually repeat the exercise adding more columns.



The next stage is one of exploring how we are going to make our strategic choices actually happen. This involves consideration of :

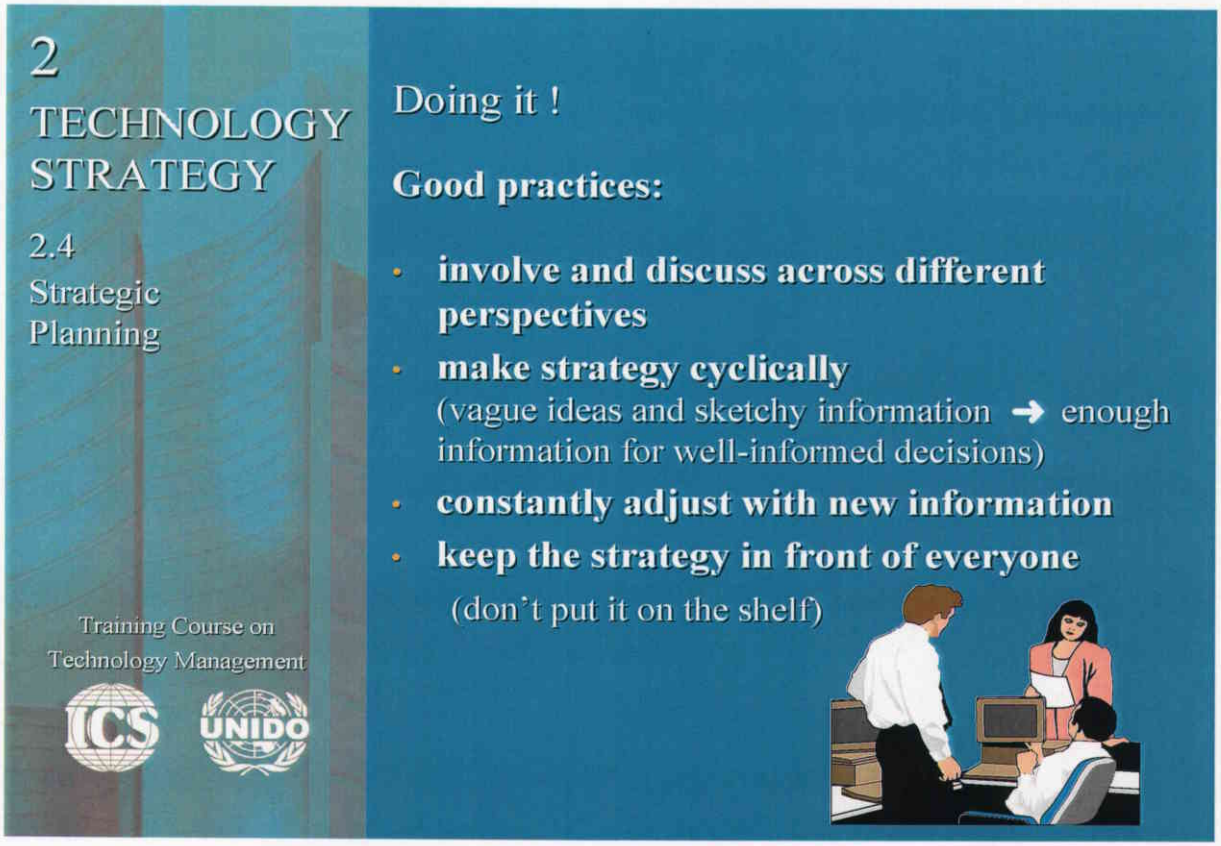
- resourcing the technology - what is the most appropriate route given our experience and current position (this theme is picked up in detail in the next module)
- the extent of change which is to be managed - is it a reconfiguration within the bounds of what we already do or a totally new and high risk venture?
- at the limit, is it a new business venture (this is the subject of another module) or a development from existing business?
- how are we going to implement and what sorts of issues might pose problems downstream-change management, market development, project management, etc.?

The range of tools here which can aid the process include simulation (both computer based and simple mental 'rehearsals' and walkthroughs), feasibility study and benchmarking of others who have already undergone such change.



One simple approach is to use 'fishbone' charts. These look at all the contributing things which need to be done in order to enable successful outcome, and help focus in graphical form on a checklist of implementation factors. Alternatively, they can be used to identify where and how problems might emerge; for example, through a brainstorming process where people try to think of the worst case which could happen to this particular project.

In each case we are using the simple framework of the 'fishbone' chart to focus attention and planning on key issues ahead of the decision to proceed.



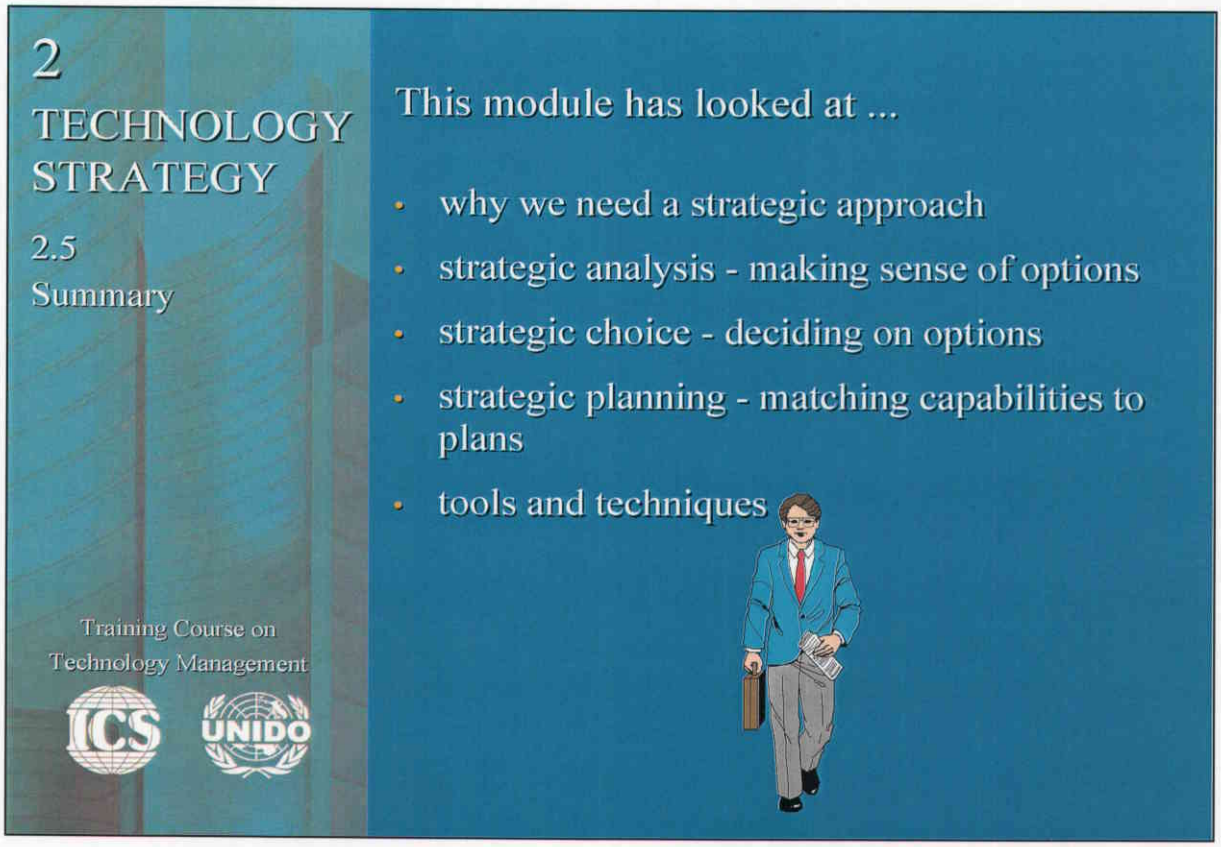
In developing technology strategy it is important to recognize the value in integrating different perspectives in the decision process. Many of the problems in technological innovation arise from the multifunctional nature of development and the lack of a shared perspective on the product/process being developed and/or the marketplace into which it will be introduced. A common problem is that 'x wasn't consulted, otherwise they would have told you that you can't do that'. This places a premium on involving all groups at the earliest possible stage - that of concept definition/ product specification. Several structured approaches now exist for managing this, including quality function deployment and functional mapping.

Examples include reviewing the possibilities for modular design, for using parts common to other products in a range, for value engineering of key components and for using different assembly techniques offer powerful ways of cutting costs and avoiding delays and problems in development. The availability of simulation technology, especially computer-aided design, has helped facilitate this kind of early discussion and refinement of the concept.

Extending this idea of early involvement in concept development, an increasingly important routine is to bring suppliers of components and subsystems into the discussion. Their specialist expertise can often provide unexpected ways of saving costs and time in the subsequent development and production process. Another important variation on the theme of involving customers in concept development is the idea of working with lead users. In industries like semiconductors and instrumentation research suggests that the richest understanding of needed new products is held by only a few organizations, who are ahead of the majority of firms in the sector. Equally finding the most demanding customer in a particular sector is a valuable approach; stretching the concept to meet their needs will ensure that most other potential users come within the envelope.

In introducing new processes the same considerations apply: how can we build in the concerns and knowledge of those who will be affected by the change? Many methodologies for user involvement now exist and have a demonstrable effect on success.

It is important to recognize in all of this that strategy is not a particularly rational process. People do make decisions on the basis of intuition and instinct and there is a high degree of uncertainty.



This module has looked at the development of a technology strategy - the process of choosing what to do in response to the wide range of possible threats and opportunities in the environment. In particular we have looked at:

- why we need a strategic approach
- strategic analysis - making sense of the options
- strategic choice - deciding which options we will go for and why
- strategic planning - making sure what we are going to do matches what we are capable of
- tools and techniques for helping with the above

The next step in the process is to implement the technological changes we have selected, and that raises the question of where and how we get hold of the technology we need. This forms the content of the next module.

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Index