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Strategic Management of Technology

From Creative Destruction to Superior Resilience

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Technology Management in its Fundamental Form

(Courtesy of Kansan Arkisto, Helsinki, Finland)

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Foreword

Very few people actually contributed to this thesis directly, but on the other hand, very many have influenced it. That is because – as I strongly believe – one's way of thinking and perceiving the world develops and takes form in adolescence and early adulthood, mainly through interacting with others. There are thus many people who have *influenced* the work directly; even though remotely and in the past. The most important was naturally my own childhood family, but I want to acknowledge also some of the many others, in a rough order of appearance.

Mr. *Unto Paltemaa* springs to my mind first. With him I spent a lot of time in all imaginable activities as a teenager (excluding sports, which I did. "Sporty" was not quite the word to characterize Unski at that era). We developed similar values, ways of seeing the world, and a sense of humour. Despite the passed years, I can still recognize his handwriting in advertisements.

In the university I had many an inspiring and rewarding moment with my classmates Dr. *Kari Laitinen*, now deceased Dr. *Tapio Pietikäinen*, Mr. *Arto Kiema*, and Mr. *Timo Huttunen*, frequently accompanied by Mr. *Tero Intonen* from a neighbouring department. Dr. *Veikko Seppänen* was the first one of our class to complete his doctorate; and what a standard his work set for the rest of us!

Mr. *Kari Ahola* and Mr. *Eero Halonen*, my boss and his colleague respectively, during my traineeship in Mobira (later to form into Nokia Mobile Phones) exemplified a healthy working attitude, including the importance of honesty in all the endeavours taken.

I became a life-time close friend of Lic. Tech. *Pekka Kemppainen* at the renowned student's association, Sähköinsinöörikilta. Pekka has always insisted never to content oneself with sloppy thinking, but to take the needed extra step for sound and solid reasoning. I remember Dr. *Hannu Hakalahti*, also a good friend and colleague, for his no-nonsense approach to scientific research.

Mr. *Kari Nieminen*, a guitar luthier *par excellence*, has demonstrated ironclad belief in his ideals and incredible persistence in striving for them. As a result, his instruments are today being praised by some of the world's most well-known musicians.

Dr. *Louis Pau* exposed me to research and scientific work at an international level while I was working as visiting research scientist at Battelle Memorial Institute in Geneva, Switzerland. A good friend since then, we have had many a memorable occasion, even though we have never worked together. More recently, in KONE, I have had countless inspiring debates on any walk of life with brilliant thinkers, of whom Mr. *Risto Jokinen* is a splendid example.

This thesis is an offshoot of a project that did not aim at academic research. However, the results proved so promising that it was only natural to develop them a bit further. Mr. *Tapani Talonen*, working in the project with me and currently preparing his own dissertation, deserves special thanks for a very pleasant co-operation and intensive sparring.

My supervisor, Professor *Josu Takala* gave encouragement, support, and valuable advice. He did not interfere in too much, emphasizing that the text must resemble its author.

I am indebted to the preliminary reviewers, Professors *Harri Haapasalo* and *L-F Pau* for their constructive criticism. My compliments to Mr. *Peter Salter* from Optimus Translations for professional proofreading.

Tech. Lic. *Heikki Leppänen* and Mr. *Jussi Oijala* from KONE deserve recognition for supporting me throughout the exercise.

I would like to direct my special thanks to the members of my entire extended family for their support and encouragement: my parents and their siblings' families, my sister and two brothers with their family members, the families of my wife's siblings and the family of her son. I have always had close, warm and trouble-free relationships with every single person of them.

My wife *Carolina* (Nida), who did not disturb me with too detailed specifics of my work, deserves very special thanks. Every once in a while she dragged me out of this little box to experience and enjoy the world outside.

Writing as such was not difficult for me - I have always found it natural – but on occasions my thinking was notably faster than what I managed to type (yes, I *do* touch-type!). Formulating concepts into written language proved, instead, sometimes problematic. I might have had a crystal clear mental picture, but if tried to write it out prematurely, the image got smashed. All that was left were the broken pieces, and nothing clever on paper.

There should be means to convert mental pictures directly into a written form. Somebody out there, please develop a technology for that!

Hernesaari, Helsinki, April 2006.

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Abstract

Hakkarainen, Kari (2006). Strategic Management of Technology: From Creative Destruction to Superior Resilience. *Acta Wasaensia* No. 162, 181 p.

Only one-third of today's major corporations will survive in an economically important way over the next quarter of a century. Why is that? It is a question of creative destruction, a phenomenon similar to Darwin's survival of the fittest. In order to survive in this turbulent competitive environment one needs tools and practices, which collectively we call the "management of technology". Technology does not mean a product or other physical object. It refers to a company's capability of assuring competitiveness. It addresses not only product or manufacturing techniques, but also management of all the relevant knowledge and skills of an enterprise: marketing, manufacturing, support processes, etc.

This study is based on a technology management model created for a major global corporation. It applies a constructive research approach where one creates an innovative and theoretically sound solution for a practical problem, verifies the solution, and makes an effort to generalize it. This thesis presents the study, discusses the findings and empiria, and draws conclusions within the constructive research framework. The thesis places great emphasis on the working definitions of the terminology for three reasons. Firstly, to ensure that the author and reader understand them in the same way. Secondly, it spans the sphere of this thesis. And thirdly, the purpose is to drill down to the core of the authentic definitions and dust off the unnecessary hype associated with them.

The main contribution to the corporation mentioned above was removing the shortcomings in the already existing processes, and creating a holistic framework. The resulting model suits the corporation's way of working and culture. The contribution to academia is in that the model is a holistic one, incorporating both a complete framework and all the related tools. These contributions can be utilized directly in other industries and even in non-profit organizations, because the model is simple but still theoretically sound.

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Key words: technology, strategic management, creative destruction, innovation, business and technology roadmaps.

Prologue

Since Columbus, the opportunities for crossing the Atlantic have continuously increased. Initially the main need was to carry cargo and emigrants. Later business growth called for faster and more efficient transport and travel connections between Europe and America.

Foster & Kaplan (2001) describe how companies competed in the golden age of sailing ships by building faster and bigger ships. By 1870, steam-powered ships had been around for nearly seventy years. They could not, however, challenge the sailing ships until around 1890, when steam engines had improved enough to be competitive.

Sailing ship companies tried to respond to competition by adding more sails and increasing the waterline, which gave the craft more speed. They also carried more cargo to improve operating costs. The seven-masted Thomas W. Lawson was the largest schooner ever built (in 1902), but was very difficult to handle and therefore required a large crew. In the end, steamers prevailed.

If we think back to that era, and continue the story where Foster & Kaplan stopped, we encounter even more drastic developments.

There was constantly increasing demand for travel between the continents. People started to have more and more time and money for leisure, while business travel – and also cargo transportation – was growing.

Steamship companies reacted to this demand, and concentrated on competing against each other in the speed and size of their ships by building ever bigger, faster and more luxurious vessels.

Competition between steamship companies was hard, and often fatal. But their mutual threat came from a totally different direction. In fact, it was the development of new technologies. Airline companies entered the arena with a completely new technology and innovative way of thinking, and the whole air transport business indisputably replaced sea transport in passenger business.

By 1957 the airlines already carried the same passenger volumes as ships, one million a year, and within ten years that figure grew four-fold. Air carriers took the Atlantic crossing business by storm, and have dominated it ever since.

Lesson #1

"Technological advance is a disequilibrium process of creative destruction."

(Schumpeter 1939)

There was another attempt to challenge transatlantic steamers before the arrival of airplanes. With a speed of 135 kilometres an hour, the airship Zeppelin took only two days from New York to London, significantly decreasing the travelling time. In fact, there was viable airship traffic between the continents running in parallel with passenger-ship traffic.

But Zeppelins never achieved a large enough capacity to pose a serious threat to steamship traffic, and as airplane technology developed it even enabled non-stop flights across the Atlantic. Although Zeppelins had some shocking and fatal accidents, these were not the reason for their decline. In reality airplanes also had accidents – in fact even more than the Zeppelins did!

Lesson #2

"Most technologies will be replaced, and most efforts to replace them will fail."

(Matthews 1990)

In order to keep technologies competitive in fierce and tough competition, we need professional processes and tools.

We call these processes and tools collectively the 'management of technology'.

Working Definitions

Definitions of the salient terms constitute a thread running through the presentation. Some terms will be defined in the text as they appear. Naturally several, slightly different definitions exist. The author has deliberately selected from different authoritative sources the ones that suitably support the approach and purpose.

Working definitions appear here before the actual text, because the author considers them fundamentally important for several reasons.

Firstly, to define the terminology so that we use the same language and understand it in the same way. Secondly, to span the sphere of this presentation. And last, but not least, the purpose is to drill down to the very essence of the terms, to their "purest" meaning, to make them concrete, and dust off the unnecessary hype often related to them.

After all, the concepts of technology management are simple and easy to understand.

Technology

'Technology' is a widely misunderstood and misinterpreted term. People often think of technology as a complicated end product of a technically demanding development or manufacturing process. The author has noticed that this is especially the case with non-native English speakers. This is probably due to the wide use of the term 'high technology' - or 'high-tech' - in past years, and the hype connected to it.

When native English speakers are asked for a definition, they usually start with "the skill of …" or "the art of …". They are on the right track: technology *is not* a product, component, part or some other physical entity.

The etymology derives from Greek: "*technologia:* systematic treatment of an art, from *technE* art, skill + *-o-* + *-logia* –logy" (Webster 2005). Literally technology thus means "*the art of technique*" (Niiniluoto 1991). Peeling off the definition, technique in turn is "*a method of accomplishing a desired aim*" (Webster 2005). Sometimes technique and method are used as synonyms.

The meaning of technique appears evident when thinking about its use in everyday life: painting technique, swimming technique, technique of interviewing, studying technique, guitar playing technique, technique of vocal training, and the technique of communication. Technique is thus related to *any* effort, mental or physical.

The definition of the English word 'art' in this context might require an explanatory glance for non-native English readers. According to Webster (2005), art is, among other meanings, "*skill acquired by experience, study, or observation*". The origin of '*art*' is 'tekhne' in Greek. Its translation into Latin is '*ars*', in German it is '*Kunst*', in Swedish '*konst*' (Niiniluoto 1991), in French '*art*' and in Finnish '*taito*'.

'Technology' is thus the understanding, art and readiness to apply proper techniques; in other words, to select among methods and exploit them to accomplish a desired aim. Scholars re-invented a very similar concept a few decades ago and coined it know-how!

Let’s take a concrete example: someone wants to make a cake. There are several steps involved, and for each step there are several techniques or methods to choose from. The art of picking a workable one is technology. Now, if our baker wants to set up business, this technology becomes the technology of a small enterprise. One can claim that companies use technology to turn raw material into products and services; technology is the means to create added value.

This is in line with Christensen’s & Bower’s (1996: 429) definition “*Technology means the processes by which an organization transforms labor, capital, materials, and information into products and services*”. Also Burgelman et al. (1996) emphasize the central role of technology in the creation of new products and services, and its related processes: ”*Technology refers to the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems*”.

Management of Technology

One of Webster’s (2005) definitions for management is “*the act or art of managing: the conducting or supervising of something*”. Referring to this, management of technology (MoT), or technology management, can be thought as *creating, supervising, maintaining and developing the skill of using techniques*.

In business MoT cannot of course be an end in itself. Its role and existence must be motivated by the objectives of an organization, as the practitioners emphasize. A classic definition from the National Research Council (1987) is:

"An interdisciplinary field concerned with the planning, development and implementation of technological capabilities to shape and accomplish the operational and strategic objectives of an organization."

Some pundits consider technology management separate from technology acquisition and exploitation, but here we refer to all three.

In this context we could also refer to a definition sometimes used in KONE Corporation (Kemppainen 2000): *"Technology management refers to systematic processes for creating and executing plans needed to form a technology strategy that optimally supports the selected business strategy"*.

Matthews (1992) summarizes: *"The 'management of technology' is, like all other management, ultimately the management of people and the processes of communication and decision-making that determine success or failure. The focus of management attention is on the dynamics of information selection and assessment rather than on the details of the technologies themselves"*.

Strategic Management of Technology

The idea and concept of strategy has been prominently on the agenda of business management since the 60's. Over the years the role of strategic thinking has been established. Writers, teachers and practitioners have created a wide, but at the same time a very diversified, set of doctrines, as pointed out by Näsi & Aunola (2002). Kaplan & Norton (2004: 5) subscribe: "*In our practice, however, we observed that no two organizations thought about strategy in the same way*".

Näsi & Aunola (2002) identify several different, good ways to approach strategy conceptually. They conclude - or concede - that "*strategy can be any of these and it can be all of them*".

Lacking a single, extensive and commonly agreed definition, let us examine what the classic strategist von Clausewitz says about strategy (von Ghyczy 2001: 123): "*Strategy determines the place where, the time when, and the fighting forces with which the battle is to be fought".*

Clearly, according to von Clausewitz's definition, strategy is about organizing oneself into a winning position. In business, resources can be considered as being the fighting forces. This brings us close to Matthew's (1992) approach to strategic management of technology in the form of a question: "*How do we manage technology as a strategic resource?*".

Management of technology is not about approaching technologies *per se*. There must be an aim. It is about general management in order to guarantee benefiting from technology as a strategic resource. MoT cannot thus be isolated. It must address all the related aspects of successful strategy creation and execution: assets, financing, regulations, different processes, etc. That does not imply that MoT is responsible for all of them. It is rather responsible for signalling the need for the measures necessary, and for making sure that the corresponding initiatives are implemented.

In this presentation we use the abbreviation 'MoT' to refer both to technology management in general and to the strategic management of technology, where there is no danger for misinterpretation or conflicts.

Tool

"*A tool is, among other things, a device that provides a mechanical or mental advantage in accomplishing a task*" (Wikipedia 2005), or "*something that helps you to do a particular activity*" (Cambridge 2005). According to Ackoff, "*tools refer to physical or conceptual means, like paper and pen, instruments, computer hardware, or mathematical concepts*" (Arbnor & Bjerke 1997).

Tools are thus not only to support physical activities or tasks. Likewise, tools do not have to be concrete; they can be conceptual means, e.g. mathematics, even though they usually take a perceivable form such as mathematical formulae.

Roadmap

Besides meaning a concrete map, a roadmap is also "*a detailed plan to guide progress toward a goal*" or "*a detailed explanation*" (Webster 2005). There are many more precise definitions, both in academia and in practice, depending on the use and purpose of roadmaps. Here we use the term to shortly and collectively refer to all the specifications, plans, definitions and other information needed to plan and execute technology strategies. They come in various forms: textual, graphical, tabular, and so on. Often they have a visual appearance and a time dimension, but not necessarily.

Roadmaps are one of the essential tools of MoT. They are the *conceptual* means for evaluating alternatives, visualizing, and concretising information, which is needed to support planning, communication and decision-making.

There are other tools needed to process and refine working information for the use of these conceptual means.

1. POINTS OF REFERENCE

The invention of the wheel, for example, or fire for that matter, was undoubtedly not a consequence of systematic research or development. On the other hand, one can safely assume that early artisans already developed, maintained and improved their techniques. Technology was even perceived as a competitive edge. Think, for example, of Chinese papermaking, or silk. Technology was in fact considered so important that it was kept secret, revealed and known only to a small group of insiders.

One could argue that one of the first, or even *the* first systematic practitioner of research and development, and consequently of developing technologies in the contemporary sense, was Leonardo da Vinci. His fundamental research into the workings of nature led him to envision devices ranging from flying machines to submarines.

It is said that the German chemical giant BASF established the first industrial laboratory to develop new technologies in 1867. Thomas Alva Edison in turn established a research laboratory some ten years later. He was clearly in pursuit of novel products and applications, but it is difficult to say how systematic his technology management was, or whether it was more a pure interest in scientific research and development. The first attempts to conceptually define and characterize technology management as a competitive asset started to emerge some decades later.

There are many schools of technology management. Their emphasis, focus and approach to technologies differ. They may be based on product platforms, core competences, product-technology roadmaps, scenario planning, balanced scorecards, etc. They are practiced in a vast variety of businesses, and some businesses may favour certain approaches.

There are also nationwide, sectoral, as well as big international programs that aim to develop or improve technologies. They are initiated, and usually at least partly financed, by governments, government offices, public technology development agencies, communities such as the European Union, and even by the private sector. Usually the objective is to improve competitiveness, and they are aimed at a group of participating enterprises.

Some distinguish technology acquisition and exploitation from technology management in three separate activities; see e.g. Ford et al. (2002).

We characterize our scope of the strategic management of technology in the following way. It covers the entire technology lifecycle, from creation through exploitation all the way to disposal or replacement. The viewpoint is that of an individual company. The approach and emphasis is managing technology as a strategic resource.

The following is the author's very subjective interpretation and opinion of the most influential agents of the strategic management of technology. Numerous others have added to this thinking but the following are the most influential, bearing in mind the approach of this study. Later we will further examine Schumpeter's and Matthews' thinking a little more closely, because their inheritance contributes very strongly to the philosophical and conceptual approach and space of this research.

1.1. Schumpeter

The roots of technology management in its present form extend right back to 1911 and the fundamental works of the Austrian Joseph Schumpeter. It was he who emphasized the principal significance of technological change in driving competition among firms, in the evolution of industrial structures, and in the processes of economic development (e.g. Pelc 2005 and Böckerman 2000).

He introduced the concepts of "disequilibrium process" and "creative destruction" in competition. He defined the types of technological innovations, and declared their significant role in technological advance and competition. Schumpeter was not only talking about new products and processes, but he also embraced new forms of industrial organization, new markets, and new sources of supply (e.g. Tidd, Bessant & Pavitt 2005 and Böckerman 2000) . His contribution will be discussed in more detail later.

1.2. Ansoff et al.

The other significant stream of literature comes from the economics, organizational theory and management science of the late 60's. For example, the scholars of strategic management, Ansoff and Stewart, focused on closing the gap between general managers and technologists in order to explore the impact of technology on business strategy (Talonen 2006). Later, in the early 70's, Prahalad further developed MoT towards an interdisciplinary field in its own right.

1.3. National Research Council

The third milestone was when the US National Research Council set up a cross-disciplinary workshop and a task force to find ways to improve US companies' global competitiveness, especially against Japanese dominance in many hi-tech businesses. The work produced the now-classic booklet "Management of Technology: The Hidden Competitive Advantage" (National Research Council 1987). It defines the key elements of MoT as an industrial practice and identifies eight primary industry needs for MoT.

The key elements according to the National Research Council (1987) are:

- The identification and evaluation of technological options,
- Management of R&D itself, including determination of project feasibility,
- Integration of technology into the company's overall operations,
- Implementation of new technologies in a product and/or process, and
- Obsolescence and replacement.

The primary industry needs derive from questions such as "*How to integrate technology into the overall strategic objectives of the firm*", "*How to assess and/or evaluate technology more effectively*", or "*How to manage the organization's internal use of technology*".

The main contribution was in declaring the hidden competitive advantage embedded in a new holistic paradigm. In large part due to the publicity of the work, technology management became a standard curriculum in international business schools in the 80's.

1.4. Matthews

The fourth point of reference is the works of Professor Bill Matthews. He published only two short articles, but has exerted a major influence on the philosophy and approach of the strategic management of technology.

Matthews did not present a holistic framework, but rather addressed some of the important concepts. His main contribution is to view technology as a strategic resource (Matthews 1990).

Before Matthews, scholars were talking about closing the gap between business and technologists, or at best about developing business strategies and technology strategies in parallel. In any case, business was seen as the driver and originator. Matthews realized that technology and business both influence each other in a recursive, iterative way. The key is to align these – technology efforts and business efforts – to benefit most from their combination (Matthews 1992).

He also raised technology management to the right conceptual level by warning about a skewed viewpoint if addressing only small details. He declared that "*the focus of management of technology is on the dynamics of information selection and assessment rather than on the details of the technologies themselves*" (Matthews 1992).

1.5. Creative Destruction

Born in Austria, Joseph A. Schumpeter (1883–1950) was one of the most influential economists of the 20th century. He contributed fundamentally new concepts and approaches to the theory of economics. He is considered to be the father of evolutionary economics (Pelc 2005).

Joseph A. Schumpeter was also an extremely interesting personality with interests and ambitions extending far beyond his academic career. A good example is the following declaration: "*Early in life I had three ambitions: to be the greatest economist in the world, the greatest horseman in Austria, and the best lover in Vienna*." According to one of his followers, a younger colleague from Harvard, Schumpeter failed to become the greatest horseman in Austria but he later added two other ambitions: "*to be an accomplished connoisseur of art, and to be successful in politics.*" (Pelc 2005).

His career was indeed interesting. He entered the University of Vienna to study economics and law. He published the famous *Theorie der wirtschaftlichen Entwicklung* (Theory of Economic Development) at the age of twenty-eight. In 1911 Schumpeter took a professorship in economics at the University of Graz. He served as minister of finance in 1919. With the rise of Hitler, Schumpeter left Europe and emigrated to the United States in 1932. He accepted a permanent position at Harvard, where he remained until his retirement in 1949 (Econlib 2005).

Innovations, entrepreneurship and technology change were central categories in his theories of economic development and business cycles (Pelc 2005). His best-known manifestation (in Schumpeter 1939) was that (Böckerman 2000):

"Technological advance is a disequilibrium process of creative destruction."

Schumpeter challenged the then prevailing theory of the tendency of economic development to head towards an equilibrium position. Schumpeter's point was that there is no economic development. By this he means that economic development is not a phenomenon to be explained economically, but that the economy, in itself without development, is dragged along by changes in the surrounding world.

If there was an equilibrium process, all the sailing ship companies in our example would have competed against each other with similar, parallel developments; the same amount of additional masts, the same amount of new cargo space, and so on. Or they would have remained in the positions they occupied.

Because of inevitable changes, companies also should change if they want to continue to exist. Due to changes in conditions, an economic system contains partial phenomena of the tendency to head towards an equilibrium position, but not necessarily towards the same one.

For this reason, there are new rules of competition and also new competitive factors after change has occurred. The development which then starts again is a new one, not simply a continuation of the old.

By creative destruction Schumpeter (1934) means that:

"… innovations cause old inventories, ideas, technologies, skills, and equipment to become obsolete."

It implies that companies must constantly renew their technologies; otherwise they are out of the game. In his view (Tidd, Bessant & Pavitt 2005: 7):

"[What counts is] competition from the new commodity, the new technology, the new source of supply, the new type of organization... competition which... strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives."

It is thus not a question of profit or performance, but the very existence of a company that is at stake. Companies must change, because the competition changes. If the competitors do not move, there will be outsiders who change the rules of the game and its structure, or may even destroy the entire business.

There are several examples of that. For example, as steamers replaced sailing ships with new technology on Atlantic crossings, steamship companies concentrated on competing against each other in the speed and size of ships. But in reality their mutual threat and new competitor was the airline companies with their totally new technology and way of thinking about business.

The once so prestigious liner companies with their glorious image could not renew, and now they do not exist any more. Why did they not react before it was too late? Because they did not understand the nature of their business. They presumed that their business was steamships, when in fact they were in the business of Atlantic crossings.

Or take the mid-size mainframe computers that once were the spearheads of technology. These companies failed to renew, they failed to understand the potential of personal computers, and now the once dominant companies have vanished. In fact, the entire business disappeared as newcomers from outside the established business changed the rules.

Schumpeter was one of the first to emphasize the essential role of innovations in technological advance, and in turn in business competition. He defined innovation in (Schumpeter 1939) the following way (Böckerman 2000):

"Technological change in the production of commodities already in use, the opening up of new markets or of new sources of supply, Taylorization of work, improved handling of material, in short, any "doing things differently" in the realm of economic life - all these are instances of what we shall refer to by the term Innovation."

Our example of Atlantic crossings is a good illustration in emphasizing how far-reaching the implications of one technological change can be. It is an illustrative example of all the types of innovations involved. There is a new transport system, aviation instead of marine. There are totally new processes: managing airports, air traffic control, ground services. There is the opening of new markets as airplanes serve also inland cities, and shorter travelling times open up markets for high-volume business travel. There are airplane suppliers instead of shipyards. New industrial players step in, infrastructure and even culture changes: airports, safety systems, new professions, aviation schools, etc.

Schumpeter was not at all unknown, but was nevertheless neglected for a long time. The reason, as Nelson (1999) points out, was that his economist colleagues did not accept his thinking because it was against the then prevailing attempts to explain economic phenomena with mathematical formulae. Schumpeter's view of competition instead is dynamic by nature, and his thinking has been difficult to harness into mathematical or statistical models (Böckerman 2000). It was not until the 60's when he started to gain acceptance, and nowadays he is an undisputed authority.

Böckerman (2000) points out that, in the literature discussing Schumpeter, his thinking has been reduced and simplified. For example, the concept of "creative destruction" has been separated from its original context of a larger argumentation on socialism and capitalism. Simplification, adds Böckerman, is however necessary because Schumpeter's thinking is so rich in its variety.

There are also subtle differences in the quotations in English, because some refer to the original German version, some to the English translation. Moreover, terminology has in some cases changed or diminished its meaning over the years (e.g. Taylorization), so it is only fair to the present-day reader to use language one understands. Most important is Schumpeter's argumentation and that the nuances are not lost in quotation. Also the author has interpreted him, both above and later, carefully trying to honour the original message and subtleties.

1.6. Inevitable Displacement

IMD professor Bill Matthews proposed a manifestation, not dissimilar to Schumpeter's creative destruction, that we could call, for example, inevitable displacement. It states one very important contradiction of technology management (Matthews 1990):

"Most technologies will be replaced, and most efforts to replace them will fail."

If we look at the performance of a technology, it is usually rather low when the technology is new. Performance improves slowly, until the technology reaches the improvement period of its lifecycle, when the improvement becomes rapid. Progress starts to slow down during the mature period, coming to an end when the natural, physical limits of the technology are reached. When performance parameters are plotted against time, they create a shape commonly known as an S-curve (see e.g. Khalil 2000, Foster 1986 or Dodgson 2000).

When technologies reach the end of their performance improvement, they become vulnerable, and will often be replaced by new and superior ones. Usually new technologies have to undergo the same lifecycle development until during their growth period they surpass the performance of the existing ones. This is exactly what happened to sail-powered ship technology when steam-powered technology was mature enough to take over.

However, most efforts by far are fruitless. They fail. This is what happened to Zeppelins when trying to capture the Atlantic crossing business from steamships. Airplanes proved superior.

The statistics support Matthews' remark. A study of industrial success shows that for 3,000 raw ideas there are only nine significant developments, 1.7 launches, and only one success *(Figure 1*). There are several other similar studies with varying numbers and proportions, but the forceful phenomenon is evident.

It is not that the technology as such would not work or that it would fail in providing a workable solution. It is more about acceptance. A new technology must provide superior enough performance in order to be adopted. Take, for example, supersonic airplanes. They could never displace conventional airplanes even though their technology was superior. After the Concorde farewell flight, one of the chief pilots said in a television interview that it was one of the best airplanes to fly and operate despite its rather high age.

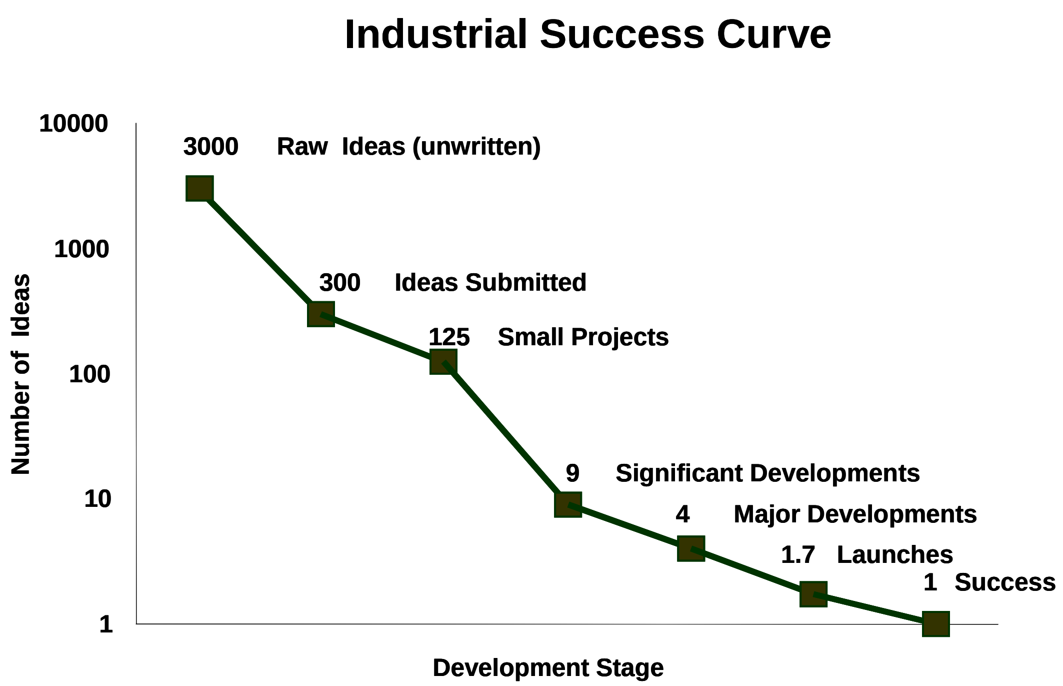

Figure 1. 3,000 ideas produce only one success! Adapted from Stevens & Burley (1997).

Maybe there was a misunderstanding about the key business drivers. Concorde was based on assumptions that speed and travelling time are the primary business drivers for its customers. In reality, customers appreciated what the established, ”old” technology could offer: lower prices, better capacity, a regard for environmental issues, and comfort.

There are numerous other commonly known examples of technology replacements that fail – for example, in telecommunications, consumer electronics (e.g. audio and video recording), or household appliances. Take, for instance, the bread-making machines that were best sellers and all the craze for a short period a decade ago. Now they have virtually disappeared. People returned to the old technologies; either to bake themselves or buy ready-made products.

Most successful technologies come into existence through evolution; this is what Schumpeter was talking about when addressing technological advance and the essential role of innovations in succeeding in competition. In the case of revolution, on the other hand, companies fall victims to creative destruction.

To prepare for, and to survive and succeed, in the inevitable replacement of technology, Matthews (1992) presents a conceptual framework for integrating technology into business strategy. He stressed that for linking these two it is essential to have a continuous process of communication and decision-making. This process makes it possible for the overall business strategy to adequately reflect technological considerations, and for the elements of the technology strategy to be derived directly from the overall business strategy. The objective is to align technology efforts and business efforts to gain the most from their combination.

The key is to have a dualistic view, constantly changing the viewpoint from business to technology, and vice versa. This discussion and dialectics address questions such as:

- What kind of business are we in?
- What kind of company do we want to be?
- How can we create added value and keep our customers?
- Where are the opportunities and threats?
- How is competition changing and how does it affect technology?
- What are the likely technology trends?
- What are their implications for the competition?

The sequence is not fixed. One may start with the order above, but during the process the strategies will have many linkages and overlaps, and the focus will vary. There may be several loops, and new information and perspectives may be generated at any stage.

Matthews also suggests a practical approach, a conceptual MoT analysis framework, to enable continuous and intensive discussion and decision-making between business managers and technologists.

This framework consists of a cycle of sessions with different viewpoints. The cycle is especially a process for generating fundamental questions, structuring answers, and focusing on potential options and trade-offs (Matthews 1992). In this framework, the technology strategy is derived from the overall business strategy. However, during the process they mutually affect each other.

As a result, MoT analysis defines the strategic business challenges including the following:

- **Business challenge definition** – In-depth understanding and definition of the strategic challenges in a certain business area.
- **Competitive strategy approach** – Key approaches to competition related to our external business environment.
- **Technology introduction plan** – Potential technological options to answer the strategic business challenges. What technologies, when, and from where.

Having this kind of dialog between technologists and business management is extremely important. Many swear by market research, customer surveys or competitor analysis when planning for future businesses. It is not sufficient. An approach driven purely by market pull is not enough because competitors also have the same information. We need a "bigger hammer" that enables us to differentiate from competitors by understanding the hidden opportunities, needs and trends.

To ensure an effective MoT analysis process, it is crucial to keep the focus in mind. There is always a danger of slipping into technical details and problem-solving instead of focusing on the selection of fundamental business information. MoT analysis should be repeated from time to time, as the external and internal environments change.

Another important concept from Matthews is “Blue Box” research (Matthews 1990). Matthews had noticed that technologists and decision-makers had difficulties in understanding each other. They lack a common language. In many organizations, investing in development projects must be justified by return on investment, payback or internal interest rate.

Sometimes a project proposal could not be justified in such a way, but was nevertheless approved “for strategic reasons”. Both the technologist and the decision-maker understood intuitively the importance of an initiative, but there were no means to justify it. Matthews concluded that there must be a way to evaluate an understandable means to concretise those “strategic reasons”. He introduced Blue Box research and strategic options, a concept originally adapted and modified from Mitchell & Hamilton (1988). Blue Box is illustrated in *Figure 2.*

The figure presents three types of technology development projects. The oval on the left represents research. Financially it is overhead, its drivers are faith and fair, and the possible release of a product is six to ten years ahead. The other oval represents product development, or productisation. Its time span is one to three years, the driver is profit, and financially it is investment.

Blue Box research is in between. Its products are strategic technological options for the future; the drivers are the assessment and selection of technologies, and the time span for a possibly ready application is four to five years.

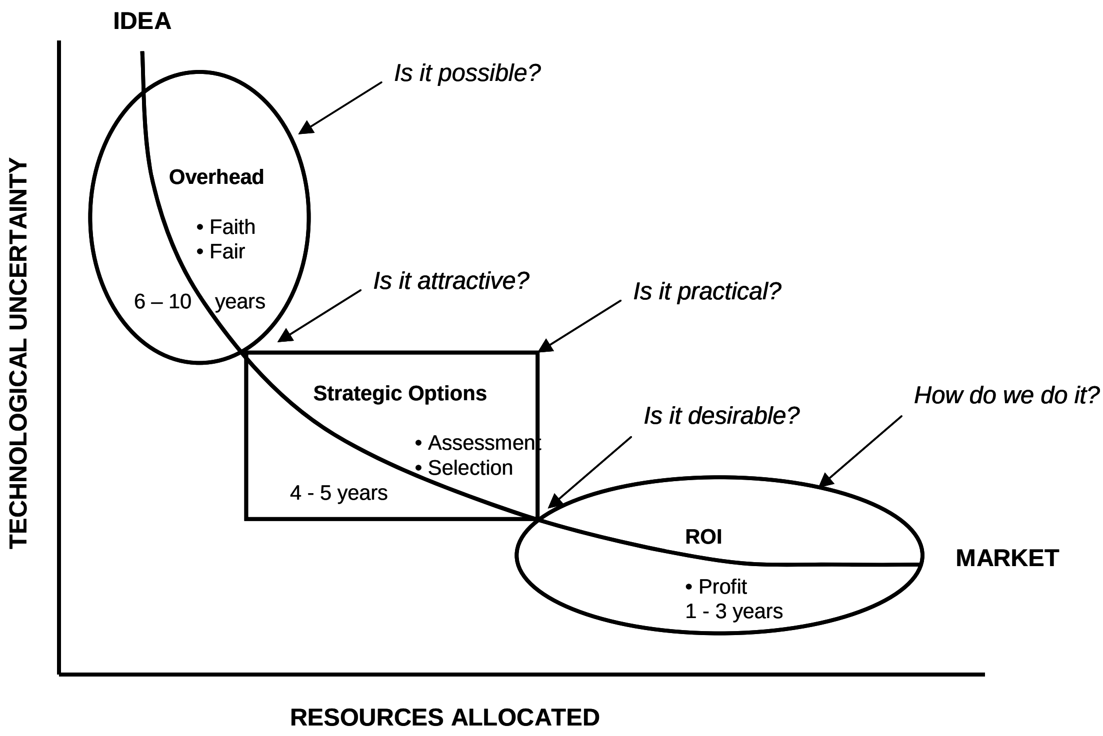

Figure 2. Types of research and development projects. Adapted from Matthews (1990).

The figure is one of the most frequently misinterpreted, and even misunderstood, according to the author's experience. Blue Box research is *not* some kind of technical feasibility study. Blue Box research is *not* a preparatory project for, nor a pre-phase of, a product development project. It is about creating future options.

Look at the illustration carefully! There is no time dimension. The coordinates are technological uncertainty and resources allocated. The line does not present a continuum from research to product creation, but rather shows how a company allocates resources with relation to technological uncertainty. In research the uncertainty is high, and a company does not allocate extensive resources. When the uncertainty has been reduced to a manageable level, more resources are available for product development.

What Matthews wanted to concretise with the illustration is how different types of technology projects place themselves in an uncertainty-commitment coordination, what are their roles, and what are their characteristics in the sense of finance. Research is overhead. Blue Box creates strategic options for the future. Mitchell & Hamilton (1988) called it "strategic positioning". These are options for possibly pursuing later product developments. These are in turn business investments aimed at generating return.

Blue Box research answers questions such as "*Is it practical*?" and "*Is it desirable*?". Or, put bluntly: "*Could we do profitable business with it*?".

In practice, there is a process that Matthews (1990) calls "kissing technological frogs", referring to a fairy tale. The analogy is that there are potential strategic options, frogs in a pond. One picks up one frog at a time and kisses it in order to see if it actually is an enchanted prince. If not, depending on the case, one throws it away or returns it to the pond to grow.

Kissing technological frogs happens by gradually reducing the technological uncertainty using carefully formulated, closed questions as research objects. For example: "*Can technology X provide the following benefits when compared to today's product Y provided that the volumes are N?*". Naturally there is always uncertainty connected to the answer. The uncertainty is reduced in consequential steps by further research until reaching a desired level.

Matthews worked as a professor in the IMI and IMD in the 80's and the beginning of 90's. Even though he published only two short articles, his influence has been impressive. One can still detect his fingerprint in the thinking and concepts of technology management in numerous multinational and global companies. This is due to his extensive lecturing and consulting in Europe and the USA.

His natural wit and charisma as an entertaining lecturer contributed to that, but these would not have helped if the substance were lacking.

1.7. In a Nutshell

The main shortcoming with Schumpeter and Matthews is that they do not offer many, if any, practical tools. Both discuss on a conceptual level. Schumpeter is in addition so rich in variety in his writing that simplification and interpretations are necessary. Matthews promotes aligning business and technology efforts, as well as creating future technology options for business, but a framework integrating his viewpoints is missing.

Conceptualising, however, can be a strength if understood in the right way, and interpreted and applied to practice correspondingly.

In conclusion, the main contributions of the thinkers and scholars discussed above may be summarized as in *Figure 3.*

Schumpeter *1911*	• Disequilibrium in competition ⇒ companies must renew constantly • Failure in that threatens their very existence • Technological advance gained and maintained through innovations
Ansoff, Steward, Prahalad *60's & 70's*	• Closing the gap between general managers and technologists for exploring impact of technology on business strategy • MoT as an interdisciplinary field itself
National Research Council *1986*	• Task force to improve US companies' global competitiveness • The main finding was a hidden competitive advantage embedded in a new holistic MoT paradigm • MoT became a standard curriculum in international business schools
Matthews *early 90's*	• Managing technology as a strategic resource • Technology and business both influence each other in a recursive, iterative way • The key is to align technology efforts and business efforts to gain the most from their combination

Figure 3. The main reference points of and contributions to the strategic management of technology.

2. RESEARCH PRESENTATION

2.1. Research Environment

KONE is a global leader in providing complete and innovative solutions for the installation, maintenance and modernization of elevators and escalators and the maintenance of automatic building doors (KONE 2005 a).

KONE's roots go back to 27 October 1910 and the founding of Osakeyhtiö KONE Aktiebolag, an electrical repair shop, as a subsidiary of Gottfr. Strömberg Oy. Strömberg's license to import Graham Brothers elevators was transferred to the new company. KONE sold just a few units before terminating the licensing agreement in 1917. KONE, then a company with 50 employees, started to make and install its own elevators in 1918 (KONE 2005 a).

During its more than 95 years as an industrial engineering company, KONE has been involved in businesses as different as textile manufacturing, medical technology and the design of hydraulic piping systems. The company's main focus, however, has always been the elevator and escalator business (KONE 2005 a).

KONE’s internationalisation started when it acquired Asea-Graham’s elevator business in 1968, as a result of which the company’s business volume tripled. KONE had market leadership in the Nordic countries. By 1976 KONE’s international operations already accounted for more than 80% of net sales (KONE 2005 a).

Through strong internationalisation and acquisitions (*Figure 4)* KONE has become a truly global enterprise. KONE's annual net sales exceed EUR 3 billion, and it has about 27,500 employees (KONE 2006). The company sells, manufactures and installs about 30,000 new elevators and escalators annually, and has some 575,000 elevators and escalators (KONE 2006) and almost 250,000 automatic building doors under maintenance contract (KONE 2005 b). KONE guarantees local service for builders, developers, building owners, designers and architects in 800 locations in over 40 countries. Its Class B shares have been listed on the Helsinki Exchanges since 1967 (KONE 2005 a).

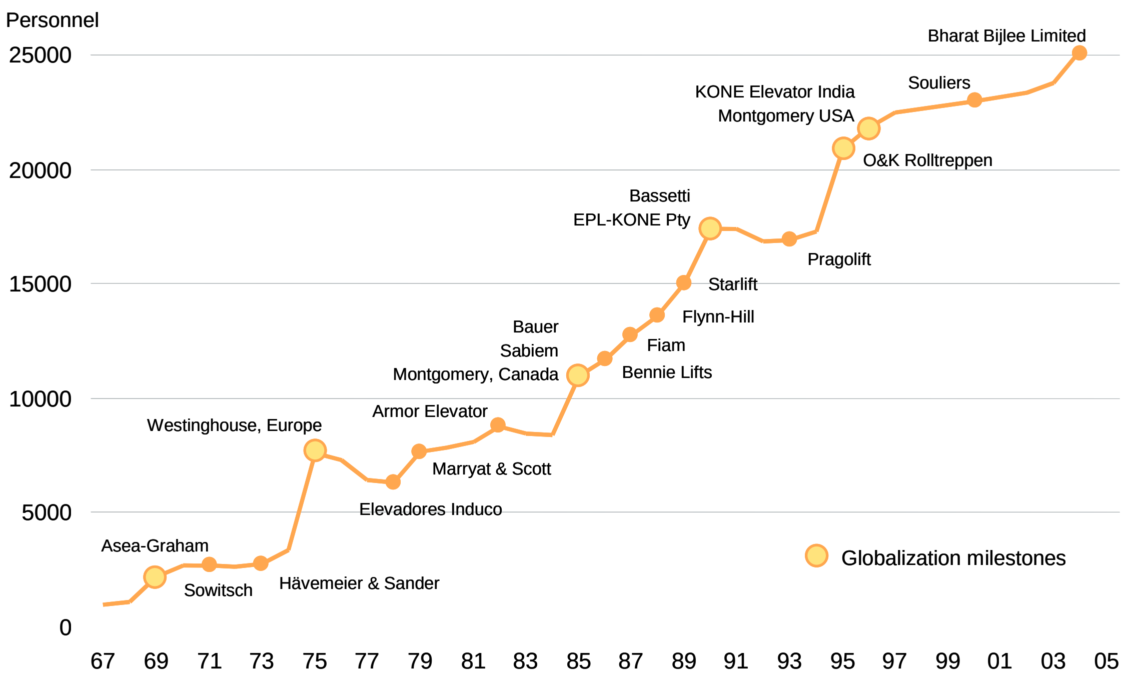

Figure 4. KONE's growth through acquisitions (KONE 2005 b).

The organization of KONE's business operations is based on a matrix. One dimension consists of business lines: major projects, service business and equipment business. The other dimension comprises market areas: North

America, Western & South Europe, Central & North Europe, and Asia-Pacific. Despite the names, these may also cover wider geographical areas. For example, Western & South Europe also serves Middle Eastern and Arab countries.

KONE has global sourcing, and a global supply from several elevator and escalator supply units on three continents. The products are global, with possible small local variations, as are also the harmonized business processes and tools. Note that when we talk about a product, we always mean a *solution*. It can be a physical device with related processes, a service, or a combination of these.

In addition, there are corporate functions and organizations – such as human resources, financing, legal, technical information services, marketing, etc., that support the primary business operations. They are mutual resources, centralized, and serve the businesses globally. They do not belong to any of the business operations' organizations, but are separate and independent.

One such global mutual resource is research and development, R&D. It is a centralized, global organization with seven R&D centres located in Finland, Italy, Germany, India, the United States and China. They share common plans, a common budget, and they follow harmonized processes. They are mutual resources available to all business units and areas.

In KONE, the term 'R&D' refers solely to an organization. The product development activity, often known as R&D in other companies, is called product creation. This is to emphasize that product creation is a corporate-wide, mutual, cross-functional effort, not only that of R&D. R&D is primarily a driver and coordinator, and a considerable share of participating resources come from other parts of the organization and partners. The main participating stakeholders come from the primary business processes.

Product creation is part of a wider concept called product lifecycle management (LCM). It has three phases: product creation, product health care, and product pension. Prior to pension there is of course retirement, which is a transition period during which the manufacture of a product is terminated. This happens when a new product replaces it. The components of the product still continue their life as spare parts. In the case of elevators these might be needed over several tens of years in future service and maintenance.

Management of technology has not been centralized, nor dedicated to a specific function. Activities happen in different parts of an organization according to their usual work context and responsibilities. Roughly, business lines are responsible and active on strategic issues, whereas R&D has concentrated on tactical plans and operational execution. Naturally much of the work is being performed cooperatively. High-level coordination takes place in annual mid-range planning and budgeting cycles. Coordination of more detailed issues occurs in normal, daily work.

2.2. Research Task

We have discussed how essential are technologies in competition, and in creating added value. No technology, however, is everlasting. This leads us to the *research problem*: how to manage technologies so that they are constantly competitive?

KONE has a long tradition of technology management in one form or another. Senior management has throughout the years shown a keen interest in product, manufacturing, and other technologies. Related strategies, mid-range plans and annual budgets have been presented to, and approved by, senior management, thus linking them with business efforts.

The methods and processes might have been somewhat dispersed and even haphazard, but the interest has nevertheless been genuine. This has provided fertile ground for further developments.

More systematic procedures were introduced at the beginning of the 1990s, when Professor William H. Matthews from the International Institute for Management Development (IMD) visited several Finnish companies presenting his approach to the management of technology. The senior management of KONE hired Matthews for further consultancy, and there were several MoT workshops on different subjects both at the senior-management level and within the R&D organization.

It can be said that the breakthrough concept of an elevator without machine room, MonoSpace®, in the mid 1990s was a direct outcome of applying MoT concepts to research. Of course, one cannot attribute the results to MoT, but one can question whether they would ever have happened without the support of a directional and goal-oriented process.

Even though the mind-set remained strongly at the back of the organization culture, practises became corrupted over the years. The main shortcomings were identified at the beginning of this research as the following.

- Management of technology was not known and adopted throughout the whole organization.
- The process was not continuous and comprehensively defined. There were discontinuities and the roles and relationships of the processes were not clear. Consequently, traceability between plans and the other results of different processes was weak.
- The set of support tools for evaluating alternatives, planning, communicating and making decisions was insufficient.

There was a clear need to brush up and further develop the processes, methods and tools. The construction task, formulated by the author of this dissertation, was defined as:

"The objective is to define, acquire, adapt, and implement an MoT process and a set of supporting tools suitable for the organizational and working culture of KONE."

The formulation and selection of the wording was careful and deliberate. *To acquire* refers to the fact that nothing new needs to be invented. The world is full of process definitions and tools, and one should just acquire and *adapt* the adequate ones according to the needs. A mere definition is worth nothing, but the results must be implemented and *taken into use*. As mentioned before, KONE already had a tradition in MoT and had many – probably most – of the tools needed. There was no sense in trying to introduce something totally new and dispose of the existing, but instead, to make the results serve the culture that already existed.

Researchers and scientists use the term "*research gap*". It refers to the gap between an existing and a new theory, between an existing and a new practice, between practice and theory, or between theory and practice. It defines the motivation or justification for the research.

Taking the generic research problem, and the practical task to create an MoT model for KONE, we can declare the research gap with the following *research questions*:

1. *What are the elements needed in managing technologies?*

2. *What are the structures that bind these elements into a coherent model?*

3. *What is and how to develop a technology management model that fits KONE working culture while improving the existing processes?*

The elements may be processes, data flows (input, output and internal), methods and practices, and possibly needed dedicated organizational functions or activities. They are the building blocks of the model. The structures bind them together, or the other way round; the building blocks form certain structures. The elements and structures together constitute the technology management model.

2.3. Focus and Scope

This dissertation deals with the strategic management of technology, i.e. managing technology as a strategic resource. It studies a conceptual model, and the practical management of a technology framework constructed for KONE Corporation.

The scope of the research can be outlined by revisiting the definition of technology, and further elaborating on it. Technology was defined as the art of applying proper techniques. Technique, in turn, is a method of accomplishing a desired aim. Note that the definition of technique does not restrict it to something physical or “concrete”. In fact it does not even mention those. It is simply about accomplishing a desired aim. Technique thus also relates to any effort – physical or mental.

Mere techniques, even if mastered, are not enough to reach a desired aim. There might be physical or other limitations that restrain or hinder the application of a technique. The ability to exploit techniques must exist. This ability and mastering a technique we could call *capability*.

A company’s competence is a combination of different capabilities: financial, commercial, operational, and so on. *Figure 5* presents the relationship between a company’s competence and its business opportunities. The author would like to point out that the viewpoint is slightly different than the one we have used so far, and the term ‘technological capability’ might have a somewhat different flavour. Nevertheless, it is a good illustration and worth examining.

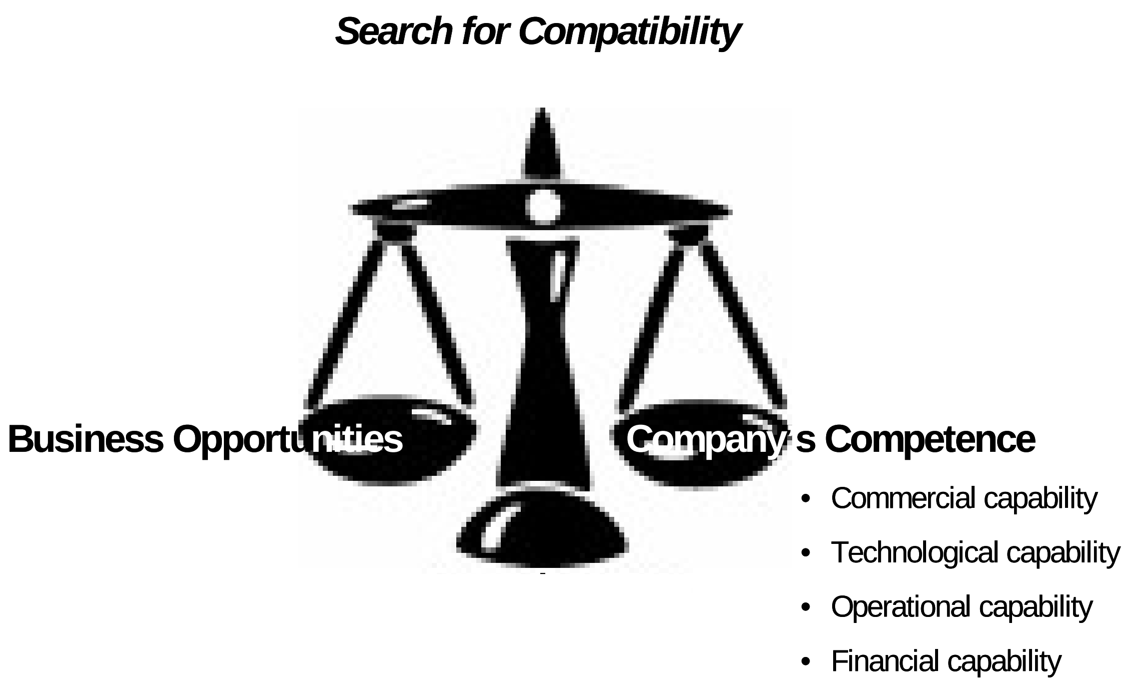

Figure 5. Management of technology is the art of balancing[1]. *(The list of capabilities is exemplary, not exhaustive.)*

There are business opportunities in one balance pan and company's competences in the other. The main message of the illustration is that management of technology is searching for compatibility between the two. It is the art of balancing. One could argue that this is the core, the essence of the management of technology.

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[1] *The author adapted the figure from a publication or a presentation from around 1996 – 1997. The original, as well as the reference were lost, and the author has not been able to locate either of them in spite of several efforts. All credits to the original author.*

Another message is that a commercial, technological or any other capability alone is not enough. There must be all of them. This is because the company's competence suffers if any one of the capabilities is missing or inadequate. For example, a company might have promising prospects for a product, but cannot develop it because of financial limitations. Or, everything else is in good shape, but there are no capabilities for capitalizing the product on the market.

This means that in a competitive situation, an organization must have all the capabilities needed. Further, it signifies that management of technology must encompass all the related and relevant capabilities. That defines MoT as an extensive, corporate-wide concept. It does not imply that management of technology is responsible for all the capabilities or that it develops them. It must evaluate the capabilities, and it is responsible for signalling the need for new or improved capabilities, and for monitoring that the corresponding initiatives are implemented. This in turn signifies that MoT cannot be isolated, but must be an organic part of the corporate functions and operations.

2.4. Philosophic-Conceptual Orientation

The research was strongly influenced by the thinking of Schumpeter and Matthews, even if it does not show explicitly in the actual construct.

The main inspirational sources were their declarations of the threads one must live with, and the means for overcoming them:

- The disequilibrium process of creative destruction by Schumpeter,
- The inevitable displacement of technologies by Matthews,

- The essential role of technological innovations in competition by Schumpeter, and
- Matthew's contemplations on how to manage technology as a strategic resource.

These are the four cornerstones of this research.

The actual construct was sedimented from the already existing management of technology practises in KONE, the author's own experience, and from numerous presentations, publications and discussions.

However, the 'spiritual home' is in Schumpeter's and Matthew's thinking.

2.5. Research Approach, Methodology and Conduct

The constructive research approach has gained popularity in business science during recent years. It is based on a division into the conceptual-analytical, nomothetical, decision-methodological and operation-analytical approaches (*Figure* 6*)* proposed by Neilimo & Näsi (in Hannula et al. 2003).

The classification is based on the purpose of information (either descriptive or normative) and the way it is acquired (theoretical or empirical). Descriptive research describes a phenomenon and explains how things are. Normative research aims at finding results that can be used as instructions when developing operations or creating something new (Hannula et al. 2003). It describes how things should be. Theoretical research starts with known and validated theories to create new ones. In empirical research one in turn generalizes individual cases (Hannula et al. 2003).

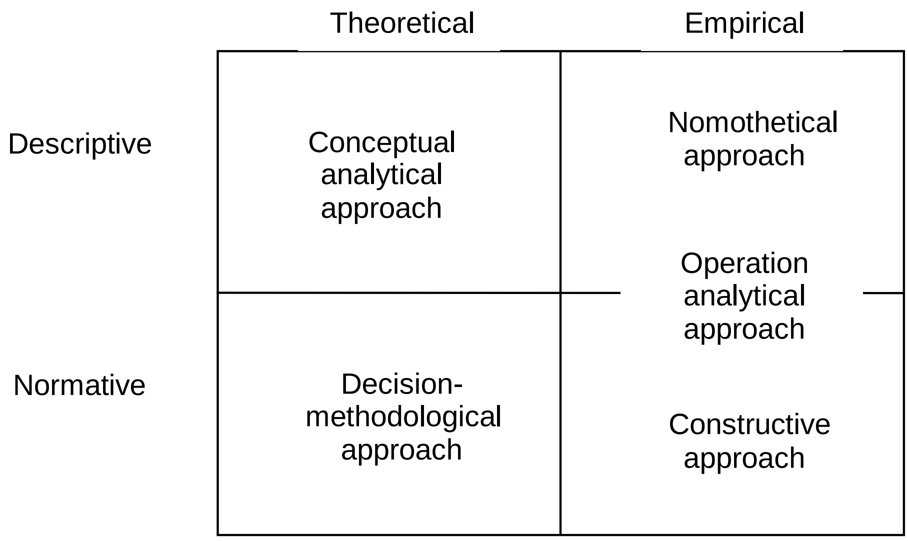

Figure 6. Research approaches in business science (Hannula et al. 2003).

Kasanen et al. have added a constructive approach to the classification. Depending on the selected methodology, it places itself close to the decision-methodological and operation-analytical approaches (Hannula et al. 2003). The objective of the constructive approach is to (Takala & Helo 2000):

- Create an innovative and theoretically sound (argumented) solution for a relevant practical problem,
- Verify the solution in practice, and
- To make an effort to generalize it.

As mentioned, the decision-methodological and operation-analytical approaches are its relatives. It differs from the first in that it has a strong empirical nature, however not ignoring the importance of the soundness of the underlying theories. It differs from the latter in that it is normative; it outlines directions, rather than only describing a phenomenon.

Suojanen (2005) presents her interpretation of a classification based on the features of different action research paradigms that can also be used to characterize the selected approach. The interpretation is based on the works of Habermas and Kemmis on the critical or emancipatory action research concept. Suojanen's definitions emphasize the objectives and interest of research, influencing mechanisms, and the researcher's role and contribution *(Figure 7*).

PARADIGM	**POSITIVISTIC, EMPIRICIST-ANALYTIC, QUANTITATIVE**	**INTERPRETATIVE, HERMENEUTIC, QUALITATIVE**	**CRITICAL, EMANCIPATORY**
Cognitive interest	Technical	Practical, interpretative	Critical, emancipatory
Way of influencing	Work	Language	Power
Purpose of a study	Cause-effect relations, prognosis	Understanding, interpretation	Development of activity, change
Theory – practise relation	From theory to practice, deductive	From practice to theory, inductive	Interaction between theory and practice
Human conception	Atomistic, externally directed	Holistic, humanistic	Holistic, self-directed
Researcher's role	Outsider expert, observer	Outsider or participant, don't try to influence	Active participant, shared responsibility, change agent
Researcher – participant	Independence, target as object	Co-operation, target as an object	Joint responsibility, participants as subjects

Figure 7. Paradigms of action research according to Suojanen (2005).

In addition to the classical positivistic (explaining) and hermeneutic (describing or interpreting) paradigms, there is a critical, emancipatory paradigm. The author's approach is evidently that one. The purpose of the work was clearly the development and change of an activity, or set of activities. There was a strong, continuous interaction between theory and practice. The author was an active participant and active agent of change.

A third possibility to characterize the approach is the methodology for creating business knowledge presented by Arbnor & Bjerke (1997). They also start with the positivistic-hermeneutical axis, and come up with three approaches: the analytical approach, the systems approach, and the actors approach. Put simply, the analytical approach is positivistic, assuming that the whole is the sum of its parts. The actors approach manifests that the whole exists only as a social construction.

The systems approach lies in between. Its reality assumptions are the following (Arbnor & Bjerke 1997):

- The whole does not equal the sum of its parts,
- Knowledge depends on systems, and
- Parts are explained (sometimes understood) by the characteristics of the whole.

The systems approach studies the characteristics of parts and their relationships, as well as the rules defining the relationships. Interpretation is important, because knowledge depends on the system or the case under study. Its methodology exploits analogies, and compares cases or theories. Referring to that, this research follows the systems approach. Existing theories and practises have been acquired and applied in creating a new construct. Further, defining the parts, or entities, their roles and relationships, has been an integral part of the research.

The actual work was conducted in four consecutive phases:

1. Mapping the current state-of-the-art management of technology
2. Development of the target process
3. Selection and adaptation of support tools
4. Implementation in the normal planning processes and operations

The first phase was to study what has happened in the area of the management of technology since the concepts were introduced to KONE by Dr. Matthews. What are the new or prevailing concepts and paradigms? What support tools are available? The research was made by a study of the literature and by discussing with practitioners and researchers of the management of technology.

The next step was to define and develop the target process. It started by studying the existing practises in KONE; their status in general, their strengths, weaknesses and shortcomings. That led to the definition of requirements for new features and elements, and consequently to the description of the target processes.

The target process was in turn used to specify the tools needed. Tools and supporting material are needed for running the processes. In communication and decision-making the tools are needed to evaluate alternatives, and to visualize and concretise plans and other information. There was no need to develop totally new tools. Most of them already existed. The rest were identified, acquired and adapted to KONE's working and organizational culture.

The last step was to implement and run-in the process and related tools in existing operative processes by applying them in normal work in workshops, business planning, development efforts, and so on.

The phases above can be considered as typical business process re-engineering (BPR). Although re-engineering in principle has been around for most of this century, it has become the buzzword during the past decade, writes Shrage (1997). She defines: "*we will consider any projects involving dramatic change in business processes … as re-engineering*." Some presume that BPR involves utilizing information technology.

Business process re-engineering has its shortcomings. Keen & Knapp (2005) claim that as many as 50-70% of re-engineering projects fail. The main reasons for that are (Shrage 2005, Weicher et al. 1995):

- lack of management support,
- resistance to accepting changes,
- looking for a single best solution,
- isolated project teams, and
- approach.

A BPR project will inevitably fail if it does not have the full support of top management. This means not only being a sponsor, but rather an active participant. Management cannot direct the work of others; it coordinates, facilitates and empowers. One cannot ignore human issues. There are fears, and the bigger the changes, the bigger the very natural resistance to these changes. Radical changes are very difficult to implement. Changes must not cause employee skills to become inadequate; there may be needs for training programs. The changes must fit the corporate culture and existing business practises.

It is a common belief in BPR that there is a single best way to conduct tasks. In addition to pursuit for a single best solution requiring excessive efforts, it is a question of resistance; an outsider comes and tells an individual to work exactly the way he specifies without exceptions and without discussing alternatives or amendments. Another problem is who and how to declare or define the single best practice. There must be practical trade-offs.

One typical mistake is to put a BPR team, often from outside the company, to work in isolation. Teams must be comprised of both managers and those who actually do the work, and the project must be owned throughout the organization; ownership cannot be outsourced. Design and actual implementation should not be separated.

Experience, more than the right approach or methodology, is the key to success. Hammer and Champy (Weicher et al. 1995) specifically warn against spending too much time studying the current process.

We tried to avoid the pitfalls as follows. We had full management support, in fact the whole exercise was initiated by senior management. Management participated in development, and parts of the model and tools were tested in real-life work as appropriate. The constructed model is not a radical change, but rather a logical complement to, and refinement of, existing practises. It fits the corporate way of working and culture, and using it does not require much facilitation after a short introduction. We did not strive for an optimal solution at any cost. The solution is one of the many possible workable models. As mentioned, the project team had members from different parts of the organization, and it worked in close connection with the company's usual operations.

The author has extensive experience of technology-related issues and of the company, so there was not much need for analysing the existing processes. It was quite apparent what tools and procedures were needed to manage technologies, and the target model started to take shape quite early on. The process was "solution pull" rather than "problem push". In this respect, the constructive research approach might differ from BPR conceptually, even though the starting point, development steps and objectives may appear similar.

Even though the phases presented earlier appear sequential, there was a continuous discussion between theory and practice in a recursive, iterative manner. How does this paradigm fit into our target process? How theoretically valid is our model? How do existing KONE practises and tools fit the target process and correspond to the prevailing paradigms? The frequent changing of viewpoints, from theory to practice and back, from induction to deduction and vice versa, is characteristic of constructive research. It is also essential in the systems approach.

2.6. Constructed Framework and Contribution

The deliverables of the construction are the following:

1. *Comprehensive set of MoT processes*

  - A complete breakdown and path from critical business challenges all the way down to individual product creation projects
  - A description of each process, its methodology, objectives and deliverables

2. *Comprehensive tool set*

  - For each process the tools needed for conducting it, and tools for concretising and visualizing the results

3. *Instructions*

  - Instructions for conducting the processes and for utilizing the tools

4. *Presentation material*

  - Presentation for MoT practitioners
  - Presentations for non-practitioner interest groups

A conceptual model is presented in *Figure 8.* One should bear in mind that it is conceptual, and does not present the real procedures and tools as such. However, it helps to highlight the philosophy and approach behind the actual framework.

The model emphasizes the importance and role of the management of technology between the areas of business strategy processes and operative business processes by linking them together.

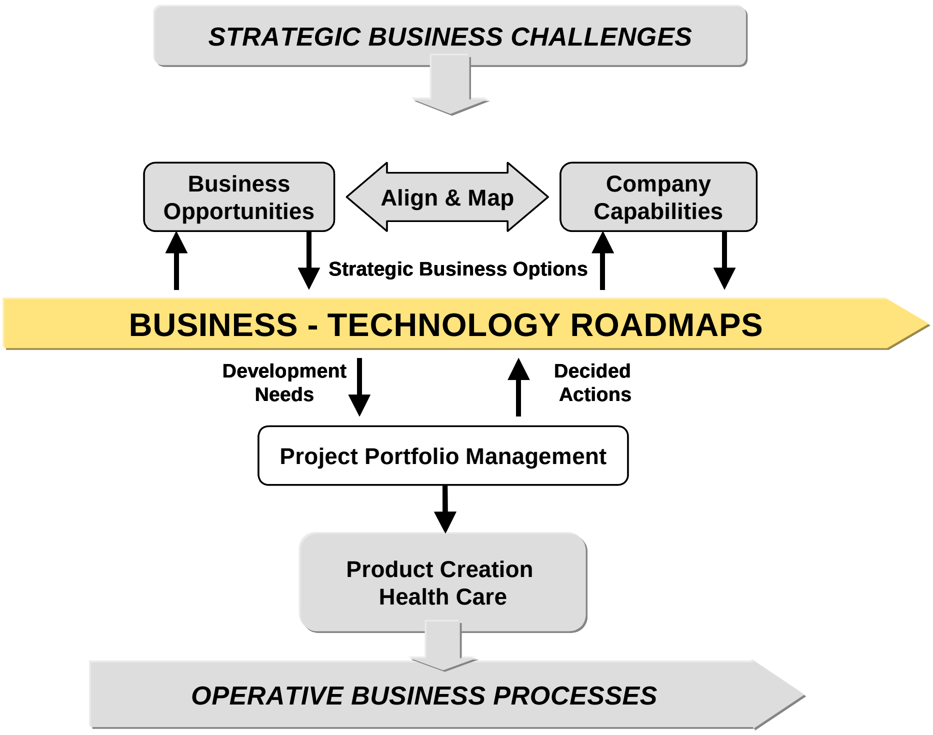

Figure 8. Conceptual framework of the MoT model.

The *starting point* of the whole process consists of the strategic business challenges. The key task is to identify and define strategic business options by aligning business opportunities and company capabilities together. These options are the potential answers to strategic business challenges. The nature of the effort is ultimately the management of people and the process of communication and decision-making that determine success or failure, as Matthews (1992) points out. To be effective, the process requires strong ownership and drive from the business management. Business managers must take personal responsibility for the process and its results.

The *results* of the process consist of different plans needed to form a technology strategy, which should be transformed into an effective and valuable mix of projects, i.e. a project portfolio, for optimally meeting business objectives in practice.

The "*backbone*" of technology management consists of Business-Technology Roadmaps. It is like a mutual archive room including *all* the artefacts that the processes need and handle. The arrow shape in the illustration symbolizes time; the roadmaps should always be up-to-date and evolve over time as the environment changes and development efforts take place. In this sense it resembles Motorola's original roadmap concept (Willyard et al. 1987). It is a rolling and living plan, and is constantly evolving and updated as frequently as needed. The idea is to get rid of the rigid strategy – mid-range planning – budgeting - operation cycles – so strongly established in prevailing business processes.

As mentioned, the framework above is conceptual. The processes and activities *do not* occur in a sequential manner. The purpose of the illustration is to show the logic of how different agents refine the same body of information. In practice, there are several loosely coupled processes on three different levels:

- Strategic level (business and technology alignment)
- Tactical level (technology planning)
- Operational level (implementation)

The strategic level is essential in linking business and technology developments together through common strategic thinking and discussion. The tactical level is both strategic and operational. It is crucial in linking short-term project-level operational activities with long-term strategic objectives. The operational level consists of disciplined work and well-defined processes to efficiently and effectively implement the strategies and plans in practice.

For each of the processes, which could also be called activities, there is a definition of its role, purpose, working procedures, and techniques, i.e. the way to use tools in the meaning of Arbnor & Bjerke (1997). The processes are rather autonomous, and there is no specific chronological order of implementation. Processes are parallel, and iterative and recursive by nature. They work on, and refine, the mutual information in the roadmaps from different directions, and for different purposes. It is the roadmaps that link the processes and their results together.

The set of roadmaps is defined using data dictionary notation in a tool dictionary. It is a comprehensive list of tools that we consider are needed in technology management. Some of the tools are naturally alternative or optional, to be used on a case-by-case basis.

The tool dictionary is hierarchical. Items of a tool (roadmap) are defined stepwise in more detail in lower-level definitions, until the necessary details are reached. The tool dictionary thus defines not only what tools to use or are available, but also their relationships. This is important for traceability reasons. It reveals how plans, developments, and other items relate to each other.

Roadmaps are the *conceptual* means for evaluating alternatives, visualizing, and concretising information, which is needed to support planning, communication and decision-making. Examples of such roadmaps are business scenario, master business roadmap, technology forecast, product mix evolution, release plans, technology sourcing plan, competence development plan, and project portfolio appraisal.

There are other tools used to process and refine working information for compiling roadmaps. These are common analysis and planning tools such as SWOT analysis, cost models, trend analysis, surveys, scenarios, competitor and market analysis, estimation models, risk assessments, simulations, etc.

The management of technology framework constructed is simple, elegant, comprehensive and theoretically sound.

Simplicity is important so that the model, its use and mechanisms can be understood. With all respect to Ansoff: who can memorize, or even perceive, his overwhelmingly complicated presentation of strategy process (e.g. in Näsi & Aunola 2002: 27)? Processes and tools must be so simple that they can be used without extensive training or facilitation.

We did not want to “force” our processes into a foreign model. The framework is elegant in that it suits the KONE way of working and its organizational culture, and enhances the existing processes.

The framework is comprehensive both horizontally (it contains all the needed processes with related tools and definitions) and vertically (there is a clear path top down from strategy all the way to individual implementation projects).

The framework is theoretically sound when compared to the state-of-the-art. The author does not try to claim that it is a superior one. It is not even surely the best one for KONE. It is one of the adequate, workable alternatives. In any case, it can challenge the publicly presented models that the author has encountered.

3. EMPIRIA

One of the definitions for *empirical* is *"based on the data of the senses"*. It means that one builds understanding upon something previously experienced or perceived. Observations play a key role in the process.

The corresponding philosophical doctrine thus emphasizes the role of experience. There might be experiments, but the results and conclusions cannot be based solely on measurements. Human observations as well as corresponding interpretations and conclusions must be involved. The extreme opposite doctrine is rationalism where the results are based on mere reasoning.

Empiria, or empeiria, is a Greek word, meaning "experience" or "trail". The latter implies that experience is gained constantly and accumulated over the course of time[1]. It is about what is learned in the virtue of trying.

This study, and the results discussed below are empirical. However, there are no experiments as such. The research is thus *experiential* by nature, rather than experimental.

In this chapter we will study and justify the results of the research. It is not recommended, and not even possible, to examine all the aspects of a research study. Neither is it advisable to split it into separate slices.

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[1] *The Finnish word for experience is "kokemus". It has a very similar primary meaning of constant accumulation of experience, learning by trying. The stem of the word is "kokea", which means examining a fish trap or a game snare.*

It is more fruitful to create some bigger and smaller, overlapping and recursive analysis and conclusion cycles around the most important contributions.

In the following we will examine

1. The overall structure of the model created,
2. The roadmapping process,
3. The role of innovations, and
4. The nature and importance of the strategic level.

3.1. A Holistic Roadmap-Centric Structure

Finally we shall place the Sun himself at the center of the Universe.
All this is suggested by the systematic procession of events
and the harmony of the whole Universe,
if only we face the facts, as they say, 'with both eyes open'.

Nicolaus Copernicus, Polish astronomer

First we will examine the construction of the model: how and why we ended up with exactly this model, what are its main features, and what are its characteristics.

3.1.1. Attempts to Model as a Process

MoT models, or frameworks, come in many variations. Probert et al. (2001) present the following: a process, a tree (”technological bonsai”), strategy framework (a funnel in practice), and a cube. The most common one is some form of a process *(Figure 8).*

There are many definitions for a process, but usually there is a defined input, activities, and output. It is normally assumed that the activities occur in a predefined order. Bal (1998) defines it as "*a process is thus a sequence of activities which are performed across time and place. A process also has a well defined beginning and end with identifiable inputs and outputs*". Webster’s (2005) definition is “*a series of actions or operations conducing to an end; a continuous operation or treatment especially in manufacture*”.

A parallel business-technology process develops the two viewpoints independently, with few interactions, and fuses them at the end. Typically there are no, or only a few, iterations.

A linear process refines the source information step-by-step, often having different viewpoints at different phases. Typically the steps follow the market–product–technology–business continuum.

A waterfall model resembles the linear process in that it also has phases. The ”waterfall” metaphor emphasizes that each subsequent step refines in more detail the results of the previous step.

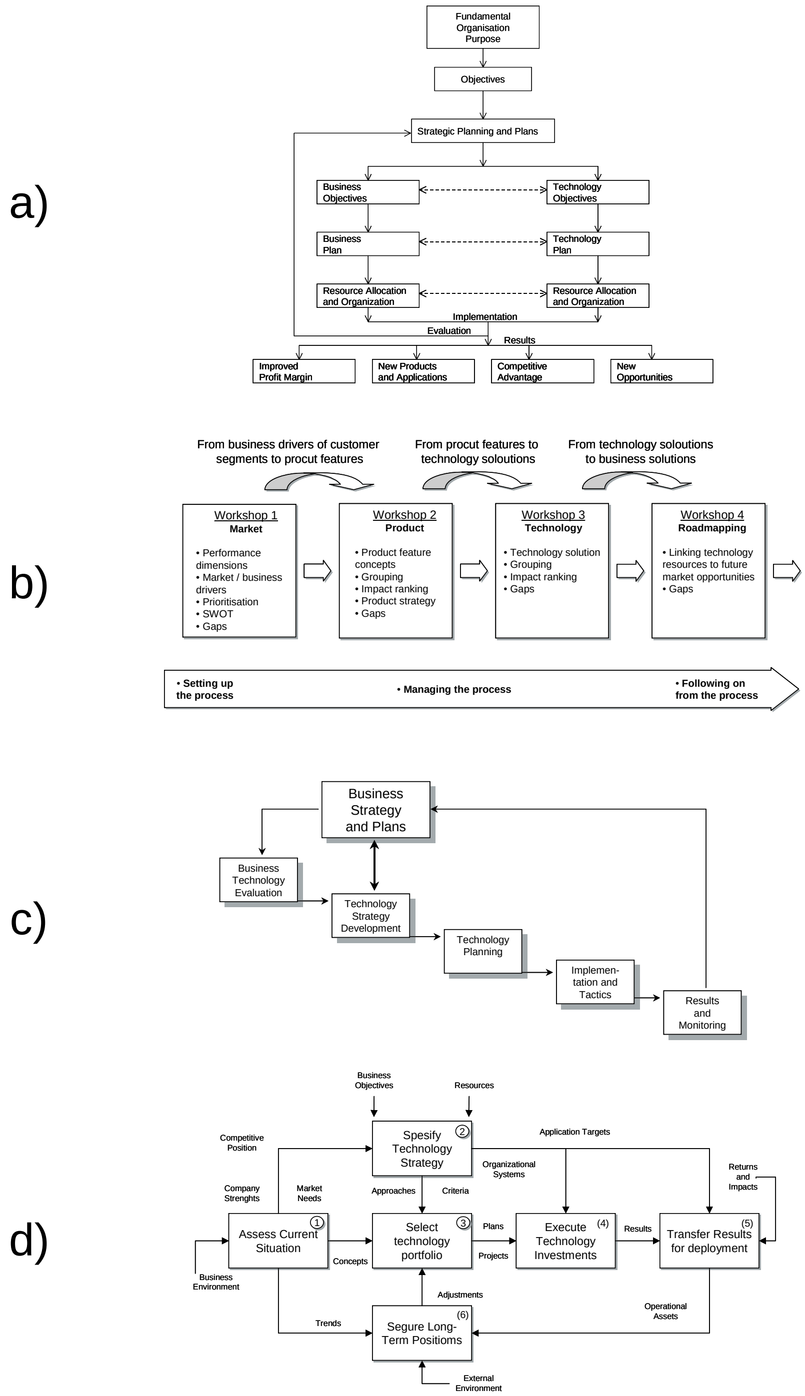

Figure 8. Examples of common MoT process types: a) parallel business-technology, b) linear, c) waterfall, and d) iterative. Adapted from Bhalla (1987), Phaal et al. (2003), Stillman (1977), and Khalil (2000), respectively.

The focus gets sharper phase by phase, whereas in the linear process each step manipulates the same information ”volume”. The waterfall also underlines the independence of the phases, even though there are typically iterations.

The most complicated is the iterative process, example d) below, which has several activities, many iterations and complex relationships.

We will not evaluate the characteristics, usage or applicability of different types of processes here. As mentioned, KONE already had most of the practises and tools of MoT in use. We did not want to force those into a ”foreign” model from the public domain, but rather wanted to create our own that reflects, fits and supports the KONE way of working and culture. Creation happened by taking the already existing processes and tools, developing them further, and adapting the missing parts from the public domain as appropriate.

Development activities in general are usually visualized by a process, so it was only natural that the author selected a process as a means to model our MoT. The aim was to develop a comprehensive, integral process all the way from business challenges and strategies down to individual product development projects and implementations.

The reader must bear in mind that the following examples (*Figures 9 to 11*) were the first drafts, and thus lacking many essential activities at that stage of modelling.

The author started to model the framework with the widely-used data flow[1] diagram notation (*Figure 9*). Along with that, we modelled the related data with a data dictionary.

The attempt was not satisfactory.

Data flow diagrams are hierarchical by nature, meaning that the lower level, and stepwise more detailed, diagrams refine the activities of the higher level until the presentation is detailed enough. It also means that the most important processes and data must appear at the top level, the second ones on the subsequent level, and so on. The author ran into problems because some of the activities considered essential were submerged inevitably deep down in the hierarchy.

It was also difficult to construct logical flows of information between activities; it was in some cases difficult to define one activity's output as the next activity's input. There were also difficult-to-model iterations and recursions.

A data flow model could have been constructed quite easily for a single, separate development, but several parallel, overlapping activities each in a different stage caused problems. Moreover, it appeared that some of the activities seemed to be orthogonal to others. Also roadmaps, represented by

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[1] *Some call them "process flow" diagrams, but data flow is more appropriate, because the visualization consists of activities illustrated as squares, and the data as arrows flowing between them.*

data storages, did not easily find their natural places. It was not obvious to identify the processes of the right level that manipulate them.

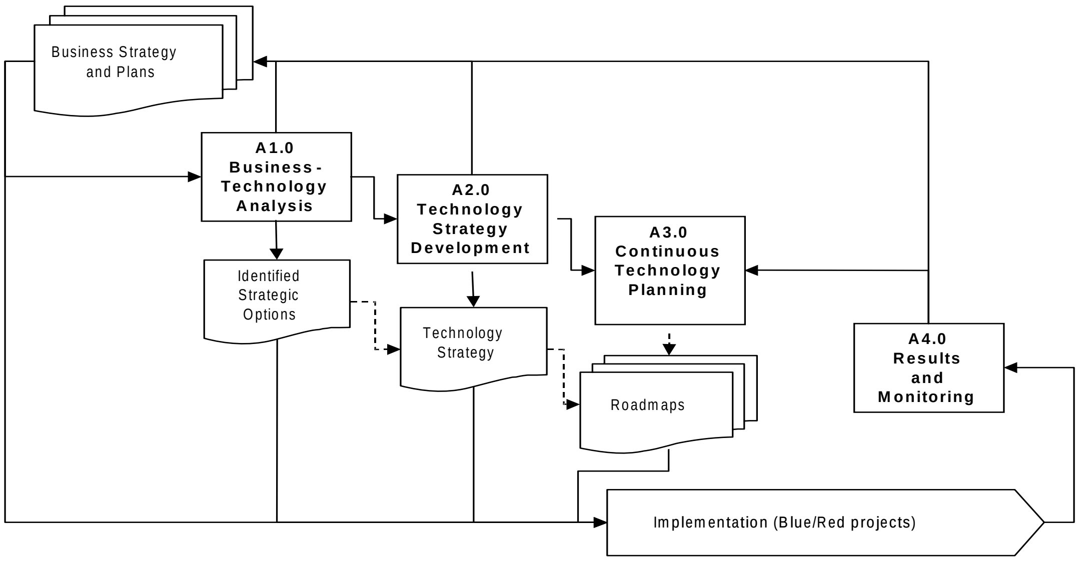

Figure 9. Top level of the first attempts to create a data flow model.

It is not that a data flow diagram could not have been constructed at all, but the author was not satisfied with the results. That led to another attempt; modelling MoT as a refining chain (*Figure 10*).

It was quite soon revealed that this was an over-simplistic view. It was one-way. There were no iterations, and interactions between the players were few even though we knew they were happening in reality.

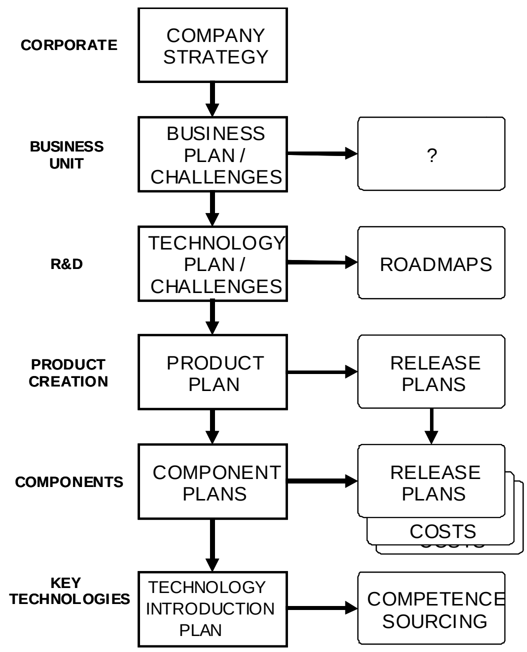

Figure 10. An initial draft to model MoT as a stepwise refining chain from strategy to technology introduction.

As mentioned, a data dictionary was constructed along with modelling the process as a data flow diagram. A hierarchical data dictionary developed relatively easily, so it was only natural to try to raise it into focus. We also identified the different organizational levels responsible for individual plans. That led to the third attempt; to modify the data flow model into an activity-based diagram (*Figure 11*).

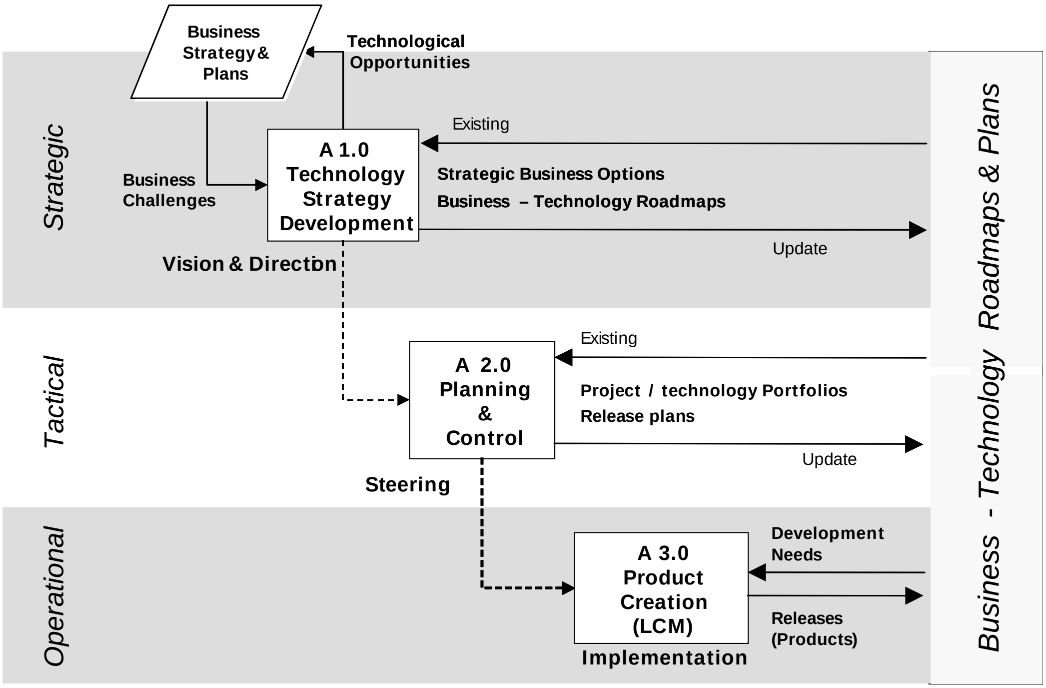

Figure 11. Top level of an attempt to produce an activity-based model.

An activity-based model is quite similar to a data flow diagram. It is hierarchical, and has activities and data flows. It differs in that the activities do not have a certain strict order of execution. The dotted lines between activities symbolize that. Activities are continuous and parallel in nature, and they are autonomous. Still they are strongly linked together and each activity's input is focused on information from an upper-level activity in the hierarchy. As there is no strict order of execution, there must be some other means, e.g. milestones, to synchronize the activities.

Another difference to data flow diagrams is that each activity has a clearly characterized purpose, nature, and location. Here they are allocated to three different management levels: e.g. strategic, tactical, and operational, according to their characteristics.

We ran into similar kinds of problems as with the data flow earlier. The top level was easy, but breaking down into lower levels proved problematic. The model appeared also to be too activity-centred; activities were dominant in the illustration, with the most important items, roadmaps, playing a secondary role.

As we had realized the importance and essential role of information being illustrated in roadmaps, it was tempting to model MoT as a dualistic counterpart to a data flow model – an activity flow. The notation in the two models is the same, but processes and data swap places: data are squares, and the processes manipulating them are the arrows between. The aim was to bring data and roadmaps also visually into focus, placing them in a central role.

The attempt did not prove satisfactory for the same reasons as the original data flow. The hierarchy caused problems, there were internal conflicts, it was difficult to craft a natural single flow from beginning to end, and so on.

3.1.2. Constructed Model

The enlightenment, and finally the resolution, came from the experience gained in previous modelling attempts and from several other directions.

- First, roadmaps appeared to be clearly the essence, they are the tools of MoT. It is natural to bring them into focus, and take a roadmap-centric approach.

- We had a pretty good idea what tools were needed to define technology strategies and their implementation. In fact, we had already used all of them, with very few exceptions. We had constructed a comprehensive data dictionary defining the tools and their relationships. Maybe it would be beneficial to reverse the viewpoint and examine what activities or processes are needed to produce the needed plans, specifications, and other artefacts.

- The three levels in the activity-based model helped us to understand the role and use of different activities. Those levels should be incorporated in the model to clarify the focus of individual activities.

- Why "force" activities, or separate, individual processes, into a rigid chain if they do not fit in there naturally?

- It is important not only to show the MoT framework, but also how the end results are implemented. Adding the operative business process to the illustration helped to understand how MoT positions and relates to it.

These insights resulted in the roadmap-centric model shown in *Figure 12*. We will now study its structure, processes and roadmaps in more detail.

The attempt to create an activity-based model gave us the idea of a three-layer, or three-level, structure with strategic, tactical and operational levels. The levels have the following characteristics (Talonen & Hakkarainen 2005):

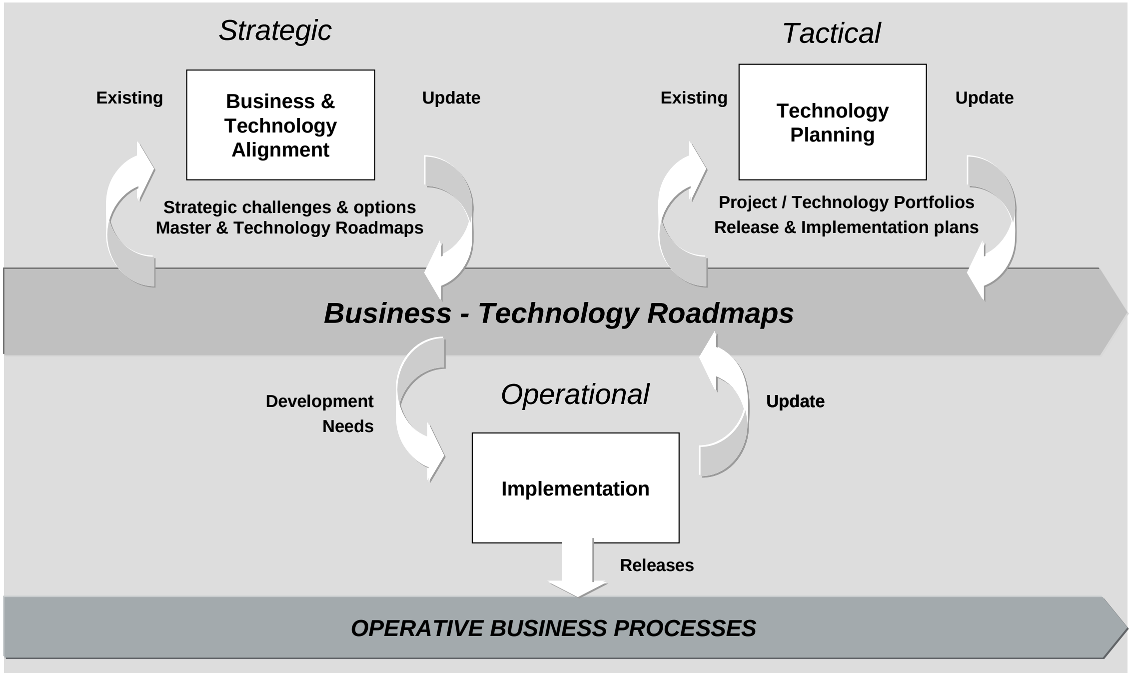

Figure 12. Top level of the roadmap-centric model.

1. Strategic Level – Strategy positioning and generation

- *Essence:* strategic positioning, renewal
- *Driver:* changing business challenges
- *Analysis:* business opportunities – strategic options – technological competencies
- *Tools:* competitive, product and technology strategies, business roadmaps

2. Tactical Level – Continuous planning and adaptation

- *Essence*: continuous planning and strategy adaptation
- *Driver*: mid-range strategic agility
- *Analysis:* customer segments – product offering and platform evolutions – technological alternatives
- *Tools:* product and technology roadmaps and portfolios

3. Operational Level – Implementation

- *Essence:* strategy implementation, technology and product development
- *Driver:* time-to-market, effectiveness, productivity, quality
- *Analysis:* customer needs – product specifications and platform definitions – project scopes
- *Tools:* projects, technology and product development process, organization development

KONE has had well-defined processes for the operational level for well over ten years. Strategy positioning and generation has also been practised for a long time, if in a less defined and standardized manner. The new aspect was the tactical level, which is also often overlooked in literature (Talonen & Hakkarainen 2005).

The division into three levels has similarities to the steps of strategic programming that Mintzberg (1994) promotes:

- **Codification**: clarifying and expressing the strategies in terms sufficiently clear to render them formally operational.
- **Elaboration**: breaking down the codified strategies into subcategories and ad hoc programs as well as overall action plans specifying what must be done to realize each strategy.
- **Conversion**: considering the effects of the changes on the organization's operations.

Having three separate levels with different characteristics and purposes helps to focus the interests and efforts. Take for example, the tactical level that serves as "glue" between the strategic and operational levels. Its role is crucial in linking operational work to strategies in practice. As a Senior Vice President, Technology, in our company stated at a review meeting:

> *"This model reveals a central problem in our management.*
> *After a short contribution on long-range strategic planning*
> *our discussion shifts quickly into acute and short-term operational issues*
> *completely isolated from strategic intents.*
> *We have had a lack of a tactical level that links operational activities with strategy."*

One has to understand that the above does not mean adding another functional level. The three levels discussed, are "virtual", and postulated to clarify the different roles of activities and focus their efforts.

Each of the layers has several processes. When constructing the model, we had already completed the tool dictionary defining the roadmaps needed. We knew what types of plans and information are needed in practising MoT. We turned the approach around, and started to define what kinds of processes were needed to produce those roadmaps. Most of the processes already existed, so the main task was to find natural places for them. Only portfolio management and roadmapping, although practised, did not have a defined process suitable in this context.

We also soon realized that there is no need to force the model into a set of subsequent processes, or to create artificial linkages between them. The result is as shown in the example of the tactical level presented in *Figure 13*. The two other levels are discussed elsewhere.

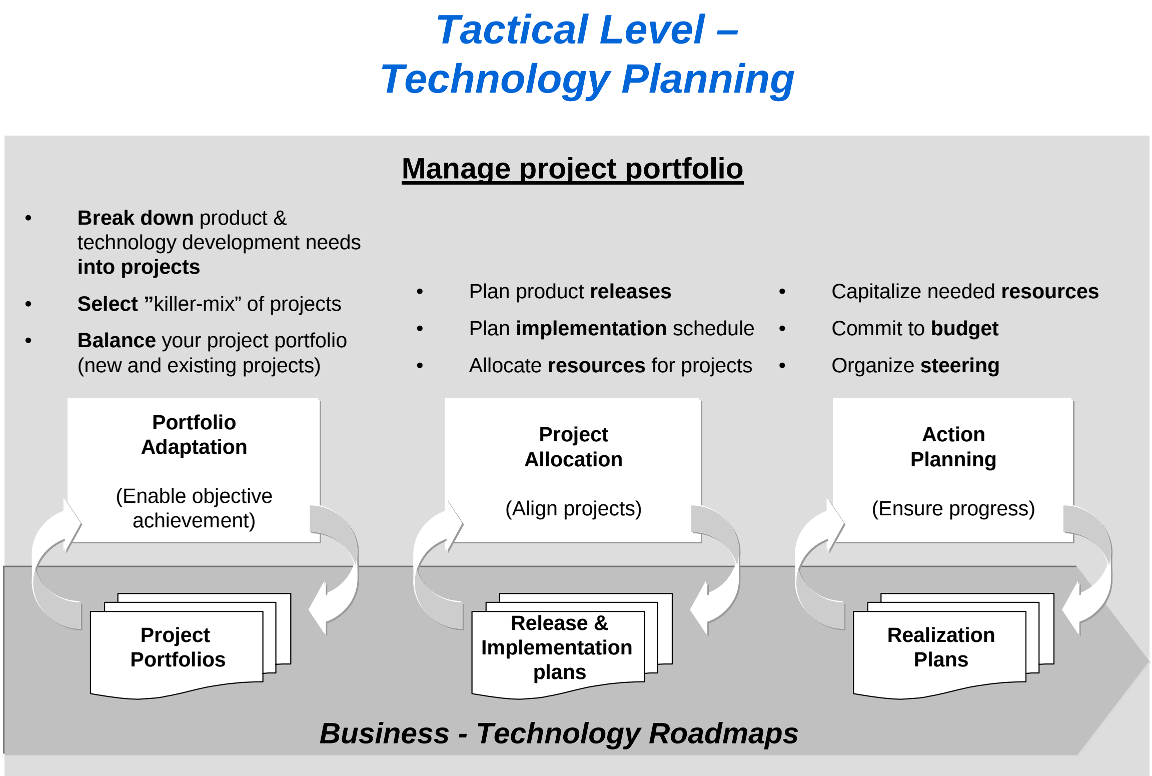

Figure 13. Processes at the tactical level.

The "backbone" of the model consists of Business-Technology Roadmaps. They are like a mutual archive room including the entire collection of information and artefacts needed to define, plan, and implement technology strategies. The collection consists of business strategies, project portfolios, product release plans, platform evolution plans, plans for product development projects, etc.

The arrow shape in the figure symbolizes that it is a rolling and living plan, is constantly evolving and that it is updated as frequently as needed. There are no annual mid-range planning or budgeting cycles, but the idea is rather that the roadmaps are constantly up-to-date.

The principle of continuous planning and constantly evolving roadmaps supports Mintzberg's (1994) thinking: *"… strategies often cannot be developed on schedule and immaculately conceived"*.

The processes are independent and parallel, and iterative and recursive by nature. There is no specific chronological order, but the processes "live their own lives". There are no direct links between the projects. The Business-Technology Roadmaps provide the connection needed. The processes manipulate and refine pieces of the common information entity from different directions and for different purposes. They get their input information from the Business-Technology Roadmaps, process it, and return the results and updates there.

The most important of the processes is Business-Technology Mapping at the strategic level. It structures the important external and internal developments and objectives into business and technology roadmaps. That is where the existing and planned actions and other initiatives concretise into strategies. The top-level is called the master business-technology roadmap that draws the big picture: what is happening in markets and the competition, and how we are going to react to that. There are more detailed, subject-specific roadmaps that refine those, e.g. a technology introduction plan declares what product technologies, from where and when, are needed to support the overall strategies.

The other processes at strategic level (MoT analysis and Blue Box studies) process and refine information for business-technology mapping. They are discussed in more detail in Chapter 3.4. The processes at tactical level

(*Figure 13*), and at operational level (*Chapter 3.3*) in turn use that information in executing strategies. Tactical level processes break down the developments and initiatives decided upon into projects, manage the project portfolio, and the operational level implements them. It is essential to keep the roadmaps up-to-date. Once a plan or portfolio is updated, or a project started or completed, the roadmaps are updated accordingly.

Mintzberg warned about systems that are too strictly formalized. Our structure of loosely coupled, quite autonomous processes aims at avoiding the pitfall he talks about (Mintzberg 1994): *"Systems do not think, and when they are used for more than the facilitation of human thinking, they can prevent thinking."*

One can easily understand that management is not a single, end-to-end process, but is rather about taking necessary measures in a changing environment. Management at large cannot be modelled by, or locked into, one continuous process, however complex.

After all, the management of technology, by definition, is management. As Matthews (1992) states *"The 'management of technology' is, like all other management, ultimately the management of people and the processes of communication and decision-making that determine success or failure."*

There is no dedicated "technology management department", but the activities are carried out by those responsible for them or their artefacts in the organization. They are, after all, the best experts on the subject matter. It is also very much a question of commitment, at least as much as skills. Even if slightly over-generalized, the owner of the strategic level is the business unit (or its manager, in practice), the owner of the tactical level activities is the R&D organization, and individual development projects run the operative level.

Neither is there a separate control function, but it is built in. The idea of constantly up-to-date plans poses a challenge for managers. It does not mean that there are no management audits; on the contrary, there must be emphasis on monitoring and business consequences. The audits are normal business audits. The auditor cannot be an individual MoT process owner, but can be the process owner and the one he/she reports to together. The business owner and corporate senior management audit the strategic top-level master roadmaps. That may happen once a year during the corporate mid-range planning cycle, with a revision during budgeting. The Vice President, Technology, and the responsible technology manager audit the more detailed technology roadmaps. The same principle holds for other subject-specific roadmaps. The auditing cycle is similar to master roadmaps.

The Vice President, Technology, and R&D management audit tactical-level project portfolios. The main audit falls naturally into the budgeting period, with a revision during mid-range planning. R&D management audits individual projects jointly with project managers. There is a well-defined, concurrent engineering model with milestones and their auditing process.

Participation from different organizational levels is in line with Mintzberg (1994): "*… strategy making is a process interwoven with all that it takes to manage an organization*" and "*… must necessarily be carried out by people at various levels who are deeply involved with the specific issues at hand.*"

Even though there is no single process from beginning to end, the roadmaps create a logical path all the way from strategy down to individual developments *(Figure 14).*

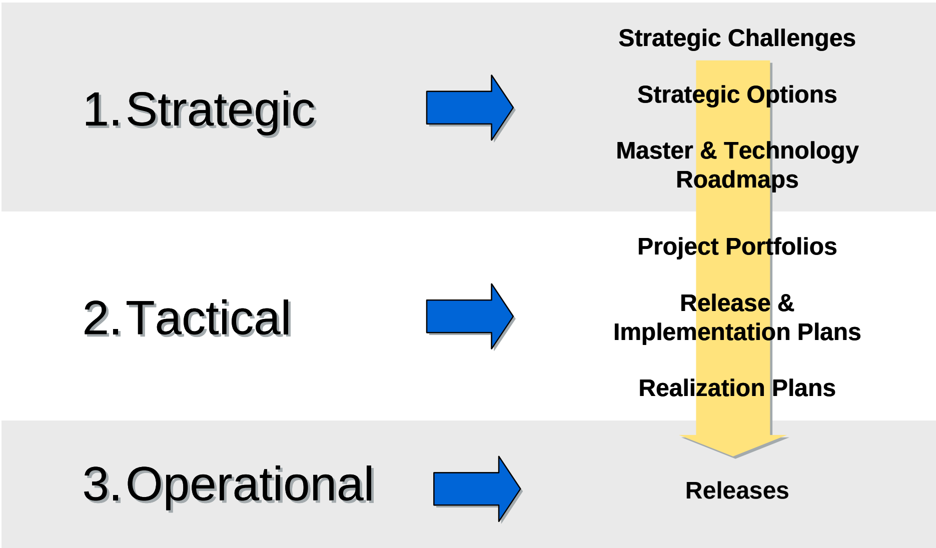

Figure 14. Logical breakdown from strategic challenges into individual projects.

As mentioned earlier, the basic idea for roadmaps is to form a living plan that should be constantly up-to-date. Parallel funding and budgeting takes place at the tactical level. Project portfolios contain both the existing and new projects. They provide the basis for funding over a time span of three years. Realization plans are draft project plans of each individual project including preliminary schedule, resource allocation and costs. These plans are the basis for annual budgeting. The draft plans are revised and refined into a project plan before a project starts.

Annual planning and budgeting cycles can be time-consuming and laborious if started from scratch and compiled bottom-up from individual projects, as is often the case – at least in budgeting. Put simply, the information needed for corporate-wide planning is a snapshot of up-to-date working plans. The items (*Figure 14)* related to the prevailing traditional corporate annual planning cycles are:

- Strategy creation: *Strategic Challenges, Strategic Options, and Master & Technology Roadmaps*
- Mid-range planning: *Project Portfolios and Release and Implementation Plans*
- Budgeting: *Realization Plans*

The tool set available for roadmaps is defined with a data dictionary notation. The notation is commonly used, and its definitions are easy to find, e.g. (Calpoly 2005*).* The notation is hierarchical by nature, and has two different kinds of items: composite data and elemental data. Higher-level (composite) elements may be defined in terms of lower-level items. Elemental data are items that cannot be reduced any further.

Composite data can be constructed in three ways: sequence, repetition, or selection of other data types (Calpoly 2005):

sequence: **+** A plus sign indicates one element is followed by or concatenated with another element.

repetition: **[ ]** Square brackets are used to enclose one or more optional elements.

| A vertical line stands for "or" and is used to indicate alternatives.

selection: **{ }** Curly braces indicate that the element being defined is made up of a series of repetitions of the element(s) enclosed in the brackets.

For example, the highest-level definition of the roadmaps looks like the following (*the text between asterisks (* *) is an explanatory comment*):

Business – Technology Roadmaps =
* *Business & Technology Alignment**
\+ Strategic Challenges
\+ Strategic Options
\+ Master & Technology Roadmaps

Technology Planning
\+ Project Portfolios
\+ Release & Implementation Plans
\+ Realization Plans

Implementation
\+ Releases

This definition declares that business-technology roadmaps consist of strategic challenges, strategic options, and master & technology roadmaps at the strategic level; project portfolios, release & implementation plans, and realization plans at the tactical level; and releases at the operational level.

Master & technology roadmaps are further refined as follows:

Master & Technology Roadmaps
= Business Scenario
+ Master Business Roadmap
+ Technology Scenario Forecast
+ Product – Technology Roadmap
+ Product Mix
+ Product Release Plans
+ Product – Component Roadmaps
+ Technology Sourcing Plan
+ Competence Plan

Refinement of higher-level composite elements continues until the elemental level is reached and an item cannot be subdivided any further:

Technology Sourcing Plan
= Technology Definition
+ Technology Introduction Timing
+ Technology Source

Technology Source
= [In-house | Buy | License | Partnership]

Now the elemental level items, or lowest-level composite items, represent tools. The data dictionary notation defines the role and place of each of them, and their relationships; thus also providing traceability between different plans, specifications, releases and other information.

Traceability declares how plans, developments, and other items relate to each other:

- What projects are needed to realize a certain part of strategy?
- Or vice versa: What is the purpose of this project? What part of the strategy does it implement?
- Or: For which technology introduction do we need to develop these competences?

The simple reason for using data dictionary notation to begin with, was to quickly and without too much effort write down the available set of tools. A more powerful expression, e.g. XML, would have enabled the use of attributes to declare the characteristics of the tools and their relationships.

An example of stepwise refinement and traceability is given in *Figure 15*.

The master business-technology roadmap draws the big picture: what is happening in markets and the competition, and how we are going to react to that. The product-component roadmap visualizes the alternative solutions and plans for some of the items on the master roadmap. The technology introduction plan declares what product technologies, and from where and when, are needed to support those plans. And the product development roadmap declares and schedules the projects needed to implement the plans mentioned.

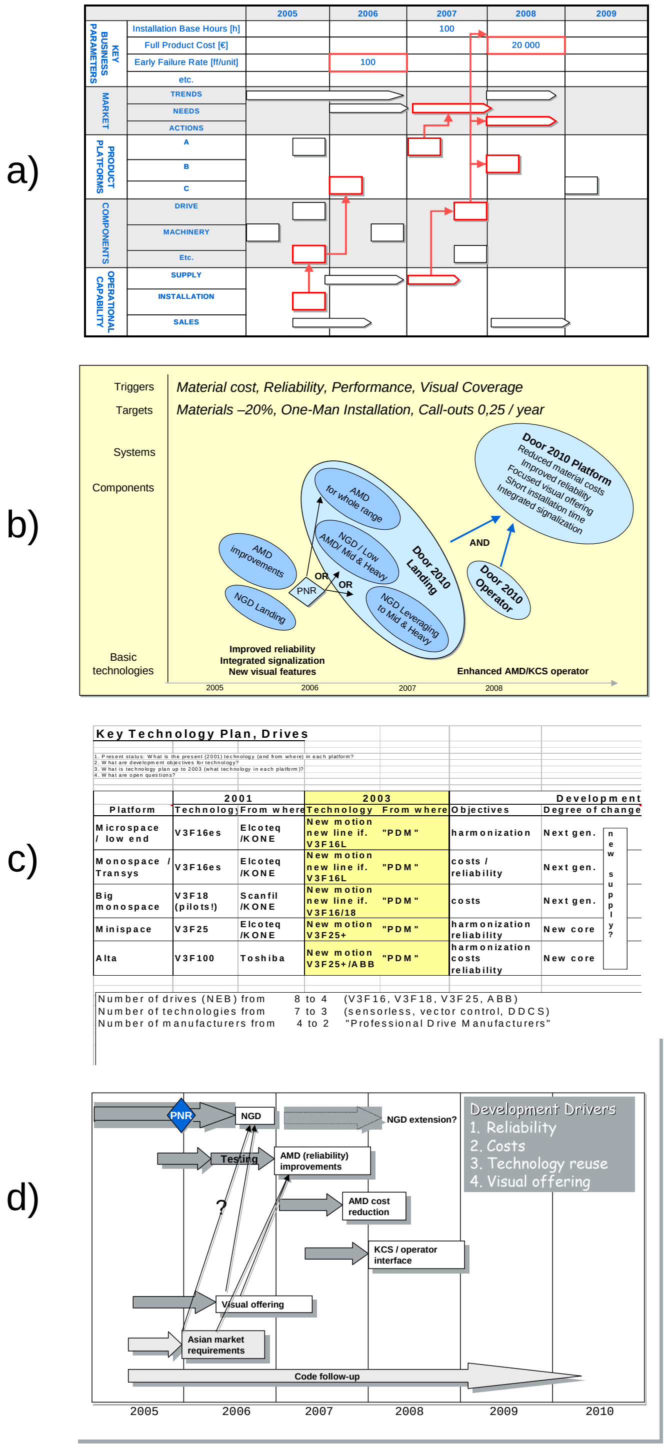

Figure 15. Example roadmaps: a) master business-technology roadmap, b) product-component roadmap, c) technology introduction plan, and d) product development schedule.

Individual processes are rather independent and loosely coupled by business-technology roadmaps. They do not have a predefined sequence, but even so their place in refining, modifying and transforming data is clear. They have defined roles, and for each of them there is a definition of what the inputs are, what tools and methods to use for processing the information, and what the outputs are. The processes and their contribution in technology management are depicted in *Figure 16*.

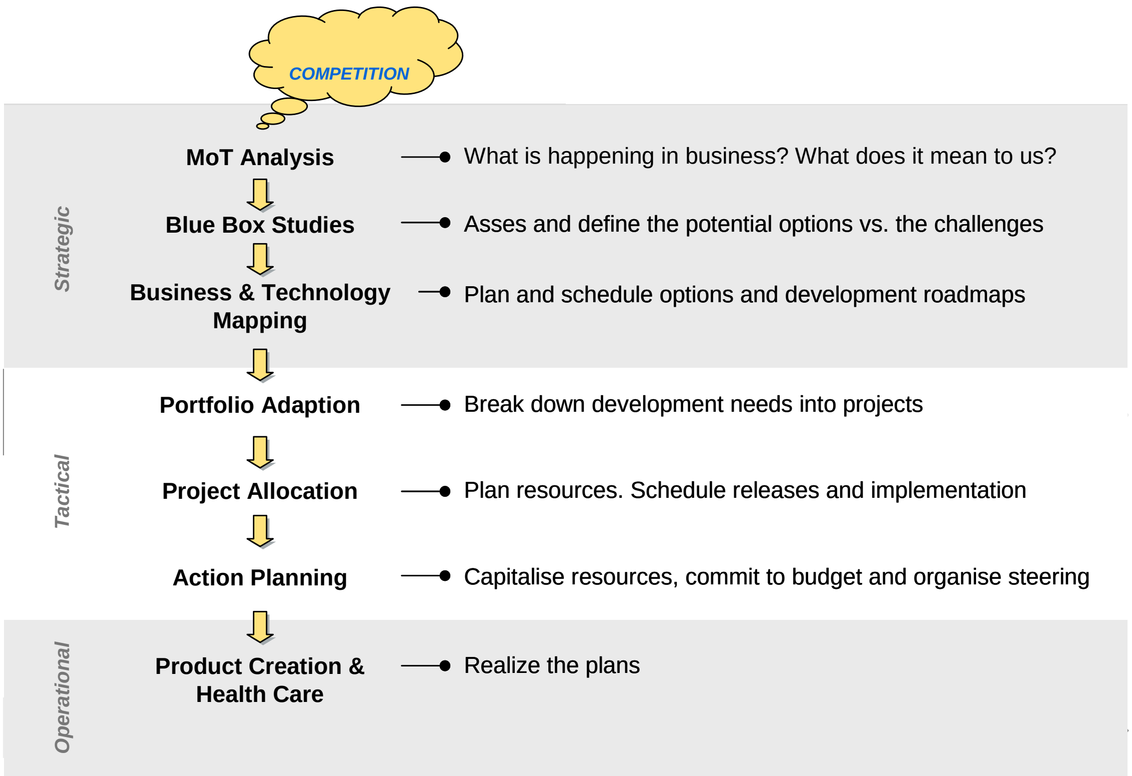

Figure 16. MoT activities and how they gradually refine information.

The author warns about mistaking the illustration as a process in reality. Its purpose is to show how the activities at different levels accumulate and refine information. It is a generic presentation. It does not exhibit activities for refining the same body of information, because that would mean that there is one, rigid process with predefined steps following a predefined order. That would be too rigid, inflexible and slow in any business. As already mentioned, the activities are independent, loosely coupled, and constantly running in a parallel, recursive and interactive manner.

3.1.3. Characteristics

In summary, the management of technology framework constructed is simple, elegant, comprehensive and theoretically sound.

Simplicity is important so that the model, its use and mechanisms can be understood. The framework is elegant in that it suits the KONE way of working and organizational culture. The model is comprehensive both horizontally (containing all the processes needed, with related tools and definitions) and vertically (there is a clear path top down from strategy all the way to individual implementation projects). It is theoretically sound, and a workable framework for the company's purposes. This will be examined further when discussing validity, reliability, objectivity and applicability.

In conclusion, the main characteristics of the model presented are the following:

- It is a comprehensive and holistic model covering all the aspects and activities of MoT.

- There are three levels: strategic, tactical and operational. The division into levels helps in focusing interest and defining the different roles of activities. Especially important is the inclusion of the tactical level, which is commonly overlooked in the literature. Its role is crucial both in detaching, and at the same time providing connection, between the two other levels.

- Roadmaps are the backbone of the model. They are the tools of MoT. A tool dictionary defines an exhaustive set of available roadmaps, their contexts and relationships. There are also templates with explanatory examples for every tool, together with instructions for its use.

- The processes have clearly defined roles in refining the information, are rather independent, and are loosely coupled. They occur in parallel in an iterative and recursive manner. The aim is to escape the trap of strictly scheduled events in a rigorous sequence, which results in an inflexible mechanism.

  The roadmaps should evolve constantly and always be up-to-date. There are no annual planning cycles in order to avoid the paralysing effect of tightly formalized, repetitive exercises.

- MoT is not institutionalised to dedicated people, but those actually working on it come from various levels of the organization and are deeply involved with the issues involved. This is to avoid the risk of isolation and problems in commitment.

- Neither is there a separate control function, but it is built in. The management audits are normal business audits for monitoring progress and business consequences.

3.2. Got Lost With a Roadmap?

A good plan is like a road map:
it shows the final destination and usually the best way to get there.

H. Stanley Judd, American author

Business and technology roadmapping is a widely adopted practice in business. Roadmaps come in many forms and shapes, but usually there is a visual illustration with a time dimension. A generic roadmap proposed by EIRMA is shown in *Figure 17*. It has different layers, presenting the developments and evolution in competition, markets, products, technologies, etc., and the relationships between them.

It is easy to intuitively understand the benefits of roadmapping in communication, sharing information, and creating mutual understanding. However, one cannot achieve the real business impact without really understanding the role and purpose of roadmapping – and knowing what, why and how to do in practice.

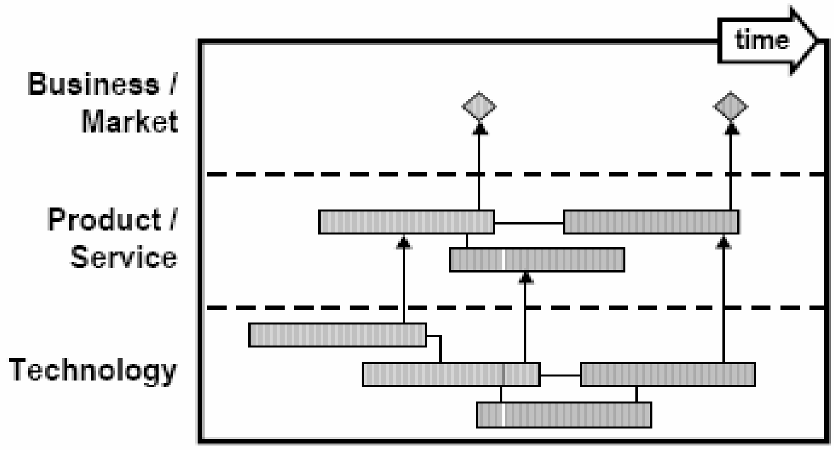

Figure 17. Schematic technology roadmap, showing how technology can be aligned to product and service developments, business strategy, and market opportunities (Phaal, Farrukh & Probert 2001).

The principles and practises are often loosely defined or missing in literature. What is the input information, what are the processes, what are the outputs, and most important, how does roadmapping link to the rest of technology management? In fact, the very original paper by Willyard & McClees (1987) is still one of the best and conceptually most coherent. As Phaal et al. (2001)

rightly state, "*One of the reasons why companies struggle with the application of roadmapping… is that there is little practical support available and companies typically re-invent the process*".

Most strikingly, even as essential an aspect as the purpose of roadmapping is not defined; or worse, is misunderstood. Of course it is for communication and mutual decision-making, but what is its *raison d' être*? What is its fundamental motivation and justification? Even Phaal et al. (2001), in their otherwise creditable article, trip up by stating: "*A key benefit of roadmapping is the sharing of knowledge and the development of a common vision of* ***where*** *the company is going*".

That is not right, and it is easy to demonstrate so with the following narrative of roadmapping and its processes by drawing an analogy to orienteering. In our orienteering team there is a group of people with individual skills supporting and complementing each other in moving ahead towards a mutual destination; similarly in roadmapping there is a group of business and process owners working towards a mutual goal.

The author is examining strategic level (master) business-technology roadmapping, but the principles and procedures are also valid for other types of roadmaps. The focus is on creating, updating and using a roadmap in business planning.

3.2.1. Preparation

When orienteering, one can buy a map. One cannot buy a business roadmap, but must prepare it oneself. Basically it illustrates the competitive situation and its anticipated development; competitors' actions and our countermeasures. A simplified illustration of the master business-technology roadmap we have used is shown in *Figure 18*.

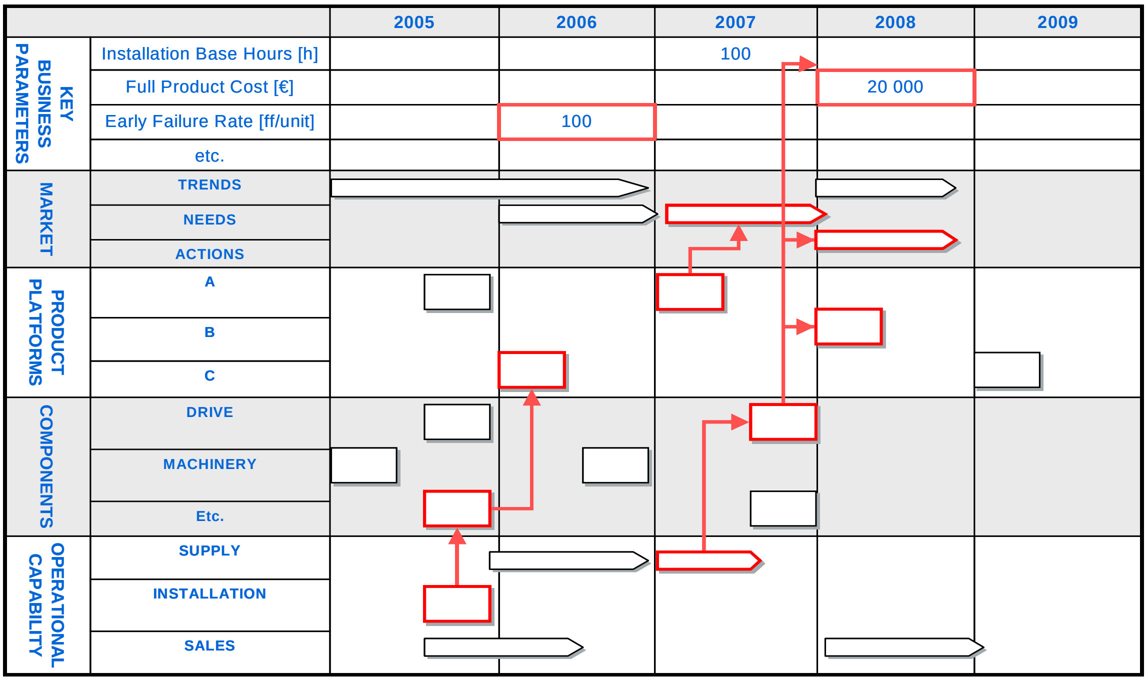

Figure 18. A simplified example of a master business-technology roadmap.

We start by defining the viewpoint.

The vertical dimension, i.e. rows or layers, represents markets, competition, product platforms, technology, processes and other aspects important to business. The layers may vary according to the viewpoint. The viewpoint of a master business-technology roadmap can be based on the entire business, a business segment, market area, or product platform, depending on the purpose and need.

The horizontal dimension represents time. The time span varies, but for a master roadmap it is typically around five years. The visibility of the planning horizon specifies the exact span; the near future may appear quite sharp, but also the more blurred distant future should be outlined as far as possible.

One needs a coordinate on a roadmap to be able to orienteer. One coordinate is time, and the other is comprised of key business parameters. By key business parameters we mean the product and company performance attributes that enable business. They address the most essential priorities in technology and product development in the long-term, and indicate technological progress. In the manufacturing equipment business, for example, the key business parameters could be production costs, product performance, installation time, set-up and ramp-up time, and so on. The list is of course exemplary, not exhaustive, and the parameters depend on the type of industry, and the roadmap at hand. Note that in this definition parameters such as sales volumes or market share are not key business parameters, but the results of achieving them. Key business parameters should not be too numerous, but merely a handful that determines success in business.

The two coordinates span our sphere of operations. Using them we can fix our location on the roadmap, and thus define the distance and direction from the departure to the destination.

The next step is to map the terrain. This is done by placing significant developments, milestones, objectives and other essential events on the corresponding rows. It is important to draft the developments in markets, as well as competitors' actions as far as they can be anticipated. Critical or otherwise important relationships between items should be marked on the roadmap. The items and their relationships constitute the possible routes through the terrain.

The values of the key business parameters over time define the intermediate goals. The objectives of independent developments should contribute to those, and only those. One must remember that the master roadmap is a summary and generalization, and that more detailed roadmaps exist with related sub-objectives for separate processes, functions and developments. Generalization also means that the master roadmap should consist only of items that are important at that level. Importance here means that they directly contribute to the key business parameters, or have significant relationships with other items on the roadmap.

It is very important to illustrate alternative developments. How otherwise can one take another route when changes occur or one encounters surprises? One must also map the terrain more widely than just the tentative route. If we draft only the route, how can one fix the position? We need to include internal and external events; they are our points of reference.

Now we have a map of the terrain, our destination defined, and potential routes outlined, it is time to select a favourable route. It may be the shortest, fastest, least risky, or most energy-saving, depending on the objectives and circumstances.

The process we follow in a master roadmapping session in practice is described next. The participants are a) the business owner chairing the session and b) representatives of the functions and processes presented as rows on the roadmap. Let us call the latter "process owners" for simplicity's sake. The agenda for a session is the following.

1. **Define the Critical Business Challenge** – *Business owner*
   Present the critical business challenges of the market area / for the platform under discussion. Explain the objectives in terms of key business parameters.

2. **Present the Objectives of the Lateral Functions** – *Process owners*
   For each of the lateral functions (marketing, supply, installation, technology, organization, support processes, etc.), define the general objectives (what, why important). Identify the essential scheduling: milestones, releases and developments. Explain why they are important and what their benefits are.

3. **Define Critical Fixed Points** – *Process owners*
   For each of the lateral functions, identify and highlight on the roadmap the milestones, releases, developments and other critical points that have little or no degree of freedom (or flexibility) in timing, context or objectives. Explain what the strict constraints are and why.

4. **Identify Conflicting Objectives** – *Whole group*
   Identify and highlight on the roadmap the potential conflicts between critical points or between objectives.

5. **Conflict Resolution** – *Business owner*
   Set up a task force to resolve the conflicts (outside the meeting). Decide where, when and how the solution will be reviewed.

6. **Summary and Conclusions** – *Business owner*
   Conclusions of the meeting. Practical arrangement for working out unresolved questions . Next steps. Next meeting.

There are a couple of noteworthy principles for our session practises that are worth mentioning here.

First, homework. The roadmap has been compiled, or a previous version modified, in advance of the input from the business and process owners. This frees the participants to concentrate on the essentials during the session. It requires preparatory homework, which is also good preparation for the participants.

One cannot rely on internal sources only when collecting and processing business intelligence into working knowledge, but must use external resources. Company internal information on business is biased by beliefs, hopes and fears. It is not neutral, but inevitably mirrored against competitors. This is also true, maybe even more so, for the business intelligence related information of one's own company.

Second, participants. We have not allocated roadmap creation to a dedicated "roadmapping department". The process owners themselves are the best experts on the subject matter, and they commit to the plans during the process. As Mintzberg (1994) points out, strategy creation in general cannot be institutionalised. It tends to get formalized, paralysed and isolated from the organization. The roadmapping session itself is so simple that it does not need outside facilitation.

There is a danger of constructing and evaluating a roadmap with participants only from inside one's own organization. The participants tend to have similar backgrounds, similar expectations, and so on. It does not necessarily lead to a very creative plan, but rather to preserving the status quo of prevailing thinking. It may also result in a mutually biased view of a company's future. It is beneficial to have external experts or advisory committees, at least to challenge a created roadmap.

Third, the nature of the session. The main purposes of the roadmapping session are communication, creating mutual understanding, and getting commitment. The most important is mutual understanding, without which it is impossible to get commitment. The primary objective of our sessions is to create a mutual understanding, all the way through to the extreme situation in which the team does not share a common opinion (which naturally must be worked out in due course).

Roadmapping sessions are not for resolving conflicting objectives. For that reason, we set up specific task forces to work out those that appear. Usually the task force consists of the process owners involved in the conflict. They work out a solution, which is presented in the next session, or communicated otherwise as needed. The solution may not come through goodwill, since stakeholders have different, even conflicting, objectives and agendas. It is the business owner who is in the end responsible for it.

3.2.2. *En Route*

Let us get back to our orienteering analogy. There is a team of people with individual skills. Some are specialists in crossing water, some in building bridges, some in climbing, and so on. They complement each other in striving towards a mutual destination; in a similar way to what process owners do in business.

The team is ready to go. They have a mutually agreed common objective, a destination. They have an orienteering map, on which they plan their route from departure to destination. With this analogy it is easy to understand that a map with a planned route does not represent where to go, but **how to get there**.

One can quibble that a roadmap shows the destination, but that is not the *purpose* of it. If a map were about *where* to go, a picture of the destination, its coordinates, or a map of its close vicinity would be sufficient. There would be no need for a map between the departure and destination.

Once en route, the team observes things that are not on the map. At best, a map is a generalization of reality and does not contain all the details. It may include erroneous information, and in any case a map, either an orienteering or business roadmap, is outdated the very instant it is published. The environment changes. The team may observe things that affect the route selection, points of reference that help in orienteering, maybe even something about the destination. When should a roadmap be updated?

Most commonly it is proposed that roadmaps are updated on a periodic basis, at least once a year (e.g. Phaal et al. 2001). This has serious shortcomings. The information is inevitably old. New, important information may surface immediately after the update, and has to wait a whole year, in the worst case, to be taken into account.

There is also a fallacy of prediction (Mintzberg 1994). He states "… *the world is supposed to hold still while a plan is being developed and then stay on the predicted course while that plan is being implemented*." How can our orienteering team know whether a bridge on the map has not possibly collapsed? Maybe one realizes only on the spot that an alternative route would be more favourable. In fact, no military body would send troops into unfamiliar territory without sending a scout to clear the way up front. And neither should any business do that, because there might be sudden disruptions in the terrain.

Lockstep schedules also have a concomitant problem. Mintzberg (1994) continues "*How else … have strategies appearing on the first of June, to be approved by the board of directors on the fifteenth? One can just picture competitors waiting for the board's approval…*"

Mintzberg (1994) highlights still one more problem with periodic, scheduled processes: they tend to get formalized and thereby paralysed, as many have witnessed in their work. They even may get carnivalised, as a senior manager confessed in his hilarious comment (Foster & Kaplan 2001): *"Our planning process is like some primitive tribal ritual: There is a lot of noise, dancing, waving of feathers, beating of drums, and no-one is sure exactly why we do it, but still there is an almost mythical hope that something good will eventually come of it, and it never does."*

Another school, especially favoured by roadmapping tool providers (e.g. Alignent 2005), suggests continuous updating. The problem here is that the roadmap changes constantly; it oscillates. It does not freeze. Naturally one has to collect and store new information, but not to change the route unless it is imperative to do so. Replanning needs extra effort, takes time, and adds risks. And moving ahead is suspended in the meantime.

The situation is still worse if the updates are done with collaborative software tools where individuals may add to the roadmap on their own initiative. How to prevent the adding of items that conflict with existing developments or developments planned elsewhere? Defining and altering the route, or parts of it, is a mutual agreement and should be done as a team.

Further, when using collaborative tools, how to guarantee that all the team members have the same information? Of course the tools have workflow support, signalling for new updates, and so on. But in a real-life business environment people have several other challenges to take care of, and do not thus necessarily have the time or possibility to check every change at the due time. This leads to a situation where different parties have different conceptions of a roadmap.

The providers of roadmapping software tools justify – and market – their collaborative products by arguing that this is the only way to have up-to-date, real-time information available to all the stakeholders in a fast-changing business environment. In reality, no business is so hectic that the plans need continuous updating on a daily basis. If so, something is seriously wrong! It is strategy and the corresponding planning horizon that we are dealing with.

The third possibility for updating, and the most important one, is at the end of each intermediate leg. This is virtually overlooked in roadmapping literature, even though it is an essential action of a business owner in practice, and is presented in general and especially in project management literature. Once completing a leg, the team verifies its position in the coordinate system, i.e. in relation to time and the key business parameters. The aim is to check that the direction is right, that progress is as planned, and then to plan the route for the next leg.

This is in fact what athletes do. The author asked an orienteer competing at international level when and how he selects the route. His answer was clear: "Leg by leg. Never the entire route. One selects a route for the next leg, and once completing that leg, for the following one." He added: "Never change the route in between. One must focus one's concentration on following the selected route and on moving ahead as fast as possible. Nothing may disturb that."

And he continued on his own initiative: "The most important thing in selecting the route is to approach a control point from the right direction." One should approach from a direction where there are clear points of reference close to the control point. One selects the route so that the control point can be noticed easily from the selected direction of approach. And there should be easily identifiable topographic formations behind the control point, in case one misses it in the first place. Approaching from the right direction is the most important thing, because running wide, and later trying to locate a control point, is too time consuming. It is extremely difficult to do this later. There is a moral also for business here: it does not pay to be the fastest if one ends up being the first – but in the wrong place!

Phaal et al. (2001) propose linking periodic roadmap updating to the company's budget or strategy cycles. Our principle is that the roadmaps are always up-to-date. They should be validated constantly when moving ahead, and new information included respectively. Only relevant information should be considered, and insignificant details must not blur the general picture. When and if needed for communication at the company’s planning cycles, one simply takes a snapshot of the current state.

The route may be changed along the way only when it is imperative. The most important, and natural point for revising the route is when completing an intermediate leg. Updating roadmaps on a periodic basis *only* has serious shortcomings, but it might nevertheless be beneficial. There might be unnoticed internal or external developments, there might be longer-term initiatives beyond the horizon of a roadmap, and there might be needs to synchronize with other roadmaps.

With the justifications above, the author proposes revising the roadmap and the path:

- when completing an intermediate leg,
- periodically, and
- at other times only when imperative.

We did not even consider conducting our business roadmapping sessions via collaborative software tools. The main reason is that the “bandwidth” is too narrow when compared to a common face-to-face discussion. In fact, we do not even use any other software, except a drawing tool for drafting the roadmap.

In our session we do not allow cell phones, nor laptops, we do not even have tables. We form ourselves into a semicircle in front of a big roadmap. We believe that this is an effective way to work, and in addition we want to convey a message that creates the right mindset: let's roll up our sleeves and do some serious work.

Such a session cannot be conducted in a piecemeal way. It is extremely important to have only one, common session with all the stakeholders present. It is not just about communication, but more about a mutual plan, common understanding, and mutual commitment.

Even in the same meeting people interpret things differently: they have different backgrounds, they have business issues bothering their minds, and mental alertness varies. If there are separate sessions, the factors for divergent interpretations multiply. It is another time and place, participants are different, presenters use alternative phrases and expressions, different kinds of questions and comments steer the discussion.

Contrary to the principle of the prevailing trend of preferring collaborative tools, we do not give the stakeholders access to complete master business-technology roadmaps. In fact, they are available in their entirety only at the session. A master roadmap is a summary and generalization of more specific maps. Each participant has his/her own, more detailed and focused roadmaps and is expected to note the effects of the master roadmap on them. From that point on, stakeholders have full freedom to plan and execute their developments and actions, provided they do not contradict with, or have side effects on, the master roadmap level.

Not supplying a master roadmap is not a question of lack of trust. It is about securing highly sensitive and confidential information. If used as material in other planning sessions, someone can lose or carelessly forget a copy somewhere. And there is no way to control further reproductions. If handed over, the second, or third, or fourth in a line does not understand, or forgets to mention the strict confidentiality, no matter how strongly it is originally stressed.

A master business-technology roadmap summarizes an entire strategy of a business line or segment. The risk of it ending up in the wrong hands is too serious to take.

3.2.3. Once There

Phaal et al. (2001) raise a natural question: "*How to keep a roadmap alive?*". As is the case with so many good business processes and practises, they tend easily to become corrupted or even forgotten over the course of time once the initial enthusiasm fades.

The answer is simple. Once the team has reached the destination, it has two possibilities. To stay there, or to trek familiar territory; the routes one has taken and places one has been. None of the two alternatives makes sense in business.

The third alternative is to define a new goal, create a roadmap with a route on it, and head for the new destination.

3.2.4. In Conclusion

It is easy to intuitively realize the benefits of roadmapping, but one cannot exploit its real business benefits without understanding its essential purpose and how to exploit it.

Afterthought:

Oh yes.

There is one situation when you need a roadmap to tell you where to go.

When you are completely lost!

3.3. The Fruits of Technology

Just as some plants bear fruit only if they don't shoot up too high,
so in practical arts the leaves and flowers of theory must be pruned
and the plant kept close to its proper soil- experience.

Carl von Clausewitz, Prussian military philosopher

"Innovation" is a widely misunderstood and misinterpreted term. Many confuse innovation with "invention". In public media and discussion, use of the term is totally inconsistent.

Webster's (2005) definition for innovation is *"the introduction of something new"*, whereas invention means (1) "*a product of the imagination*" or (2) "*a device, contrivance, or process originated after study and experiment*." Rogers (1971) states as follows "*Innovation is an idea, practice, or object perceived as new by an individual*".

He continues *"It is the perceived or subjective newness of the idea for the individual that determined his reaction to it. If the idea seems new to the individual, it is an innovation"*. An innovation does not need to be new, it is sufficient to seem new to an individual. This might appear odd at first, but it certainly makes sense.

The practitioners of innovation processes and innovation management generally apply the term to mean turning an invention into a product, or into something having an economic impact. For example, Thecis (2005) uses the term to *"mean the process that transforms ideas into commercial value"*. The distinction between **"**invention**"** and **"**innovation**"** is that *"invention is the creation of a new idea or concept, and innovation is turning the new concept into commercial success or widespread use."*

Usually the practitioners presuppose that there is an invention behind an innovation, and that it is an essential part of it. Characteristics such as creativity and inventiveness are thus, at least implicitly, connected to and even emphasized with innovation.

The span of an innovation process is typically defined "from idea to launch" (e.g. Cooper 2002). It starts with brainstorming or idea generation. The most common process model is "funnelling" (see *Figure 19*) or "screening" (e.g. Cooper 2002). In both models the process starts with a broad range of inputs that get refined and evaluated in several sequential stages. Usually the process is a one-way, step-by-step development from idea to launch. Some process models may have iterative loops, which are very common in software engineering, but a linear one is dominant.

The emphasis of the innovation process is on the early stages, often called "the fuzzy front end" (e.g. Innovation Management 2005, IMI 2005).

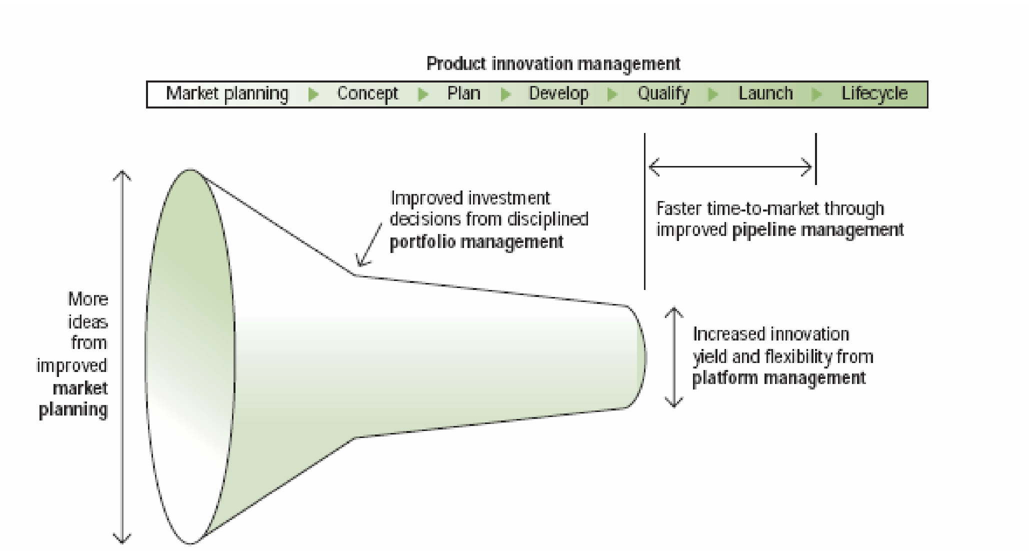

Figure 19. Simplified presentation of a funnelling model (IBM 2002).

As is the case with "strategy" (Kaplan & Norton 2004: 5), different organizations use the term innovation differently. Most use it, as mentioned before, for the process of "from idea to launch". Fewer, e.g. Metso (2003), use it in a very broad context, even to the extent of including what we call technology management. And they have a right to do so. However, there are clear differences between the two, as illustrated in *Figure 20.*

The table, compiled together with Talonen (2005), is a summary of tens of literature sources. Naturally these sources have different viewpoints and definitions, and the table thus represents the authors' subjective interpretation of generally agreed characteristics, commonalities and differences.

	Strategic Management of Technology	**Innovation Management**
Basic Driver	Sustainable Competitive Advantage	Economical and social utilization of technology
Field / discipline	Interdisciplinary	Engineering
Context / Scope	Strategic. Integrating technology and business	Dynamics of innovation. From idea to launch.
Means / Methods	Technology strategy. Communication and decision making.	Innovation process. Creativity.
Technology – market relationship	Coupling model (Both Technology Push / Market Pull in balance)	Market Pull / Technology Push
Starting Point	Strategic business challenges.	Customer needs / Idea generation.
Object / Result	**Technology as a strategic resource**	**Products and processes as competitive assets**

Figure 20. Technology management compared to innovation management.

The basic driver for MoT is the company's sustainable competitive advantage, whereas innovation management (IM) literature emphasizes the economic and commercial success of an innovation. There is also a social aspect, which is threefold. An innovation must be accepted in order to be commercially successful. Inversely, an innovation affects society by changing our life, work, etc. Thirdly, "innovation" generally has a tone of something good or positive, so innovation is connected to providing society with something better or more ethical. Seldom does one hear about e.g. military innovations, at least outside military circles. Rogers has discussed these social aspects at length in his classic book (Rogers 1971).

MoT is interdisciplinary by nature, whereas IM leans more towards engineering. The essence of MoT is strategy, and its most important means are communication and decision-making. IM emphasizes creativity and the subsequent innovation process. The starting point in MoT is the strategic business challenges, and in IM it is the customer's needs or ideas.

With regard to the market and customers, market pull or technology push is general in IM, while a coupled push/pull model dominates in MoT. Market pull in innovation management may sound odd, because the innovation process is thought to start from an idea. Innovation *management*, however, is interested in an innovation also being accepted.

In fact, technology push / market pull is a much more complex duality. One cannot actively seek out an innovation that is not known to exist, as Rogers (1971) points out. Individuals tend to expose themselves to those ideas that accord with their interests, needs and existing attitudes. It implies that a need for an innovation must usually precede awareness-knowledge. An individual can, however, develop a need when he learns that an improved method, an innovation, exists (Rogers 1971). Does a need precede the knowledge of a new idea or does knowledge of an innovation create a need for that new idea? Perhaps this is a chicken-or-egg problem, concludes Rogers (1971).

The biggest difference between the two is ultimately the results, or objects, they manage. MoT regards technology as a strategic resource. Innovation management exploits products and processes as competitive assets.

This is not to suggest that MoT is somehow more advanced or more extensive. It is only a matter of the angle of view selected. Generalization is always risky, but an innovation management approach is perfectly fitting for certain types of businesses. Examples are small and medium-sized enterprises; or companies with a considerable market share in highly specialized, narrow niche markets where there is a constant need for certain products with new features and characteristics.

The role and place of innovation in the context of technology management is poorly discussed in the literature. Where does it belong? How does it contribute to the rest of technology management? In innovation management literature, the innovation process is often considered as the entire mechanism that creates new products and services (see e.g. Dodgson 2000, Burgelmann 1996, or Christensen 1997). It seems that these two schools have different points of view that do not easily blend together.

Schumpeter declared that technological innovation covers much more than only new products. He defined the following types of innovation in the context of technological advance (*slightly reformulated*):

1. Introduction of a new product or qualitative change in an existing product
2. Process innovation new to an industry
3. The opening of a new market

4. Development of new sources of supply for raw materials or other inputs
5. Changes in industrial organization

Schumpeter's list of types of technological innovations impressed immediately because it is simple but still complete. It is exhaustive in respect of technological advance: it is very difficult to add anything, just as it is to remove some items. No wonder Schumpeter's list of innovations appeared essential, but their role in the strategic management of technology was not evident. Where in the process do they belong? The outputs are clear, but what and where are the inputs?

An initial enlightenment came from an insight at the conceptual level. Innovations are the means to bridge the gaps between the current state and the vision. They implement the migration paths defined in *Figure 21*. They are the means to implement technology strategies.

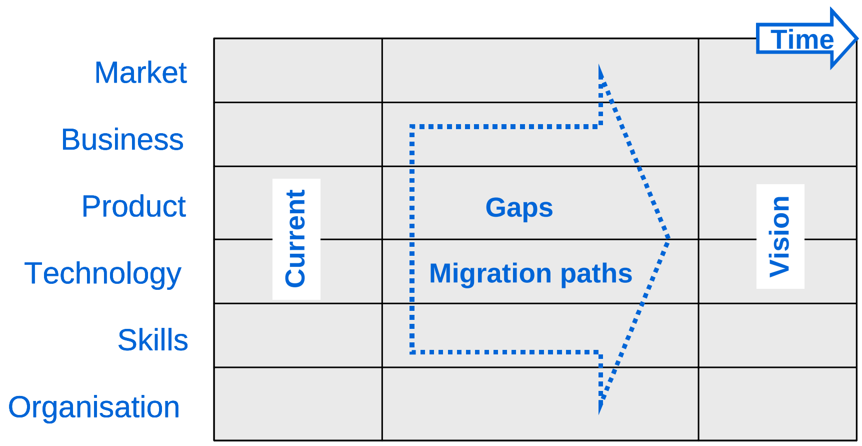

Figure 21. A roadmap focusing on the development of a vision of the future business, in terms of markets, business, products, technologies, skills, culture, etc. Adapted from Phaal, Farrukh & Probert (2001).

On a conceptual level the picture was clear, but how does it fit into practice? If innovations close the gap between current states and visions, do they not in the same manner stretch over and cover the entire area of the management of technology? Are they part of our model at all? They appear to be somehow contradictory to our technology management process, or are they somehow orthogonal?

If the emphasis is at the front end, as is usually stressed, what comes *after* innovations? The front-end of our model is the strategic level, but how can one put innovations there? They implement strategies, not create them. By intuition Schumpeter's five innovation types appeared important, but it was laborious to find a natural place and role for them in our model. That bothered the author for a long time.

The key for a solution came from two sources and from different directions:

1. the definition of innovation we have used, and
2. Schumpeter's list of technological innovations.

The author applied the most "naked" definition of innovation, "to introduce something new", i.e. take into use, or mobilize, something new. It does not imply that something must be invented. The "new" can be developed in-house, borrowed, copied, bought or licensed. It is enough that it is new for us! Naturally it does not exclude inventing.

The second key was Schumpeter's list itself. In general, the literature about innovation does not restrict the number, nature, types or targets of innovation. Schumpeter's exhaustive list[1], on the contrary, clearly defined the possible types of technological innovation, their purpose and objects. That helped to define the nature of innovations and fix their position within our framework. They all focus on the operative business processes!

That made innovations click nicely into place in the framework. Contrary to most of the prevailing approaches, innovations in our model are **the last, implementing step**, not the front-end (*Figure 22*).

Innovations can be understood as end results or as activities. As end results they are the results of MoT planning, allocation and implementation processes. They are produced by product development projects, product health care activities, business process developments, organization changes, and so on. The essence is disciplined work to efficiently and effectively implement the strategy in practice.

The product development projects follow a well-defined concurrent engineering model, where the product and related processes and capabilities are being developed concurrently. A project is divided into development

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[1] *The author learned only afterwards that the original list was maybe not meant to be exhaustive, as Schumpeter had added "any 'doing things differently'". This slight misinterpretation, however, gave grounds for some fertile thinking.*

phases, and there are milestones separating them (a state-gate model). There is a project-independent external audit of progress at each milestone.

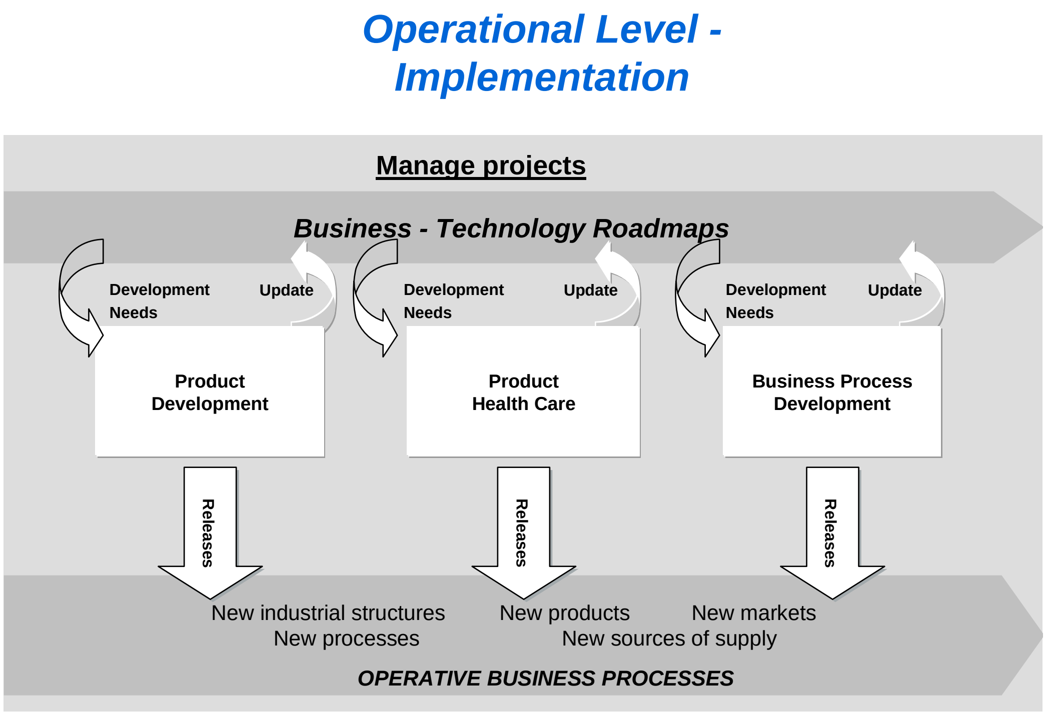

Figure 22. Innovations transfer the results of technology management activities to the operative business processes.

Different developments are scheduled and controlled at the tactical level through project portfolio management. In essence it is linking short-term, project-level operational activities with long-term strategic objectives.

One can also perceive innovations as activities. In that sense they are the actions (in operative business processes) that are needed to take the new products, processes, and so on, into use.

In both views, innovations are the "glue" between MoT and operative business processes. They convey the results of MoT activities into business operations.

Innovations in our model have the objective of bringing commercial value, as defined in innovation literature, but the emphasis and location are totally different. In our framework, this is their natural, and only possible, position.

Cutting corners slightly, innovations provide an organization with the means, mechanisms, products and structures needed to create added value. They are the tools in competition among firms. They are the fruits of technology.

We can take the fruit tree analogy even further. As innovations are the fruits of technology, so is technology a fruit tree. Fruits start to grow until they are ripe for harvesting. After that, new fruits will start to develop, often after some kind of rest period. New fruits may appear that are similar to the previous ones, but they are inevitably different. A tree changes slightly over time - it grows or evolves in other ways – and the quality of the fruits depends on the age and condition of the tree. Even though the fruits differ in size and quality, they come from the same tree. Conversely, a tree cannot produce different fruits.

A tree lives longer than its fruits, its roots are deep in the soil, and the soil affects the condition of the tree and the quality of its fruits. Most trees need to be pruned and kept close to their proper soil-experience to bear good quality fruit in good quantities.

3.4. Strategic Resilience

Resilience: an ability to recover from or adjust easily to misfortune or change.

Merriam-Webster Online Dictionary

As already mentioned, Kaplan & Norton (2004: 5) claim that no two companies have the same definition for "strategy". For clarity's sake, let us refer here to the classical strategist von Clausewitz, who wrote (von Ghyczy 2001):

"Strategy determines the place where, the time when,
and the fighting forces with which the battle is to be fought."

In business the fighting forces can be thought of as products, technologies, processes, human and other resources, organizational capabilities, and so on. Strategy focuses on organizing these for competition.

Matthews (1992) proposes a conceptual framework for integrating technology into business strategy (*Figure 23)* that enables continuous and intensive discussion and decision-making between business managers and technologists.

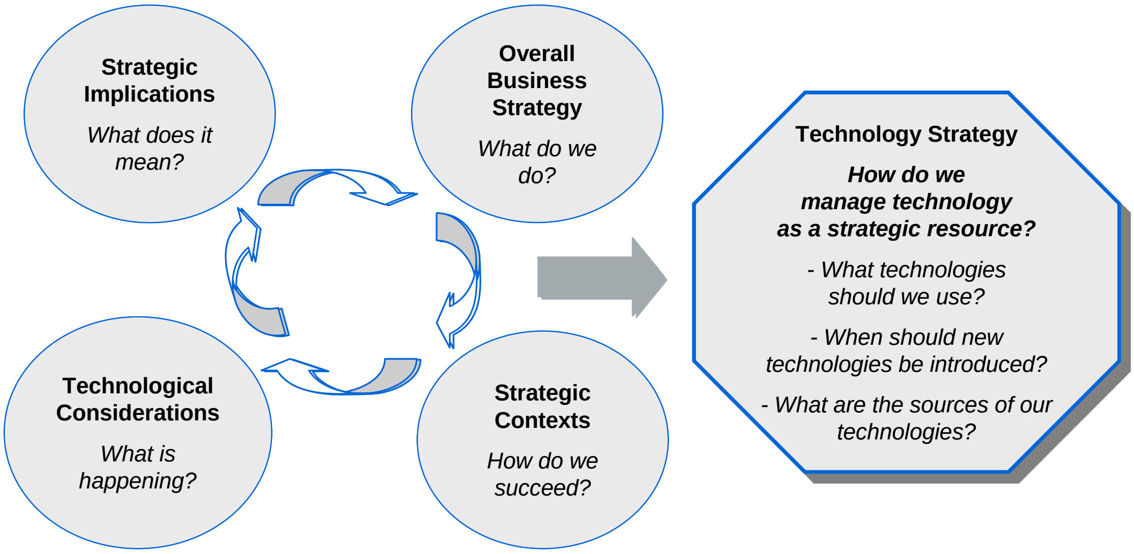

Figure 23. Framework for an integrated approach. Adapted from Matthews (1992).

This framework consists of a cycle of sessions having different viewpoints. The cycle is especially a process for generating fundamental questions, structuring answers, and focusing on potential options and trade-offs. In this framework, the technology strategy is derived from the overall business strategy. However, during the process the strategies will have many linkages and overlaps and thus have the potential of reinforcing each other if managed effectively (Matthews 1992).

The arrows suggest a logical flow of considerations. *How does the current strategic context and its developments influence technology? What are the implications of technological developments to the strategy? Where are the opportunities and risks? What kind of organization do we want to be?* And so on.

The four main considerations are:

- Overall Business Strategy – *What do we do?*
- Strategic Contexts – *How do we succeed?*
- Technological Considerations – *What is happening?*
- Strategic Implications – *What does it mean?*

New information and perspectives may be generated at any stage, and the processes of analysis, synthesis, and decision-making are iterative in nature (Matthews 1992). There maybe several loops, and the iterative cycle repeats itself until it is "frozen" or stabilized, so that one can extract the technology strategy.

Matthews's framework is conceptual, and it needs an application in practice. As he states (Matthews 1992): "*… managers must still rely on 'gut feeling' to make the key decisions. Systematic approaches can however stimulate the creativity and debate that are necessary to reach an informed consensus…*"

Our approach is presented in *Figure 24*.

There are three autonomous activities or processes with their own roles and purposes: MoT analysis, Blue Box studies, and business & technology mapping. They are coupled together by a set of business-technology roadmaps, which is their source of data, and to where they return the results and updates. The arrow shape of business-technology roadmaps in the figure symbolizes time; that they are evolving, and constantly up-to-date.

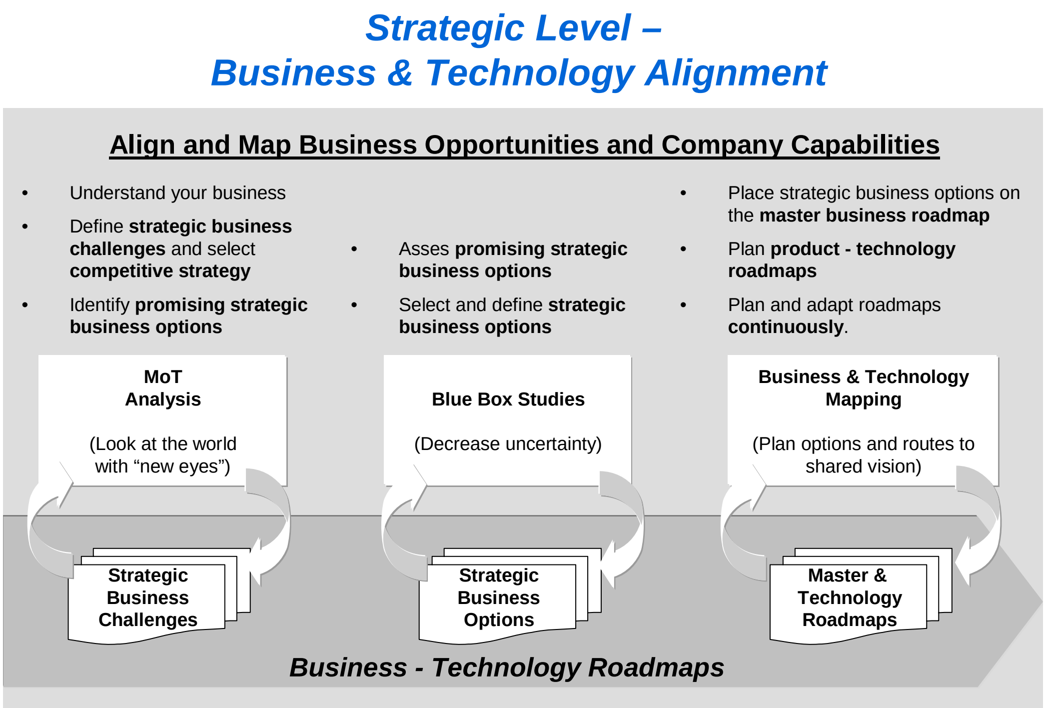

Figure 24. The three activities at the strategic level.

In the following we will examine the three activities.

3.4.1. *Understanding the Competitive Situation*

The first activity is MoT analysis. MoT analysis focuses on understanding the changes and discontinuities in the external and internal business environments, and on identifying strategic business challenges respectively. The purpose is to select a basic approach to competitive strategy, and to identify new promising strategic business options for further study as potential answers to strategic business challenges. MoT analysis is an irregular activity, meaning that the impulses for using it, or increasing the intensity of it, come from changes and new challenges in the business environment

The definition of the business environment and challenge is based on an external and internal appraisal, e.g. SWOT analysis. *What is happening, what are the probable trends, what are competitors' actions, and what are our measures to react?* Strategic challenges are vital in dealing with opportunities and threats. The challenges are characterized by defining critical success factors. They represent the *long-term* 'must' issues, where the company must not fail and where it has to be better than the competition.

Competitive strategy defines how we are going meet the challenges by addressing fundamental business questions such as:

- What business are we in, and do want to be in?
- Where is our competitive advantage and how can we improve our competitive position?
- What kind of organization do we want to be?
- How can we create added value and keep our customers?

Competitive strategy sets foundations and a focus for research and development. It is a starting point for technology and competence strategy as well as for product and platform strategy.

In practice, MoT analysis consists of a set of workshops and the task force works between them. It is a cross-functional exercise, but must still be strongly owned and driven by the management of the business under consideration. We follow the slightly applied process proposed by Matthews (1992), where one examines strategic challenges, customer needs and competitive strategy, market and technology grids, and technology lifecycles. The tools applied are common business and technology analysis tools, such as a competitive strategy matrix, customer chain analysis, SWOT analysis, technology trees and technology S-curves.

As a result, MoT Analysis creates **Strategic Business Challenges** that include the following data:

- **Business Challenge Definition** – In-depth understanding and definition of the strategic challenges in a certain business area.
- **Competitive Strategy Approach** – Defines key approaches to compete related to our external business environment.
- **Technology Introduction Plan** – Potential technological options to answer the strategic business challenges.

MoT analysis should be repeated from time to time, as the external and internal environments change.

3.4.2. Generating Strategic Options

By far the most important activity on the strategic level – and in MoT in general – is to generate technology-related strategic options for the business. This happens by sorting out from a big pool of ideas the desirable product development initiatives that generate commercially successful products in the future. It is what Matthews (1990) calls the art of "kissing technological frogs."

There is a pool of frogs, the ideas. Each of them has the potential of being a prince, a useful idea that *could be developed* to become a king, i.e. a successful product for the business. The only way of finding out whether the frog is a prince is to pick it up and kiss it.

There are four separate steps (Kemppainen 1995):

1. breed the frogs to ensure that all the time we have enough of them in the pool
2. pick a frog
3. kiss the frog
4. evaluate the results of kissing

The ideas for the pool come from anywhere, the initial source is not so important[1]. What is essential is that we have a mechanism for recording the ideas so that they are not lost, that they are ready and available, and we have an accepted mechanism for an initial evaluation of them.

One picks up a frog and kisses it. If the frog is definitively *not* a prince we throw it away immediately, otherwise we will put it into the next pond to grow bigger and to be subjected to the next test later. When the answer indicates that the idea might be a prince, there are two alternatives:

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[1] *In fact, Matthews considered the widely emphasized brainstorming or idea generation secondary in this context (Matthews at a KONE Strategic Management of Technology Workshop in Hyvinkää, Finland, 1991).*

- if considered that the idea appears clearly likely to become a king, a pre-study is initiated to develop the preliminary specification and project plan for realization, or
- further questions are defined to get more detailed information for decision-making.

In practice, the method for kissing technological frogs is the Blue Box study. This is commonly mistakenly taken to mean some kind of technical pre-study or preparation for a product development process. In Matthews's (1990) concept, questions such as *"Is it possible?"* and *"Is it attractive?"* have already been clarified prior to a Blue Box study. Blue Boxes in turn search for an answer to questions like *"Is it practical?"* and *"Is it desirable?"*. In short, *"Could we make profitable business with it?"*.

The nature of Blue Boxes becomes evident when remembering that Mitchell & Hamilton (1988), whom Matthews refers to, call it "strategic positioning". A Blue Box creates strategic options, and any subsequent product development is a business investment with the purpose of generating a return.

It is thus known to be possible to realize the idea; the laws of nature do not prevent that. We want to know whether the company really wants it. The main goals of Blue Box projects are (Kemppainen 1995):

- managed reduction of the risks, keeping in balance the remaining risks and committed efforts,
- early rejection of ideas that do not promise success, and

- establishing and utilizing communication between business and technology to fully exploit the needs of the business and the possibilities provided by new technologies.

Also the nature of Blue Box studies is commonly misunderstood. People often think that it is a loose, even haphazard process. In reality, it needs to be well-defined, well-conducted and well-managed in order to bring the desired results.

Matthews did not define the process in his publications. The principle of our method is to find answers to well-defined strategic questions in consecutive research steps. Well-formulated questions are of major importance; the objective of a step is defined by the questions. Common requirements for the questions are (Kemppainen 1995):

- *specific* to make sure that the effort is focused on providing the information needed for effective decision-making. A good question looks like: *"Can technology X provide the following benefits when compared to today's product Y provided that the volumes are N?"* A good question is a closed one instead of an open one. It gives a clear goal for the research.
- *concrete* so that they can be understood by both business and technology people
- a question must define the *context and scope* of the research to be conducted
- the *positive answer*, i.e. an answer that will allow the next step to be taken, should be guessed when defining the question

- the questions should be defined so that it finds an *optimum* between the two contradicting objectives; minimizing resources while maximizing the probability of finding the idea to be a pure frog

Naturally one single generic question is not enough for research purposes in most cases. For that reason the main question may have subsidiary questions that illuminate the issue in more detail or from different perspectives *(Figure 25).*

The Blue Box project progresses step-by-step to keep a balance between the committed resources and remaining risks. At the end of each step we study the following

- what is the probable answer,
- what is the uncertainty level of the answer and on which assumptions, and
- what are the actions to reduce the uncertainty at the next step?

As a Blue Box question is a closed one, the answer is binary: either "*Yes, considered that…*" or "*No, unless…*". Note that the answer may change from yes to no, or from no to yes, as the study progresses. The uncertainty can at some steps get higher, which may be counter-intuitive, but new information can in fact reveal unknown sources of risk. The process continues step-by-step until an acceptable uncertainty level is reached, or a dead end is reached, meaning that additional efforts do not sufficiently reduce uncertainties.

Is it possible to create a profitable business in HDB market based on existing KONE products?

Customer requirements

Q 1	Can we meet the customer requirements with minor modifications to existing products?

Business case

Q 2	Can we make HDB profitable on the long run?
Q 2.1	Can we profitably meet the price level of other elevator companies?
Q 2.2	Can we develop profitable service contracts?

Technology

Q 3	Can we justify the development efforts needed in terms of return on investment?
Q 3.1	Can we justify the needed modifications?
Q 3.2	Can we justify the needed Product life cycle management effort?

Figure 25. A well-defined Blue Box question with subsidiary questions.

We commit ourselves to only one step at a time. This is very important for the mindset. Far too often studies are pursued to the bitter end just to prove something, which is only natural, no matter what emerges. As Matthews (1990) remarks: "*A negative decision* [to continue] *is not a "failure" of the "Blue Box" project manager, but a direct consequence of the desire to assess many options and select only a few*." On the contrary, a decision to stop will save effort and enable concentrating on other, more attractive candidates.

As a result, Blue Box Studies create **Strategic Options** including the following data:

- **Strategic Business Options** – Defined and assessed potential alternatives and choices for future business.
- **Novel Product Concepts** - Product concepts for product creation projects.

Different Blue Box studies should run almost continuously, researching potential candidates for strategic business options.

3.4.3. Aligning Business and Technology Efforts

The third activity at the strategic level is business and technology mapping. This involves communication and decision-making on strategic business options for the future and placing them on the business and technology roadmaps. The roadmaps provide "a visualized map" for agreed and common strategies between organizational functions.

Roadmapping is not only mechanically placing items, development initiatives, milestones, etc., on a time scale. The purpose is, besides communication and decision-making, to reveal potential conflicts in schedules or objectives and to resolve them. The objective is to ensure that the plans are synchronized over functional units so that every stakeholder has the same direction and commits to it.

In practice business & technology mapping consists of a set of cross-functional road-mapping meetings and task force efforts in between. Mapping can concentrate either on an individual product family, market area, customer segment or entire business area. These meetings must be owned and driven by the management of the business area under consideration. The actual roadmapping process itself is discussed elsewhere.

The results of the other strategic level activities are presented in business scenarios and in a master business-technology roadmap. The purpose is to create the big picture; to plan options and routes to the shared vision. Business scenarios are generic descriptions of the competition and business, and their developments. The top-level master business-technology roadmaps schedule actions with market developments and synchronize them between different organizational units. The idea is to align business and technology efforts.

Items on master roadmaps are defined in more detail stepwise in focused technology roadmaps, as needed, thus creating a hierarchy of roadmaps. Examples of technology roadmaps are product release plans, product-component roadmaps, and technology and competence development plans. Lower level roadmaps may evolve freely as far as they do not conflict with the items, objectives, schedules and relationships agreed and included on a higher-level map.

Conversely, one can perceive a master business-roadmap as a summary, compilation and generalization of all the lower level, more detailed roadmaps.

As a result, Business & Technology Mapping creates **Master and Technology Roadmaps** including the following data:

Master Roadmaps:

- **Business Scenario** – Generic description about future challenges, trends, success factors, potentials, strategic options, and plans in a certain business area.
- **Master Business-Technology Roadmap –** Top-level framework for discussion and for synchronizing plans between the functions of a business.

Depending on the case, the viewpoint may be a platform, product, market or segment.

Technology Roadmaps:

- **Scenario Forecast –** Description and comparison of different technological opportunities and potential development paths in the future.
- **Product Mix** – Describes and visualizes the product mix evolution over generations and platforms.
- **Product Release Plans** – Common plans for timing product and component introductions.
- **Product – Component Roadmaps** - Relations and dependencies between technologies, components, and products; and timing for developing them. Description of optional solutions.
- **Technology Sourcing Plan** – Defines sources and timing of technologies.
- **Competence Development Plan** – What competences are needed to enable the plans; when and how to acquire them, and from where

Planning and adaptation of roadmaps should be continuous. That does not mean all the time, but rather that roadmaps should be up-to-date, reflecting the changes in the internal and external environments.

However, the agreed paths from current position to destination should not be changed too often. Preferably the course is validated, and when needed, altered at intermediate goals. Especially the top-level master roadmaps should remain rather stable. One should not change the course in between intermediate goals for the reasons argued in the description of the roadmapping process.

The strategic level may be summarized as in *Figure 26*.

<table>
<tr><td colspan="2"><u>OBJECTIVE</u>
▪ Identify what technologies are needed to accomplish the business challenges, and how technological opportunities may affect on the business and competitive situation</td><td><u>OWNER</u>
▪ Business Management</td></tr>
<tr><td colspan="3"><u>ESSENTIAL WORK CONTEXT AND MAIN STEPS</u>
❑ Define strategic business options and create business – technology roadmaps which describe in detail how to meet the essential business challenges.</td></tr>
<tr><td><u>INPUT</u>
❑ Business challenges and trends
❑ Technology development trends
❑ Existing roadmaps</td><td><u>ACTIVITIES</u>
❑ MoT Analysis
❑ Blue Box Studies
❑ Business & Technology Mapping</td><td><u>RESULT</u>
❑ Strategic challenges & competitive strategy
❑ Strategic business options
❑ Master & technology roadmaps</td></tr>
<tr><td colspan="3"><u>ACCEPTANCE CRITERIA</u>
❑ Business roadmaps discussed with key stake-holders and approved by business owners
❑ Technology roadmaps derived from the business roadmaps and mutually agreed by business owners and R&D</td></tr>
</table>

Figure 26. Strategic level objectives, main activities and deliverables.

Strategy is about defining and organizing oneself into a winning position. The strategic level is thus the most important one in the strategic management of technology. It is decisive in success or failure. Even though the tactical and operational levels are also very important, they are still instrumental. Their role is to refine and execute in a straightforward manner what was planned and decided. Their most important characteristics are fast execution, leanness, simplicity, and agility in changing situations.

A good strategy is based on strategic options, real options for future business. And the options must reflect both technology and business. Far too often the two strategies are separate, or a technology strategy is derived from business strategy. Aligning business and technology efforts through continuous, iterative discussion between business and technology people is essential.

The process should run constantly, meaning that the strategies, and information behind them, are up-to-date all the time. Annual, repetitive strategy planning cycles tend to lead to inflexibility and formality with little real content.

There must be the means to illuminate and concretise the results. A comprehensive set of roadmaps, with clearly defined roles and contexts, forms the tools for communication and decision-making.

3.4.4. Interlinking of Survival and Resiliency

There are a numerous well-known examples of companies that are successful with their technologies; such as Nokia, Black & Decker, Sony, HP, IBM, Canon, Honda, Toyota, Ericsson, Philips, Shell, GE and Motorola, that are often cited in periodicals or textbooks (e.g. Tidd 2005, Christensen 1997, or Pietersen 2002). They come from very different businesses: automotive, telecommunications, computers, power electronics and industrial automation, conglomerate giants, consumer electronics, etc. Their approach, focus and emphasis in managing technologies differ. They may be based on product platforms, core competences, product-technology roadmaps, scenario planning, or balanced scorecards. Nevertheless, they have managed to create successful technology strategies, and to execute them efficiently.

Why is it that not everybody succeeds? Foster & Kaplan (2001) claim that if history is a guide, no more than one-third of today's major corporations will survive in an economically important way over the next 25 years. The big turnover in indices like Standard & Poors 500 and the Financial Times 500 give further proof. This very Schumpeterian phenomenon is not a recent development, but has existed throughout the history of the indices. Many scholars, e.g. Foster & Kaplan (2001), Christensen (1997), and Hamel & Välikangas (2003 a), present and discuss several well-known cases of such failures.

If strategy is about defining and organizing one's forces into a winning position – and is thus extremely crucial to an organization's survival – then why do so many companies fail in this? Of course strategy implementation may fail, no matter how carefully crafted and "orthodox" the strategy is, but the reasons for failure can be horribly deep-rooted: lack of understanding – or even simple disinterest.

The authors witnessed evidence of such disinterest a few years ago. In a plenary discussion at an international technology management seminar (RTEC 2003) surprisingly many representatives of multinational, even global, enterprises said that strategic technology planning is virtually non-existent in their companies.

The most shocking statements were about top management approving an annual R&D budget with the instruction: ”Here is your money. Go and invent anything, and come up with something to sell, but do not bother us in the meantime.”

This may appear unbelievable, but Scott's (2000) study on critical technology management issues in hi-tech companies supports it. Some of the experts believed that, in reality, technology planning methodologies and plan implementation techniques are lacking in their company.

Then there is the question of understanding. The entire strategy creation in (even) big companies is amazingly primitive, claims Dr. Välikangas from the Woodside Institute in an interview (Talouselämä 2004). She argues that barely one out of ten companies think about strategic options! By strategic options she means real strategic options for future business, not just extrapolating the current situation into future.

Strategic thinking tends to be anchored to existing technology and history, and radical new options are not considered, says Välikangas. "*Strategies are intellectually empty documents filled with number crunching.*"

As Välikangas rightly states, numbers are not a strategy, but a result of it. Very many mistake results or goals for strategy. How many companies have something like "growth" defined as their strategy?[1]

Mintzberg (1994) shares Välikangas's opinions by saying that "*managers confuse real vision with the manipulation of numbers*" and "*…strategies that are extrapolated from the past or copied from others.*"[1]

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[1] *Heard incidentally on radio years ago: "Growth" is a valid strategy only for cancer cells.*

Even a good strategy is not sufficient if it is rigid. A successful company needs what Hamel & Välikangas (2003 a) call "strategic resilience". In most cases companies move from crisis to crisis, and renew only when imperative. By strategic resilience they refer to the capacity of an organization to renew itself before it is forced to by an impending performance crisis. It is about taking action when the range of options is still relatively broad.

Hamel & Välikangas (2003 a) in their article state that confidence in the future of any company depends on the extent to which it has mastered three essential forms of innovation related to strategies:

Revolution: Unconventional strategies are needed to produce unconventional financial returns. Industry revolution is creative destruction.

Renewal: Renewal is about reinventing industry, changing the rules of business. Often the reformers are newcomers, or those from outside the established business. Incumbents have it harder, they must first reinvent themselves. Strategic renewal is creative reconstruction.

Resilience: In most cases a performance crisis is required before a company is forced to renew, whereas resilience refers to a capacity for continuous reconstruction.

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[1] *This raises an interesting consideration. Wouldn't it be better to have no strategy at all than to follow a rigid, number-stuffed "strategy" that is based on extrapolation?*

Resilience is very close to what Schumpeter means by the importance of technological advance in competition, and by the essential role of innovations. Revolution calls for victims to Schumpeter's creative destruction.

Hamel & Välikangas (2003 b) say that any organization that hopes to become resilient must address four challenges:

The Cognitive Challenge: A company must become deeply conscious of what is changing, and perpetually consider how those changes are likely to affect its current success.

The Strategic Challenge: Resilience requires alternatives and awareness — the ability to create new options that provide compelling alternatives to dying strategies.

The Political Challenge: An organization must be able to divert resources from yesterday's products and programs to tomorrow's.

The Ideological Challenge: The ability to continuously renew itself requires that an organization must be able to concentrate its efforts much more widely than on mere operational performance.

Even though we discuss it here in the context of technology strategies, resilience must be inbuilt throughout a company's functions, operations, and decision-making.

After all, no matter how good the procedures and tools are, people are the most important. Systems do not do thinking, even though systematic approaches can stimulate the creativity and debate needed to come to a mutual understanding. People are also crucial to a company's survival. Even a good strategy is worth nothing if an organization is not able to renew itself to adapt to changing situations.

Hamel summarizes aphoristically (Hamel & Välikangas 2003 a):

"Companies are successful until they are not."

4. DISCUSSION

Not more than one-third of today’s major corporations will survive in an economically important way over the next 25 years, and the development is even more drastic further down the food chain. Why is that?

It is because a struggle for survival is taking place. Business competition, and economic development in general, is in a disequilibrium process of creative destruction; innovations cause old technologies, equipment, etc, to become obsolete. This competition strikes not only at the margins of existing firms but at their foundations and their very lives. It is thus not a question of business results but the very existence of a company that is at stake; companies must constantly renew their technologies; otherwise they will drop out of the game.

As technologies become obsolete, better ones will replace them. And if a company does not replace the old technologies, someone else will. The problem in replacing them is that most efforts to do so will fail. For that reason, one must steer technological development. Mere management without a purpose or goal is futile. In order to succeed in competition, a disciplined approach to strategy is crucial, because it is strategy that defines positioning and organizing resources in attempting to win in the competition. We must thus manage technologies as strategic resources; emphasizing technology as the most prominent factor in competition. This is strategic management of technology.

The research and the construct developed are strongly based conceptually on the thinking of Schumpeter and Matthews. They both describe a phenomenon, and the means to cope with it *(Figure 27)*.

	Schumpeter	Matthews
Phenomenon	Disequilibrium process of creative destruction	Most technologies will be replaced, and most efforts to do that will fail
Response	✓ Types of technological innovations ✓ Role of innovations in competition	✓ Conceptual framework for integrating technology into business strategy ✓ Strategic options

Figure 27. Schumpeter and Matthews both describe a phenomenon in competition, and present the means to cope with it.

These four items span the conceptual space of this research. They also form the foundation plate for the model constructed, even if not very explicitly visible in the actual model developed.

For clarity's sake, the figure does not imply that Matthews coined the term "strategic options". He adapted it as a solution to a certain need. Neither did Schumpeter "invent" innovations, but he clarified their roles in creating competitive advantage.

In the previous chapter we examined some of the features and aspects of the research and the MoT model constructed; its general structure, roadmapping, the role of innovations, and the strategic level. In the following we will address these in a larger context, give evidence of the validity of the model, and evaluate its applicability.

4.1. Contemplation

4.1.1. A Holistic Model

We will discuss here three aspects of the model: its comprehensiveness, its scope, and its essence.

The MoT models presented in public were not satisfactory for our needs. There are generic frameworks, but practical tools are missing. There are collections of tools with little information about how they are linked together and what their relationships are. And there are models that address only a part of the sphere of our MoT concept. This is not to claim that those models are not good, or that ours is superior. They surely serve their needs well, but did not appear sufficient for us.

The model presented here is comprehensive, naturally with respect to the purpose and the approach. The framework encompasses all the aspects of the strategic management of technology. It incorporates all the processes needed, all the way from strategy creation down to individual development projects.

The roles of the processes and the relationships between them are clearly defined. There are all the tools that the processes need and use, and the set of tools create a logical breakdown from strategic challenges to implementation. The tools also provide traceability between objects top down and bottom up.

There are instructions on how to run the processes and how to use the tools. Other supporting material includes general and topic-specific presentations, instructions, templates, sample cases, etc, to help in running the processes without extensive facilitation.

Talonen (2005) remarks that traditionally strategic management consists of two parts: 1) strategy development and formulation, and 2) strategy implementation. Mintzberg's approach divides strategy development and formulation into two parts in practise: strategy creation and strategy planning. Taking that into account, and by adding strategy evaluation, Talonen (2005) comes up with a scope that strategic management must cover:

1. Strategy creation
2. Strategy planning
3. Strategy implementation
4. Strategy evaluation

Rightly so, because in other disciplines there are evident parallels that support this. Deming's circle PDCA (Plan – Do – Check – Act) in total quality management is similar. Waterfall models in software engineering are also the same: specification – design – implementation – test. One has to understand that even though the models appear to have separate steps, there are inherent, natural recursions and iterations embedded in them. Further refinements and extensions, spiral or otherwise, are usually only unnecessary complications for practical work.

In fact, the above model is a very generic one, and applicable to virtually any human activity aimed at accomplishing something: decide or define what to do, plan how to do it, then do it, and finally validate the result. Take for example a case where someone needs to get somewhere in a town. The first step, the need and definition of where to go, is already done. There are several possible routes, so one plans a favourable one. Getting to the destination is implementation. Once there, one evaluates – or in this case validates – reaching the destination by identifying it.

The same process, smaller and bigger, recurs all the way. Of course most of this happens unconsciously, but nevertheless, the steps are there. Even conducting the research at hand, as well as creating this dissertation, incorporates the very same steps!

In our model we have three levels: strategic, tactical, and operational. Each level consists of several processes.

The strategic level is about analysing and defining business opportunities, strategic options, and technological competencies. It aims at finding answers to questions like "What business are we in?", "What kind of organization are we?", "What is the technological leverage?", and "What are the trends and forecasts?". It is the first step, strategy creation.

The tactical level is continuous planning and adaptation. It consists of three activities: portfolio adaptation, project allocation and action planning. That is step 2, strategy planning.

The third, operational, level is implementation. The tools are projects, technology and product development processes, and organizational developments. The operational level produces new product releases, new processes, new organizational structures, and so on.

So where in our model is step 4, strategy evaluation? It takes place when we carry out an MoT analysis the next time. It addresses questions such as:

- How well do we succeed in comparison with our competitors?
- Where is our competitive advantage and how can we improve our competitive position?
- What can technologies do to improve our competitiveness?
- What kind of company are we and what kind of company do we want to be?

The technology management model discussed here differs from the typical ones in public in both its essence and nature. Most of the models are represented as rigid processes, in one form or another. Most of them have little or no feedback or iteration, but rather proceed from beginning to end by following strictly defined steps.

Goldsmith's technology commercialisation model ASBDC (2005), discovered only after our model was constructed, comes close. It has certain similarities with ours.

Goldsmith describes his model (ASBDC 2005) as "taking a technology from concept to market". He further declares that the technology commercialisation model is a road map to developing strategic plans and actions for the commercialisation of advanced technologies.

The model breaks the process down into a sequence of three major phases: investigation, the development phase and the commercial phase. The first two phases should be evident. The third one refers to the period when the product is on the market, i.e. sales and product lifecycle management activities.

Each phase has technical, marketing and business activities that must be considered as one moves through the process. Examples of such activities are technology feasibility, a market study and a strategic business plan.

Note that Goldsmith uses the term "technology" to refer to an existing product or concept. This becomes evident when looking at some of the considerations inside the technology feasibility activity: "*Do you have a working model of the product?*", "*Have you evaluated the environmental factors?*", or "*Have you evaluated the feasibility of producing the product?"*

The model is clearly aimed at companies that have strong engineering or product orientation, but often forget to concentrate on developing the actual business. Also mentioned in the introduction (ASBDC 2005) is: "*Too often, inexperienced innovators focus on accomplishing all of the technical steps, up to and even including production, before addressing critical marketing and business considerations*". A question concerning a virtually self-evident aspect in the strategic business plan activity emphasizes this: "*Have you selected a board of directors (or advisory team)?*"

There are similarities to our model. Both have three layers; in our model levels, although Goldsmith call them phases. In both models the layers have several activities or processes. Both incorporate technological and commercial or business considerations.

There are, however, also significant differences. The focus of Goldsmith's model is on investigation, development, and sales and distribution. Our main focus is on creating strategies and converting them into actions. Even though Goldsmith talks about a strategic view, there are only a couple of considerations loosely related to it.

Goldsmith does not have a time continuum, as we do, even though it is somewhat abstract. Goldsmith's activities are separate and individual, and there does not seem to be any specific link between them. Technical, marketing and business considerations run independently in sequence and in parallel. The model gives an impression of a bottom-up approach, even though it has three top-level phases. Our model is definitely top-down.

In his article on strategic planning, Mintzberg warns about systems that are too strictly formalized. He remarks that systems do not do thinking. Ironbound processes can even hinder it! In our model there are individual, loosely coupled processes at different levels, which is totally in line with his thinking.

They form an almost organic structure. The processes in our model have well-defined roles and they handle different objects, or the same ones from different directions and for different purposes. That enables those deeply involved people at various levels of the organization to participate, as Mintzberg further claims.

The model discussed here is a roadmap centric one. This means that the processes are rather autonomous and are coupled together only through the Business – Technology Roadmaps. The roadmaps carry all the information needed by the processes, and all the artefacts created by them. It is like a mutual archive room containing whatever information is needed or created by MoT.

The roadmap centric approach keeps processes individual, thus avoiding the pitfall of a system that is too rigorous. The processes are rather autonomous, living their own lives. They manipulate objects in the roadmaps constantly in a recurrent, iterative manner each at its own pace. This is to keep the roadmaps always up-to-date. There are no annual or other periodically repeated updating cycles.

The problem with periodic cycles is that the information is inevitably old at least to some extent; in the case of annual updates, by up to a whole year in the worst case. Another problem is that they assume the future is predictable. It is not. New information emerges, and there are unexpected surprises in both the internal and external environments. These would have to wait for the next cycle to be taken into consideration. Business developments do not follow periodic cycles.

In addition, periodic, scheduled events easily tend to become formalized ceremonies with no real substance – and thus paralysed – as many have witnessed in their work.

If needed for a company’s budgeting and other planning or synchronizing needs, one simply takes a snapshot of the relevant roadmaps.

4.1.2. Roadmaps Link Strategies Together

There are common company-wide strategies that are shared over the departmental and functional boundaries. This means that no single organizational function can independently create and plan any of these strategies. Business and technology roadmaps represent a crucial tool in linking these company-wide strategic plans, by integrating and exploring the strategies, transforming them into actions and making them operational.

It is intuitively easy to realize why roadmapping is beneficial in communication, in sharing information and in creating mutual agreement. The full business benefits cannot be achieved, though, without really understanding the role and purpose of roadmapping – in other words knowing what it is, why it is needed and how to do it in practise.

The principles and practises are often loosely defined or lacking in the literature. What is the input information, what are the processes, what are the outputs, and – most importantly – how is roadmapping linked to the rest of technology management? Most strikingly even an aspect as essential as the purpose of roadmapping is not defined – or worse, is misunderstood. Of course it is for communication and mutual decision-making, but what is its *raison d'être*? It could be claimed that a clear definition is not so necessary. In fact, it is absolutely essential for a simple reason: why should someone do something if he or she does not know or understand why! Some literature is even misleading in stating that roadmapping is telling people where the company is going. That is totally wrong; roadmapping is about how the company will get there.

There are two main, and opposing, schools of thought about when and how often a roadmap should be updated. One school favours continuous updating. The other favours updating during the company's normal annual planning cycles. These are not sufficient in themselves. Furthermore, both have inherent and serious risks. Continuous updating does not let the roadmap stabilize. New information pours in, and the roadmap is in a constant state of turbulence. The situation is not stable, but instead fluctuates. It is impossible to orienteer if the direction changes constantly. The problem with annual updates is that the information is inevitably old; significant changes do not happen in pre-defined cycles. The best method is to update the roadmap after completing each intermediate leg. Annual updates might be needed, e.g. for synchronizing with other roadmaps and developments.

The often over-hyped collaborative software tools are not a necessity. On the contrary, their use carries inherent dangers if not applied in a disciplined way. How can one control a roadmap if a group of people, even a very restricted one, can freely modify it at will? In fact, one can manage well with a sheet of paper and markers by organizing a walking session in the Creek philosophers' manner. Following practical steps, roadmapping is simple and easy, in contrast to often being considered difficult and laborious.

4.1.3. Role of Innovations

Sometimes it is beneficial to drill down to the essential definition and to the very meaning of terms. One such term is innovation.

Certain groups are trumpeting that after a decade of the Knowledge Society – and another decade of the Information Society before that – we are now entering the Innovation Society. What do they mean? Were there no innovations earlier? What are the innovations we are about to enjoy?

When looking closer at their declarations, they usually free themselves from the burden of defining what they mean by the term. That leaves the term obscure and without substance. The main common thread seems to be that the knowledge society is somehow more "developed" or "smarter" than the information society, and the innovation society in turn is somehow even more "advanced" or "fancy" or "intellectually challenging". Still the same omnipresent mobile technologies, information technologies, telecommunications and other media are lurking behind as the guarantee to success. It must be something exciting.

In a more general use innovation is often confused with, or at least connected to, invention. The verb "to innovate" strengthens the connotation. The author has noticed it being used as a counterpart for "to invent". In this usage innovating produces something abstract or conceptual in the same way that inventing produces something concrete and tangible.

Especially scientists, researchers, scholars, lecturers and those in public should be careful and strict with their terminologies. The audience should understand and interpret the terms in a common way in order to be able to discuss, argue, and exchange opinions.

The scholars and practitioners of innovation management *do* define and describe the term. However, they use it with large variations. By all means they have a right to do so, provided that the definition is at hand for discussion. Some use the term innovation in a very narrow scope (in the meaning of creating something), some relate it to creativity in general, and some use it in a very wide context covering practically the entire scope of technology management. Typically innovation assumes a commercial or other success.

Even though the definitions differ, they most often refer to a certain part of the product creation process, namely “from idea to launch”. An idea is a result of brainstorming or emerges from idea screening. Usually the focus of management is on the early phases, the “fuzzy front end”. In common also – even if not always explicitly voiced – is an assumption of some kind of invention being involved.

For a lengthy period the author had problems in crystallizing the relationship between technology management and innovation management in the context of this study. The role of innovation remained obscure, and finding a place for innovations in our MoT model did not come naturally. Innovations appeared to be somehow orthogonal to MoT, or even to reside in some other conceptual dimension.

The enlightenment came from two different directions:

1. The definition of innovation we have used, and
2. Schumpeter’s list of technological innovations.

The author applied the most “naked” definition of innovation: “to introduce something new ”, i.e. to take into use, or mobilize, something new.

The second one was Schumpeter’s list of types of technological innovations, which immediately impressed because it is so simple but still complete. There was clearly something important and essential in it. When starting the research, our aim was to study the state-of-art in technology management, learn what has happened during the last fifteen years, clarify what are the prevailing schools, and define what new elements we could bring in to our existing model. Surprisingly enough, it turned out that one of the most important findings, and an essential conceptual foundation, would be based on thinking that is a hundred years old.

Schumpeter’s technological innovations – novel products, changes in processes and organization, new markets, and so on – all address the operative business process. That led to an insight that they provide a bridge between MoT and an operative business process. They bring something new into it.

Technological innovations thus found their place in our model as the last, implementing agent, not at the front-end. This insight helped in understanding and clarifying the role, place and nature of certain MoT processes and functions, especially that of product creation, and wider product lifecycle management.

The role and task of product creation and the R&D function is to effectively implement strategic plans: by transforming them into operations, and by mobilizing them in the operational business processes. The author had already come to this conclusion a long time ago, and now the role of innovations provided reasoning and justification to the thinking.

The role does not diminish the importance of product creation by any means. On the contrary, it becomes even more crucial in supporting operational efficiency, once the viewpoint is understood. Instead of being an invention shop, product creation turns into a high-octane project performer. Its performance parameters are speed, agility, flawlessness, and predictability.

Product creation becomes a lean, mean innovation – or implementation – machine. This shifts the focus from managing individual development projects to managing technologies in securing a company's future competitiveness. This is a step in the right direction.

4.1.4. Technology is a Strategic Resource

Practitioners and scholars usually announce that technology and business management should be aligned; or better, that technology management should come closer to business management. The author claims that this is not sufficient; technology management and business management should be intertwined. They should affect each other in an interactive, recursive manner.

Most "business people" understand and accept the need for the symbiosis, but in everyday operations they tend to return to a "business"-dominant mindset. According to the author's experience, technologists understand and adapt the dualistic view much more comfortably than those responsible for daily business.

Maybe this would be understandable if technology were considered a newcomer in business. Perhaps it is, as a practical science or school – but surely not in practise. Before someone can do business, one has to have something to offer. In the case of a physical product or commodity, one must be able to gather, to cultivate and harvest, or to produce something. If it is service in question, one must possess skills to offer. Both require technologies, i.e. abilities to adapt and use techniques.

One could claim that, in the extreme, the strategic management of technology *becomes* business management. All that is omitted are the day-to-day operational activities.

Let us draw an analogy to an athlete. One of von Clausewitz's definitions is "*strategy determines the place where, the time when, and the fighting forces with which the battle is to be fought*". As said earlier, in business the fighting forces can be thought of as products, technologies, processes, organizational capabilities, and so on. In our approach, determining these fighting forces and the time and place of a "battle" is a result of the strategic management of technology.

In a similar way, an athlete has a goal, creates a strategy for how to reach it, and then starts to develop skills and capabilities accordingly. Once the competition or combat starts, the only possibility is to follow and fulfil the strategy. It is too late to redefine it, or to improve skills. All is operational, applying what one has learned and developed.

One might claim that the example is over-simplified. Since most businesses have more than one person working together, let us consider a team. As a team

– and individually – the members set goals and create strategies, and develop individual and team capabilities in a similar way to what an individual athlete does. One could maybe further argue that yes, but there are also other people involved. There are managers and coaches that select the members, organize a team, define their roles and playing styles, and so on. The purpose of all of this is to improve performance by introducing something new in different areas. In this sense that resembles the types of technological innovations defined by Schumpeter. Again, in competition, the most essential aspect is to adapt and use as smoothly and efficiently as possible what has been learned and developed. It is purely operational.

The athlete analogy leads us further to wonder if goal setting and strategy creation should in fact start from "inside". An athlete surely considers the innate physical and other capabilities, earlier development, current performance, and realistic potential for improvement. How many companies define a strategy based mainly on external facts, without really taking into account its existing technological capabilities and actual potential for performance development?

Strategy is paramount to a company's success and even to its very existence. Still, surprisingly few companies actually make real strategies, for technology or for anything else. Why is that? A big reason is the lack of understanding. Many think that a strategy is about market shares, growth or other developments based on the past. It is not. Strategy is simply about defining a winning position and organizing one's resources accordingly. And technology is simply about an ability to adapt and use different techniques to reach an end.

Strategic management of technology is their combination. It is about treating technology as a strategic resource.

4.2. Validity, Reliability and Objectivity

The research gap was declared around the following research questions:

1. *What are the elements needed in managing technologies?*

2. *What are the structures that bind these elements into a coherent model?*

3. *What is and how to develop a technology management model that fits KONE working culture while improving the existing processes?*

The constructed model, incorporating the elements and structures, was presented in *Chapter 3.1.2*. Here we will discuss it generally with some examples.

The set of tools create a logical path from strategy to implementation. For example, there is a breakdown from a master business roadmap all the way to technology introduction plan on the strategic level. These plans are further refined in project portfolio management at the tactical level, and finally completed into separate project plans in implementation.

The tool set aims also to address all the related functions and operations of an enterprise; the overall business challenge definitions, marketing plans, competence management, training needs, needs for process improvement and organisational development, etc. The tools are in quite a good balance on the generic level, but the more detailed and refined the plans, the more these issues get under-emphasised, and bias turned towards product-related aspects.

The set of loosely coupled, parallel processes are rather independent. They link up through business-technology roadmaps that carry all the information needed by the processes, and all the artefacts created by them.

There are instructions on how to run the processes and how to use the tools. Other supporting material includes: general and topic-specific presentations, templates, sample cases, etc, to help in running the processes without significant facilitation.

The model fits to KONE working culture. It did not introduce radical changes or extensions, but rather linked the existing processes together in a logical way and amended some of the shortcomings. The model is straightforward to take into use because it is simple; so it is easy to understand and thus use without heavy training or facilitation.

The Senior Vice President's comment – *"the model reveals our central problem of shifting quickly from strategic planning into acute and short-term operational issues because we lack a tactical level"* – proves two important things.

First, the model fits into the company's culture, because the Senior Vice President was able to perceive it and relate it to the existing procedures on the spot, detecting a serious shortcoming in them. Fitting into the organizational and working culture was one of the basic conditions for the model, because we did not want to invent something new for no reason, nor to force the working of the company into a foreign process from outside.

Second, the realization that the previously missing tactical level caused a central problem reveals that the model introduced something important that should help in overcoming that. While fitting nicely into the model, introduction of the tactical level repairs a certain discontinuity and adds a missing link. It also fits nicely into the company's working culture by building a bridge between strategic planning and operational issues.

In the constructive research approach the validation of a solution is often done by so-called market tests:

- *A weak market test:* the construction is in use somewhere or someone wants to use it,
- *Semi-strong market test:* the construction is widely in use, and
- *Strong market test:* the construction has provided benefits.

The results pass at least the weak market test. The model has been presented to the senior management, who accepted both the model as a whole and also all the details presented.

Parts of the construction also pass the semi-strong market test. For example, business and technology roadmapping has become a common practise in certain organizations. We did not want to make a big bang introduction, but rather take the parts of the model into use case-by-case, as appropriate. The structure, with its loosely coupled and relatively independent processes, makes it possible.

Sykes (1991) has identified in literature several criteria that can be used to assess the data or findings in qualitative research.

Apparent validity or *face validity* holds when a research method produces the kind of information that is wanted or expected (Sykes 1991). This research fulfils apparent validity in that it amended the shortcomings identified in the then existing MoT model and related processes. The Senior Vice President's reaction when presented with the model confirms that the results were expected. In addition, passing a weak market test further proves apparent validity.

Internal validity refers to the coherence of the findings – to the snugness of the fit between the data and the findings and conclusions (Sykes 1991). Talonen's (2006) dissertation proves internal validity. He uses the same data, and comes to similar conclusions from a slightly different approach. The fact that the model amended the shortcomings, fits the company culture, and reuses most of the already existing procedures, proves *instrumental validity*. Even though it cannot be claimed that the model is the best one for the company, it is one of the working alternatives and it nicely fulfils its purpose.

Theoretical validity refers to the justifiability of research procedures in terms of established theory (Sykes 1991). This dissertation itself is a proof of theoretical validity. In addition, there are papers presented in scientific conferences (Hakkarainen & Talonen 2006, Talonen & Hakkarainen 2005), an article in a leading periodical (Talonen & Hakkarainen 2006), and also Talonen's (2006) dissertation.

Moreover, the author has submitted manuscripts for publication in business journals on the same subject. *Consultative validity* refers to the validation of data or interpretations through consultation with those involved in the research process (Sykes 1991). Senior management was active throughout the process. They actively participated in discussion, provided feedback, appointed a steering group to examine and accept the intermediate results, and the final results were presented to, and approved by, senior management.

The difference between *reliability* and validity is that validity focuses on the meaning and meaningfulness of data, whereas reliability focuses on the consistency of results (Sykes 1991). There may be acceptance that a research method is capable of producing 'valid' results but doubt as to whether it can be relied upon to do so (Sykes 1991). What this means is that separate research studies on the same data may produce different results. Are the results thus reliable?

The fact that the parallel work of Talonen (2006) arrived at similar conclusions proves reliability. The review of the papers (Hakkarainen & Talonen 2006, Talonen & Hakkarainen 2005) in scientific conferences provides additional proof. Because different methods may lead to different results, it is important that the entire process is made 'transparent' to readers of the research (Sykes 1991). What Sykes means by that is that the research must be documented so that a reader can follow the researcher's assumptions, reasoning and interpretations.

In fact, Sykes' argument can be interpreted in the extreme to mean that sufficient proof for reliability and validity is that a research study is well documented. It should be possible for the observer to see how and why the results of separate research studies might differ, and to be able to exercise his or her own judgment in deciding which to accept. The author has defined the research problem and objective, described the construction process, justified decisions and selection between alternatives in the course of work, and characterized the resulting framework as documented in chapters 2 and 3 of this dissertation.

The author was an active participant and agent of change in constructing the model. Does that imply that the results are not *objective*? No, that is only the way to participate in a critical, emancipatory research paradigm. It does not relate to the results.

They key question about objectiveness is: "*Could someone else have come to the same conclusions?*". Someone else could have, but the author doubts if that would happen in practise. Even with the same background and experience, there would be different weightings and constructs. Probably the most important subjects of development would have been the same.

Talonen's (2006) work supports the results, but as such it is a weak indicator of objectiveness. There was much teamwork and cooperation in constructing the model. We must find other proof. First, objectiveness does not mean that there is only one acceptable solution or result. It means rather that the results are not biased and they are generally acceptable. There can be several different solutions that are all objective. Acceptance of the article (Talonen &

Hakkarainen 2005) is a proof of objectiveness. Acceptance of the result by senior management is another proof. Maybe the strongest proof is passing the weak and the semi-strong market tests. No-one would take the model or parts of it into use if it were perceived as biased and of subjective construct.

4.3. Applicability

One of the key issues in the constructive research approach is an attempt to generalize the results.

There are no reasons, innate or constructed in the model, that prevent the model from being applied to any industrial enterprise. Remember that we are dealing with creating, maintaining and improving technologies, i.e. the skills to adapt proper techniques to accomplish an end. Physical or mental. Concrete or abstract.

The author already emphasized at the beginning that when referring to a product, he always means a *solution*. It can be a physical device with related processes, it can be a service, or a combination of these. A product is a solution to the customer; be it a consumer, another industry, or some other organization.

When talking about products, those in service business often want to teach others that service is also a product. And they continue by explaining how different and difficult it is as a business and as a development object. The message is that service business is so much more difficult, requires a different kind of expertise, and is thus sexier than producing physical products. Perhaps the reason for the difficulty of intuitively perceiving that product refers also to service is that the term has a strong and traditional connotation of a physical device. Maybe using its synonym "a produce" would help. Anyway, the author does not see any reason why the model could not be used for managing service technologies as well.

In general, any type of industry that uses technology as a competitive advantage can apply the model. Industries use technology to turn raw material into products and services; technology is the means to create added value. Even businesses as remote from manufacturing as the entertainment industry could apply it. There are no reasons why public administration or the non-profit third sector could not use it and benefit from it. Once again; we are creating, maintaining, and improving skills to adapt proper techniques. And one must bear in mind the results; the Schumpeterian technological innovations: new markets, new or improved processes, new industrial structures, and so on.

There are businesses such as commerce, financing or trading that do not use technology for adding value, at least not directly. Of course they have techniques to reach an aim, and they develop those techniques and skills, but it would be far-fetched to call that technology management.

There are industries, typically small and medium-sized enterprises, that do not need full-blown technology management. They can manage with a slimmer, more straightforward model. Or, they can follow innovation management practises that in many cases suit them better.

4.4. Contribution

As discussed earlier, KONE had already in use many of the technology management activities. However, they had deteriorated in the course of time, and there was thus a need to brush up and further develop the processes, methods and tools. The task for the research was *"to define, acquire, adapt, and implement an MoT process and a set of supporting tools suitable for the organizational and working culture of KONE."*

The main deliverables of the construction were a) a comprehensive set of MoT processes, b) a comprehensive tool set, c) instructions for conducting the processes and for utilizing the tools, and d) presentation material both for MoT practitioners and for non-practitioner interest groups. There are also templates and illustrative examples for a), b), and c).

The resulting framework has removed the earlier shortcomings and it provides the tools that were missing. It is elegant in that it suits the KONE way of working and its organizational culture, and it intensifies the existing processes.

The contribution to academia and to the generic body of knowledge is in that the model is a holistic one, incorporating both a complete framework and all the related tools. The framework is comprehensive both horizontally (it contains all the processes needed with related tools and definitions) and vertically (there is a clear path top down from strategy all the way to individual implementation projects).

The contribution to other industries and even to non-profit organizations is the same as for academia. In addition, the model is simple, but still sound. Simplicity is important so that it is easy to use, understandable and does not require dedicated facilitation. As stated above, there are no inherent reasons or created characteristics why it could not be applied in any type of industry, in public administration, or in the third sector.

4.5. Further Development

It would probably be easier to discuss further development if this were a theoretical study. Constructive research creates a solution to a specific practical need, and in this case for a specific company. The model works and serves its purpose and there are no immediate needs for further development of it.

The MoT model and related tools should be practised and exercised for a considerable period before taking any additional initiatives. Too often the author has witnessed someone rushing to "improve" a process because it seemingly does not work in the best possible way. The result is usually worse than the starting point because the problem might not be in the process itself.

The problem is often in understanding, applying and adapting a model or a process. One must really be sure of thoroughly understanding a process, its basic idea and its essential nature, to realize what is wrong in it, and to know how to improve it, before taking any actions.

The model is a generic one, aimed at addressing all the relevant aspects of technology management in a company. Its main shortcoming, however, is that it is partly biased towards research and development. On the strategic level the business and technology considerations are balanced, but the tactical level places the focus too much on product technology development, and on the operational level even more so. One could say that at the highest level the focus is right, but when refining it down into practical operations, it becomes too centred on product development, with business considerations remaining somewhat abstract and lacking practical tools.

There are a couple of reasons for that. First, the background of the author. Although the author carefully tried to follow business and other aspects, he fell into viewpoints emphasizing product technology at times. The second reason is that there are well-defined, proven processes for product development. Of course also organizational changes, human resource developments, etc., take place, but the culture is not very strong. Their processes are less defined or are defined on a case-by-case basis; at least from the viewpoint of this thesis. The third reason is the author’s delivery. The business considerations mentioned were present in the author’s thinking when developing the model and while compiling this presentation, but maybe they remained too implicit.

A technical shortcoming is in declaring the tools with a data dictionary. One could use XML or another modelling language that better enables using attributes to declare the characteristics of the tools and their relationships. That might also help in declaring business and technology aspects, their roles, inter-relationships and implications. It would help to understand especially the implicit business aspects.

However, one can benefit from the existing model. In a case where there are no immediate development needs, one can consider what internal and external changes could lead to such needs arising. Changes in the internal organization, the business concept or other internal changes will not have an effect because the model is independent of those. It is also difficult to imagine external changes leading to development needs. The essential characteristic of the model is resilience; the ability to adapt to the ever-changing competitive and business environment.

Let us conclude with a philosophical remark. It is better to have something working and benefit from it, rather than endlessly strive for the one and only optimal and ultimate solution. And instead to redirect one’s view to new challenges.

5. IN CONCLUSION

Only one-third of today's major corporations will survive in an economically important way over the next quarter of a century, and the phenomenon seems to become even more drastic over the course of time. Why is that? It is a question of creative destruction, an occurrence close to Darwin's survival of the fittest. In order to survive in this turbulent competitive environment one needs tools and practises, which we call collectively "management of technology". Technology does not mean a product, part or any physical entity. Technology is a company's capability to assure competitiveness. It addresses not only product or manufacturing techniques, but also managing all the relevant knowledge and skills of an enterprise: marketing, manufacturing, support processes, etc., that define success or failure in competition. After all, the concepts of technology management are simple and easy to understand.

This study is based on a technology management model created for a major global corporation. It is not only a case study, but it rather follows the constructive research approach where one a) creates an innovative and theoretically sound, argumented solution for a relevant practical problem, b) verifies the solution in practise, and c) makes an effort to generalize it. This thesis presents the study, discusses findings and empiria, and draws conclusions in the constructive research framework. The empiria and discussion also cover implications in a wider context of research and applications.

The theoretical and practical foundations for the research are strongly based on the author's experience, earlier knowledge, contemplations and conclusions, which have been sedimented and refined from literature sources, presentations and numerous discussions.

The thesis places great emphasis on, and starts with, working definitions of the terminology for three reasons. First, to ensure that the author and reader use the same language and understand it in the same way. Secondly, it spans the sphere of this thesis. And thirdly, the purpose is to drill down to core of the authentic definitions and dust off the unnecessary hype.

The main contribution to the corporation was to integrate the already existing processes together in a holistic framework, and to remove the shortcomings. In addition the model suits the corporation's way of working and its culture, thus intensifying the existing processes.

The contribution to academia and to the generic body of knowledge is in that the model is a holistic one, incorporating both a complete framework and all the related tools. The framework is comprehensive both horizontally (it contains all the processes needed with related tools and definitions) and vertically (there is a clear path top down from strategy all the way to individual implementation projects). In addition, there is a novel role for technological innovations. Usually innovations are considered as the front-end of technology or innovation management processes. In this framework their natural place is as the last, implementing agent that convey the results into operative business processes.

The contribution to other industries and even to non-profit organizations is the same as for academia. In addition, the model is simple, but still sound, and thus easy to apply.

The essence and key concept of the research was management of technology. The related core and a thread of this thesis are managing it as a strategic resource. Another important underlying concept is resilience. Mere strategy is not enough, a strategy must be resilient; ability to continuously adapt to the changing environment is essential to survival.

After all, another alternative still remains:

"It's not essential for a company to change.

It can just die instead."[1]

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[1] *Yrityksen ei ole pakko muuttua. Se voi myös kuolla. Helsingin Sanomat 18.1.2005, p. A9. [Advertisement of PHS advertising agency].*

Knowing is not enough; we must apply.
Willing is not enough; we must do.

Bruce Lee, Chinese philosopher

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