Chapter 1

Bringing technology to the boardroom: What does it mean?

Hugo Tschirky

Abstract

The presence of technology in the boardroom reflects a top management process in which business decisions are taken with an awareness of the fundamental opportunities and risks associated with technological change. To comply with this responsibility, relevant questions need to be raised and answered within top management. These typically cover the quality of company policy, the availability of technology competence within top management, the nature of company culture, the inflow of relevant business (technology) information, the completeness of strategic business planning with respect to technology and innovation issues, and the implementation of management instruments that integrate the technology aspects of all major enterprise functions.

Keywords: Technology Management; Technological Change; Technology Competence; Strategic Business Planning; Integrated Technology Strategies

1 Understanding technology as an ordinary unit of general management

It is common to consider money as a basic unit of management. Cost, expenditure, assets, investments and finally bottom lines are expressed in Dollars, Pounds, Roubles and now in Euros. Time is another such unit. Working and operation times are measured in hours, project completion times are planned in months and sometimes strategic planning horizons are depicted in years. Technologies are de facto similarly manageable entities. Technology constitutes specific knowledge, abilities, methods and equipment, facilitating deployment of scientific and engineering knowledge.

In order to remain competitive, companies are mastering a countable number of technologies with four purposes: they enable researchers and engineers to develop new products and services, they allow products to perform specific functions, they serve manufacturing to produce products and finally they enable companies to operate their administrative processes and infrastructure. *Product technologies* on the one hand deploy scientific or engineering principles, e.g. from optics, electronics, nuclear physics, aerodynamics, etc. dealing with a specific effect and determine how an effect occurs. This effect allows the fulfillment of a specific product function, e.g. "detect fire" which - from the point of view of the market - is oriented towards expected customer needs, e.g. "protection from fire damage", as outlined in Figure 1. Product technologies that can fulfill this product function are for example light scattering, ionization or temperature technologies.

R&D faces the challenging task of making a reasoned choice between various technologies - both current and to be developed - representing variables in order to realize product functions.

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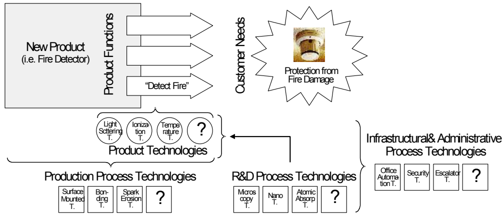


Figure 1: Product and process technologies constituting product creation
(Example: Development of fire detection sensor device) (Tschirky 1998: 228)

Process technologies on the other hand deploy the *effects* of an existing product technology. R&D process technologies are used for performing R&D activities and may include technologies such as microscopy, nano and atomic absorption technology. Typical production process technologies include casting, milling, galvanizing, soldering and surface mounted technology (SMT). They also consist of logistics and quality assurance technologies. Administrative process technologies usually comprise office automation technologies and, finally, infrastructural process technologies typically may comprise security, elevator, escalator and air conditioning technologies.

The above refers to an understanding of technology in the *limited domain* of product and market. As technological change permeates many social and economic domains, a further-reaching, *holistic* understanding of technology must also be developed. This extends beyond the domain of product and market and encompasses higher concepts of technology progress, quality of life and the social efficacy of technology.

2 How does technology management relate to general management?

With the vision that technology management should be part of general management, an immediate question comes up: what is an appropriate framework of general management to constitute a meaningful shell for technology management issues? When attempting to answer this question, it becomes obvious that the number of available frameworks is limited. Among them, the concepts of “Potential and Process Approach to the Enterprise” and “Integrated Management” appear to be best suited to the purposes:

With respect to concepts of *enterprise management* it is widely accepted that considering tasks on the *strategic* and subsequently on the *operational level* is indispensable to general management. For the management of the technology enterprise, however, a restriction to these two levels is not satisfactory since factors beyond strategy play an important role. Primary among these are company policy, company culture and original enterprise structures. This deficiency is taken into account in so-called "Integrated Management” concepts (Ulrich 1984, Bleicher 1991), in which the strategic and operational levels are grouped under a higher *policy level* of management[1] (Figure 2).

[1] In the original literature (Ulrich 1984, Bleicher 1991) this top level management is referred to in German “normative”. A literal translation into English would lead to “normative”. Since this translation may lead to confusion, the term “policy level” is used instead.

Firstly, on the *policy* level, primary decisions must be made according to the long-term goals of the enterprise. This requires the development of a consistent *company policy*. At the same time an awareness of the culture permeating the company is essential. Company culture includes the values held collectively by its employees, which is expressed, for example, in how employees identify with company goals and in the company´s behavior towards the environment, and manifest themselves in the company´s ability to change and innovate. On the normative level it is not only the *making* of long-term decisions which is vital for the company's future. Just as essential is *who makes these decisions*. This question involves the upper decision-making structures of the company. The far-reaching nature of technology decisions requires that technology expertise be applied to the decision-making process from the outset. The guiding principle for the normative level is the *principle of meaningfulness*.

Figure 2: Three levels constituting general management (Ulrich 1984: 329)

On the *strategic level* it is essential that company policy is transposed into comprehensible strategies. Strategies lay emphasis on the selection of those technologies necessary for the development and production of present and future products and services. In particular, decisions are made as to whether these technologies will be developed in-house or in conjunction with other firms, or whether they will be purchased completely from other companies. Relevant trends in strategic technology management indicate that strategic alliances, process management and innovative and innovation-boosting structures are taking on increasing significance, as is technology scanning and monitoring, i.e. the comprehensive and systematic collection and accumulation of information concerning existing and developing technologies. This "early warning function" is often referred to as *technology intelligence,* which is part of an overall business intelligence system. A further focus involves concepts of socio-technical systems design which postulate the quality of work-oriented deployment of technology *and* work. On the strategic level the *principle of efficacy* - meaning "doing the right things" - is prime.

Finally, on the *operational level* of management, responsibility is taken for transforming strategies into practice in the context of short-term goals. Operational management expresses itself, for example, in concrete R&D projects in which the necessary personnel, financial and instrumental resources are deployed according to a plan. Here the pointer is "doing things right", implying accordingly the *principle of efficiency*.

According to this view technology management can be conceived as an integrated function of general management which is focused on the design, direction and development of the technology and innovation potential and directed towards the policy, strategic and operational objectives of an enterprise.

This concept of technology and innovation management will be exemplified now in detail.

3 Technology and innovation management as an integrated part of general management - practical examples

3.1 Example 1: Expressing technology and innovation values in visions, policies and mission statements (policy level)

The longest-term decisions taken by company management are expressed in documents like *company vision, company policy, and mission statements*. As a rule, these kinds of statements are generalized which nevertheless aims at verbalizing the company's uniqueness. The content usually covers long-term objectives, main areas of activities, geographical dimensions of businesses, major resources and competencies, innovative ambitions, the desired relationship with customers, attitude towards societal and ecological expectations, the role and development of human capital and the values that determine communication and collaboration.

For companies relying on technology it is necessary to stress this dependence within such normative statements, because they represent strong signals inside and outside the company. In particular, in times of increasingly flattened hierarchies, such signals are gaining importance as guiding ties around decentralized responsibilities and competencies.

The following examples in Figure 3 illustrate normative statements that mirror the technology dependence of companies.

Compaq's Vision

Inspiration Technology
As an industry we talk a lot about speeds and feeds, and that's fine. Performance matters. But the real power of technology is not the machine; it's in the inspiration. The web was not a product of technology. It was one part technology and three part inspiration. The decoding of the human genome was less a technological achievement than a human inspired achievement, enabled by technology. At Compaq we look at it this way: People enabled by great technology can achieve great things.

Michael Capellas CEO, Compaq

President's Message

We are used to seeing technological development as a help to improve our standards of living.

Today, we are increasingly alert to their impact as to sustainability, efficient use of energy and environmental protection - for all our tomorrows.

We in ABB - as leaders in several key industrial areas - are at the very center of these challenges.

With our leadership role comes the responsibility to secure real and practical innovations.

Every year we invest a significant amount of our resources in research and development (R&D) in order to ensure that we remain a leader in our industry.

Our aim: to sustain growth and profitability through meaningful innovation.

That is the thought behind our ABB group slogan "Ingenuity at Work".

Göran Lindal
President and Chief Executive Officer, ABB

Figure 3: Examples of normative statements of technology-based companies

3.2 Example 2: Taking into account the vital link between technology & innovation strategy and company culture (policy level)

The uniqueness of each enterprise is primarily defined by its *organizational culture*. Understanding the organizational culture is an indispensable prerequisite for successful leadership of an enterprise under rapidly changing environmental conditions. Only cultural characteristics can ultimately explain why a new strategy has been implemented satisfactorily or not. In other words: Working on a new strategy must aim at reaching a "cultural fit", i.e. correspondence has to exist between the behavioural pattern under which a strategy can be implemented effectively and the given culture determining current enterprise behaviour. Achieving such a cultural fit can mean intentionally changing the organizational culture as a proactive alternative to adapting a strategy to a given culture. This has been the case, for example, at ABB after the merger between BBC and ASEA (Figure 4):

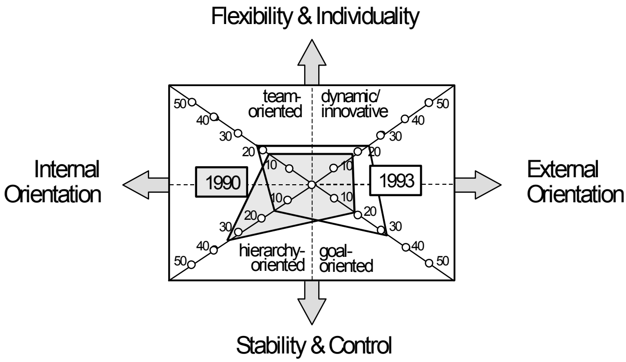


Figure 4: Examples of normative statements of technology-based companies (Meyer 1994: 47)

After the merger on 5th January 1988, ABB was challenged by enormous managerial problems. These included the organizational integration of companies in more than 50 countries, the creation of 3500 profit centers, the execution of programs to increase productivity, to realize numerous strategic alliances, and to maintain a high level of innovation capability despite cost reductions.

The main challenge consisted of implementing the new decentralization strategy "think global - act local". These fundamental changes were accompanied by investigations to determine the extent to which the company culture is responding to these changes. To this end a concept of company culture was developed as shown in Figure 4. Two main dimensions of cultural orientation were identified, which are internal orientation vs. external orientation and stability/control vs. flexibility/individuality. The results of the study are interesting: whereas in 1990 the company culture had a focus on internal orientation and stability/control, a distinct shift towards external orientation and flexibility/individuality could be observed in 1993.

3.3 Example 3: Equipping top management decision bodies with technology competence (policy level)

As a consequence of technology change and its inherent - often existential - opportunity and risk potential, a well balanced representation of technological and non-technological competences to make business decisions is required. In this context, the composition of the board of directors and the top management group is of primary importance. For example, this criterion is key to corporate governance at Intel (Figure 5 left).

A frequently chosen solution is to nominate a Chief Technology Officer (CTO) as a member of the top management group. According to a study completed by Roberts from MIT in 1999, this solution is realized in 95% of Japanese companies, the corresponding figures for Europe and the US are 32% and 8% respectively (Figure 5 right).

> INTEL CORPORATION BOARD OF DIRECTORS GUIDELINES ON SIGNIFICANT CORPORATE GOVERNANCE ISSUES
>
> 5. Board Membership Criteria
> The Nominating Committee is responsible for reviewing with the Board from time to time the appropriate skills and characteristics required of Board members in the context of the current make-up of the Board. This assessment should include issues of diversity, age, skills such as understanding of manufacturing, technology, finance and marketing, and international background - all in the context of an assessment of the perceived needs of the Board at that point in time. Board members are expected ...

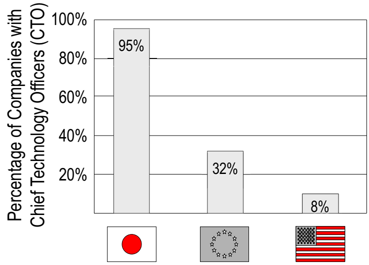


Figure 5: Competence structure of boards of directors and top management groups (Figure right: Roberts 1999: 5)

3.4 Example 4: Keeping the scope of technology strategic options wide open (strategic level)

Let's first ask the question: what are technology strategies? The answer often refers to leader or follower strategies. This may be correct but the useful content of strategies goes much further. In general, strategies are mid-term decisions on business activities and allocated or to be built-up resources. It can be useful to differentiate strategic statements from statements on "what will be reached?" (goal statements) and "how shall we reach the goals?" (path statements). This idea is expressed in Figure 6 left.

In terms of technology strategies this means that on the one side "goal statements" focus, for example, on decisions on core technologies, base technologies, support technologies and obsolete technologies. Often, decisions are taken on the level of strategic technology fields, which represent a grouping of structured technological knowledge around selected core technologies. On the other hand, "path statements" reflect decisions taken on being a leader or a follower in reaching the goals and on pursuing cooperation strategies, make or buy strategies or other selected strategies.

3.5 Example 5: Developing integrated technology strategies (strategic level)

The development of technology strategies is not an isolated activity but rather ought to occur within a joint and simultaneous collaboration between those responsible for functional and strategic business unit strategies (Figure 6 right).

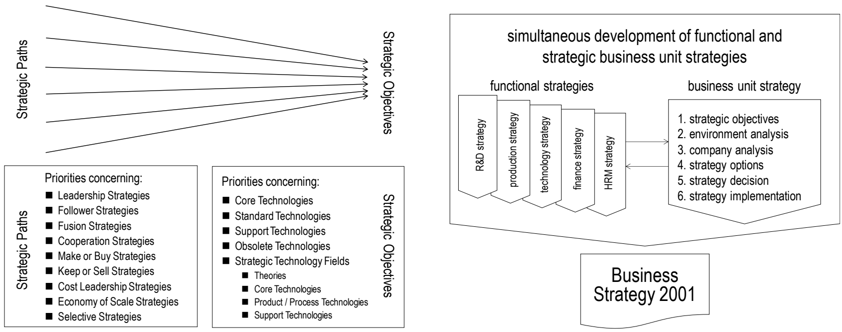


Figure 6: Content of technology strategies as a result of simultaneous development of functional and strategic business unit strategies (Tschirky 1998: 295)

The pattern of such a collaboration could, for example, consist of a stepwise and iterative integration of technology issues into the typical steps of strategic planning, such as setting strategic objectives, analyzing the environment, analyzing the company, elaborating strategic options, taking strategic decisions, implementing the strategy (Figure 7). This means, for example, when setting strategic business goals such as market shares and ROE-goals, matching strategic technology objectives such as innovation rate, quantitative quality goals (i.e. six sigma) and patent position are simultaneously set.

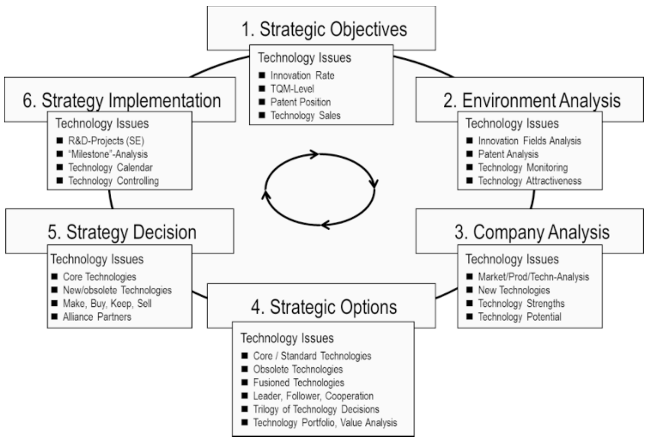


Figure 7: Integration of technology issues into strategic business planning (Tschirky 1998: 295)

In other words, pursuing such a procedure means closing "technology gaps" which are often observed in strategic business planning. These gaps are typically informational and are apparent in the following areas: technology objectives (see above), technology forecasting and assessment; technology networks relating technology and business units or relating product technologies to process technologies; market-product-technology analysis; defining technology potential; identifying the strategic technology position portfolio; specifying strategic technologies and, correspondingly technology strategies; defining technology projects consisting of R&D projects to develop product and process technologies; and, finally, the technology calendar, which represents a schedule for technology introduction.

3.6 Example 6: Analyzing carefully the current and prospective innovation rate (strategic level)

To be innovative is undisputedly a well justified recommendation for all business activities. Being innovative however is a quality which still characterizes a limited number of companies. Among them, 3M is certainly a good example. In the annual report for the year 2000, the new president W. James McNerney Jr. proudly reports that $5.6 billion or nearly 35 percent of total sales has been generated from products introduced during the past four years, with over $1.5 billion of sales coming from products introduced in 2000. A closer look at the company's management practice makes it easy to explain this impressive achievement, since above all, taking every measure to keep the company culture open and creative is obviously an outstanding leadership competence.

Becoming innovative may start with the analysis of the innovation rate, a recording of the amount of annual sales from new products. To this end, firstly, criteria for "new products" has to be established, which in the case of 3M, means market introduction over the past four years. Further steps focus on analyzing the innovation rate for the past few years and comparing the values with estimated values from competitors. Then, a decision has to be taken on how the innovation rate ought to develop in the years ahead.

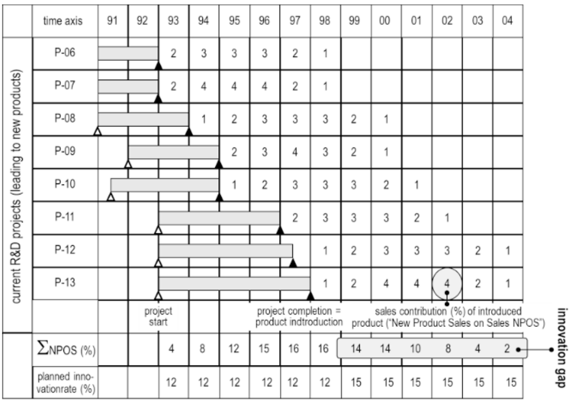


Figure 8: Analysis of the past and prospective innovation rate (Tschirky 1998: 342)

As a rule, it would be most unrealistic to assume that the long-range innovation rate will not rise. Whatever assumption is made, the natural question has to be how well the company is prepared to meet the prospective innovation requirements. It is in other words, the question on the appropriate content of the often cited "pipe line". The first answer to this question can be obtained relatively easily from the following analysis (see Figure 8):

First, using a suitable matrix, all ongoing R&D-projects are listed according to their starting and completion times. Then for all the projects, individually planned prospective sales contributions are "translated" into percentage values equaling "new product sales on sale" NPOS. Next, the NPOS values are calculated vertically for each year. Comparing these yearly values with the planned innovation rate allows a first estimate of how well the future innovation target will be met.

In the fictitious case, in (Figure 8), the company is facing a considerable innovation gap over the next few years, quantifiable in terms of percentage of sales. In this case the next steps are evident. They will have to focus on additional "innovation contributors", which may include increased buying-in of components and technologies, increasing market attractiveness of products in development, extending life cycle of existing products, setting-up research collaborations or planning additional R&D projects aimed at attractive new products.

3.7 Example 7: Optimizing technology knowledge resources: trilogy of technology decisions (strategic level)

Strategic technology planning as part of business strategy planning implies making three fundamentally different but mutually complementing decisions: The *first decision* ("Which Technologies?") originates from an extensive analysis of current and future products. In particular, key technologies that determine the product performance, and the process technologies required for product production and infrastructure. This analysis is based on so-called technology intelligence activities, which include cross-industry search of current technology, technology forecasting and technology assessment. Based on this analysis, a decision has to be made as to which of the available and yet-to-be developed technologies are required for the continuous development of the enterprise. The *second decision* ("Make or Buy?") is concerned with the question as to whether the required technologies are to be made available through acquisition, collaboration with other companies or through in-house development. The *third decision* ("Keep or Sell?") deals with whether available technologies are to be applied exclusively for company purposes or can - or even must - be made available to other companies.

These three decisions are tightly interdependent, and together, represent the "trilogy of strategic technology decisions" (see Figure 9). Having this trilogy in mind and working on the three decisions quasi-simultaneously offers various advantages. Above all, it allows productive use of information since all three decisions rely on mostly identical information concerning technology performance, technology application, technology forecasting, technology assessment, technology users, and technology providers. Then, an increased coherence of the three answers is to be expected, which certainly contributes to the quality of strategic technology planning. Finally, the trilogy concept leads to innovative structural solution. It consists of combining the buy- and sell-activities of technologies within an organizational element which can be called „Technology Intelligence Centre". Its basic role is to improve the trilogy of strategic decisions, for example, with the establishment and operation of a company specific technology early warning system, with the actual execution of buy and sell negotiations of technologies and finally with the elaboration of proposals for technology strategy decisions. This concept, is in sharp contrast to classical company organization, where the procurement department and the marketing units are usually widely separated entities.

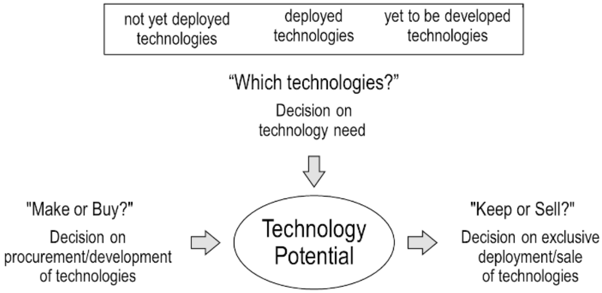


Figure 9: Trilogy of strategic technology decisions (Brodbeck et a. 1995: 108)

This so-called functional integration might manifest itself in practice as a central unit bringing together - partly temporarily and partly permanently - representatives from R&D, production, marketing and finance and carrying joint responsibility for periodic elaboration of strategic technology decisions.

Working on the trilogy concept leads to the hypothesis that, in the future, technology-intensive companies will need to position themselves in two quite different market domains: the traditional supplier-consumer market and the technology supplier-technology user market (Figure 10). This visionary concept of technology marketing has to be investigated further, under the assumption that its systematic implementation will contribute considerably to successful technology management.

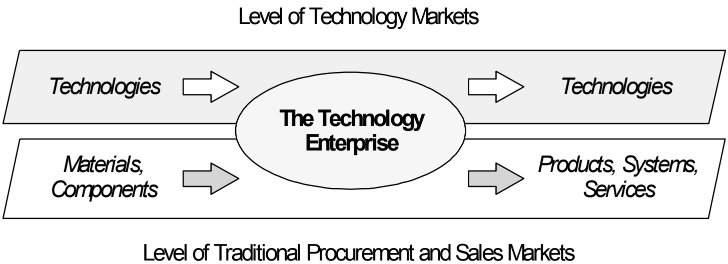


Figure 10: Prospective two-level market activities to be mastered by technology-based companies (Tschirky 1998: 302)

3.8 Example 8: Overviewing technology strategic positions completely (strategic level)

One instrument of Technology Management in particular has been seen to gain relatively wide acceptance early on: the Strategic Technology Position Portfolio (Figure 11, left).

It is a matrix tool that provides an easily interpreted and communicated overview of current and future technology positions. Its popularity is attributable to the fact that thinking in terms of portfolios is fundamental to strategic business planning, where strategic product and business positions are to be dealt with.

This portfolio rates and positions all major technologies according to their "Technology Attractiveness" with respect to their innovation and market potential, and their corresponding "Technology Strength", i.e. the resources currently available within the company.

This rating can be carried out in several ways. One, a theoretical approach, consists of making extensive assessments of the numerous factors which determine the two dimensions of the portfolio, such as market potential of new products, potential contribution to earnings and potential for multiple use (for technology attractiveness) and number of knowledge bearers, R&D expenditure and number of patents (for technology strength).

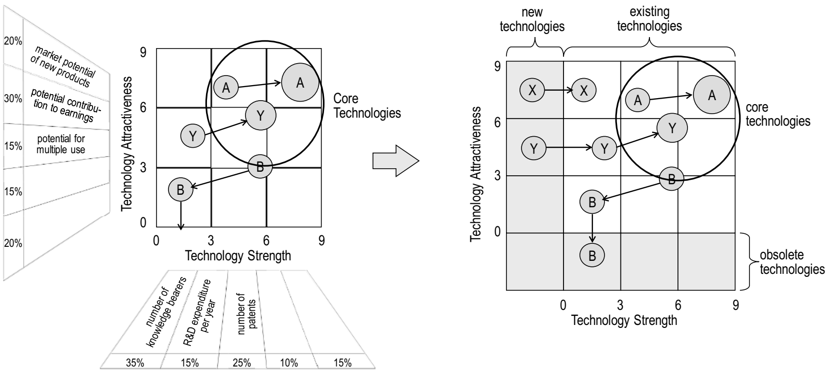


Figure 11: From the traditional to the dynamic technology portfolio (Tschirky 1998: 315)

Another, practice-oriented but nevertheless useful, consists of independently inviting experts from inside and possibly from outside the company to express their opinions on the attractiveness and competitive strength of various technologies. This procedure leads relatively quickly to the data required to draft the portfolio. This second approach has been successfully implemented recently by several Swiss companies from the mechanical, electrical and even the pharmaceutical industry.

Once the portfolio has been developed, its strategic evaluation can take place. This focuses on setting priorities as to the promotion or reduction of technology development resources or even the phasing-out of aging technologies. The latter decision usually follows intensive internal discussions. In particular, consensus has to be reached on core technologies. They constitute strategic knowledge assets of companies and are usually developed in-house with high priority (see next example).

The main merit of the technology portfolio lies in its high degree of condensation of strategic information and at the same in its ease in communicating strategic decisions. In addition, a successfully finalized technology portfolio reflects completion of a constructive collaboration between experts from R&D, production and marketing, which is a valuable goal on its own.

Despite the undisputed popularity of technology portfolios, they are still lacking essential strategic information. In its traditional form, the portfolio visualizes the positions of technologies which are currently being used by the enterprise and therefore their corresponding technology strength can be identified. It does not represent however, technologies which are attractive despite the lack of company resources. This information is significant, because the future promotion of new technologies will require company resources, in addition to that needed for the promotion of existing technologies. In order to include this information in the technology portfolio, the use of „Dynamic Technology Portfolio“ (Figure 11, right) is recommended instead; in addition to the traditional portfolio, it is extended by the column „New Technologies“ and at the same time by the line „Obsolete Technologies“. This allows the inclusion of information about technologies that had once been part of the company’s technology activities. Overall, this expands the time horizon of the portfolio.

3.9 Example 9: Core technologies as strategic backbone of technology and innovation management (strategic level)

In recent years, the notion of “core competencies” has become a widely accepted concept in general management. More precisely, it is a strategic concept which aims at explaining a company’s competitive strength. Earlier competitive positions were related to available resources, such as capital, human resources and logistics potential. In contrast to company resources which can be obtained or “bought”, core competencies describe capabilities that result from organizational learning over years. They are therefore more inherent, more genuine to the company and certainly less “purchasable” than resources. A typical core competence of Sony for example is miniaturization. Honda’s distinct core competence is mastering “high revolution engines”, which started in the early days when Honda produced high revolution scooters and mowing machines. This core competence enabled Honda to enter the Formula-1 competition successfully, at an amazingly early stage compared to its competitors.

Core technologies fall into the category of core competences. These are usually key technologies that give the company its unique competitive advantages. As mentioned, core technologies are preferably original technologies developed with priority funds within the company. Whereas companies depending on their size have to master hundreds or up to thousands of technologies, the number of core technologies is limited and may amount to a small proportion of all technologies. The ionization technology, described earlier, has been a core technology for Cerberus, a leading fire security company for over twenty years.

A final example refers to Advance Issue Sciences Inc. This company is renowned for its capability to produce human tissues. In essence, this capability is based on mastering two core technologies (Figure 12): cultivating human cells and building biodegradable scaffoldings. By combining these two core technologies the company is in the position to manufacture two- and three-dimensional tissues. The first batch of products, artificial skin in various configurations, is on sale. The next batch of products will consist of orthopedic cartilages and ears.

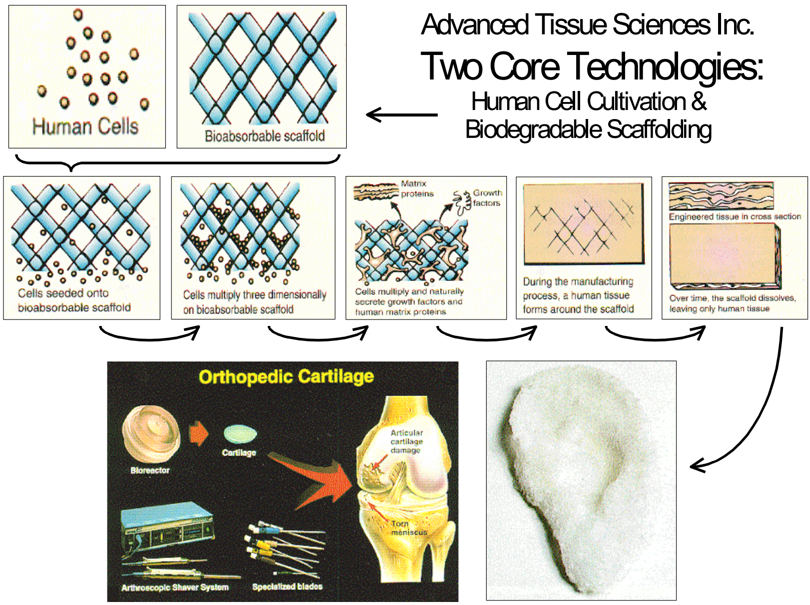


Figure 12: Example core technologies: Advances tissue sciences Inc. (2000)

Core technologies play a central role in strategic technology planning. Often they constitute the core of so-called strategic technology fields (STF), which as a structure can be used to reduce the complexity of the large number of technologies that usually need to be handled. STF's are the counterpart to Strategic Business Areas (SBA) which assemble knowledge on specific markets and their relevant customer needs/benefits, product functions, products and services.

Within STF's in addition to core technologies, relevant theories, product, process and support technologies are grouped which as a whole represent a strategic entity suitable for setting strategic priorities. Optimizing the technology potential, for example, means reducing the number of STF's to an economically and strategically justifiable minimum. At the same time, penetration of STF's throughout the SBA is aimed for (Figure 13).

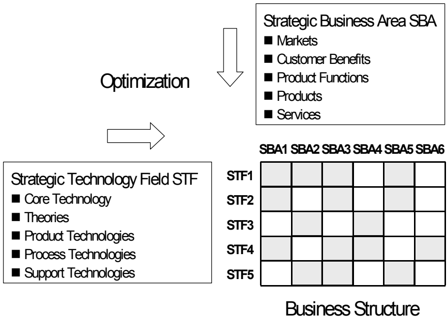


Figure 13: Optimizing core technology penetration in the strategic business areas SBA (Tschirky 1996: 80)

3.10 Example 10: Visualizing core technology forecasting effectively using technology roadmaps (strategic level)

Technology roadmaps are widely used strategic technology and business management tools which depict comprehensively the predicted development of essential technologies over time. They result from extensive research on available information on technology intelligence combined with concise company internal evaluation of technological in-house development. The following examples may illustrate this technique by illustrating the development of wafer and stepper technology predicted by Canon (Figure 14):

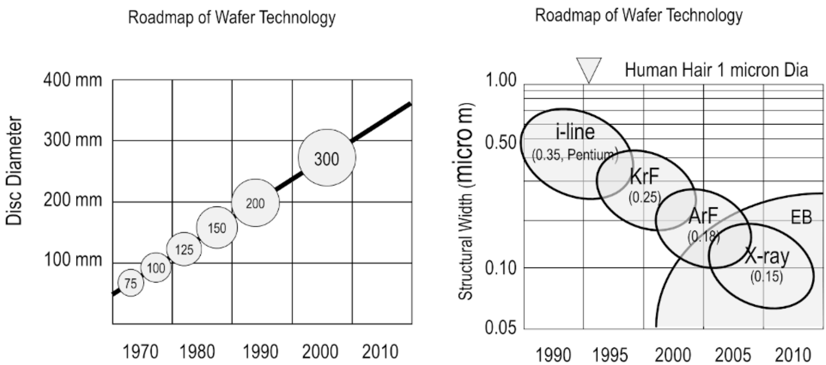


Figure 14: Technology roadmaps visualizing the predicted development of wafer (left) and stepper (right) technology (Canon, 2000)

3.11 Example 11: Relating the value of technology strategies directly to the company's value (strategic level)

A further strong link between technology issues and the general management perspective consists of evaluating technology strategies in such a way that allows for directly relating the value of technology strategies to the company's value. In the past, so-called investment and pay-back calculations have been applied in order to financially justify technology strategies or single R&D-projects. The decision to approve or reject project proposals was usually based on minimal rates of return (i.e. 15%) or maximum pay-back periods (i.e. 3 years).

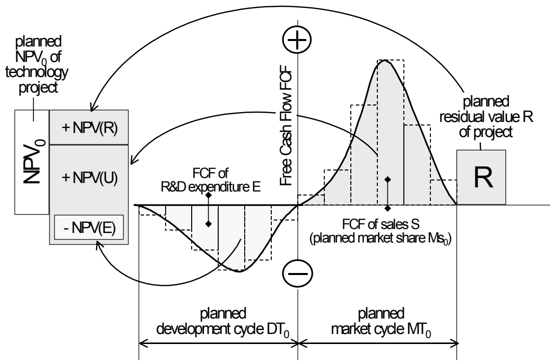


Figure 15: Establishing R&D projects net present values NPV (Tschirky 1998: 348)

Using the discounted free cash flow analysis, according to Rappaport (1986), it is possible to establish strategy and project values in terms of Net Present Values NPV (Figure 15), which represent numerical values referring to increases or decreases of the total company value. It is evident that, through this procedure, the interest of top management in technology strategies and R&D projects is much higher than in financial project data which only express a “local view” from the R&D department.

3.12 Example 12: Technology calendar: documenting interdisciplinary consensus (strategic level)

This technology management tool has a high integrative value. It provides an overview of all product and process technologies with respect to their timely introduction in existing and new products and in the production process respectively (Figure 16).

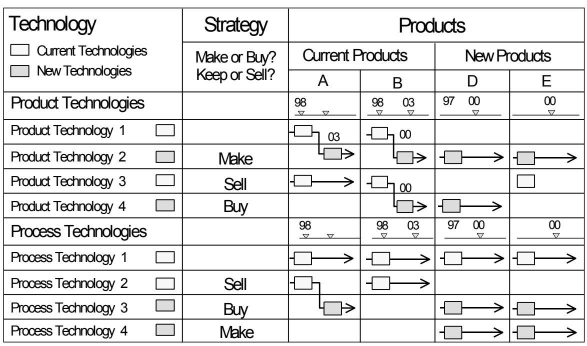


Figure 16: Technology calendar (Tschirky 1998: 320)

The elaboration of the technology calendar requires a high degree of interdisciplinary collaboration since it summarizes plans from marketing, R&D, production and financial points of view. Therefore, in addition to being a useful management tool it represents a documented evidence of above average level of internal communication quality.

3.13 Example 13: Gaining time to market using simultaneous engineering (operational level)

Given the accelerated pace of technological change, the main focus of R&D management has shifted from keeping project costs under control to timely introduction of new products. According to an often cited investigation by Siemens (Figure 17), a project cost overrun by 50% causes reduced earning in the order of 5%. However, if a five-year project is exceeded by only six months, the earnings are reduced by 30%.

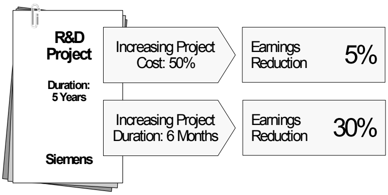


Figure 17: Project completion time: its leverage on earnings (Tschirky 1996: 95)

Project completion time can be reduced by what is commonly known as Simultaneous Engineering (SE; Figure 18, left):

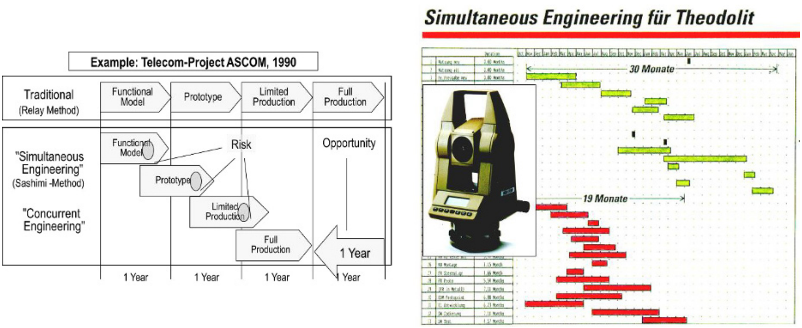


Figure 18: Project management by way of simultaneous engineering; case from practice (Development of Leica Theodolite) (Tschirky 1996: 101)

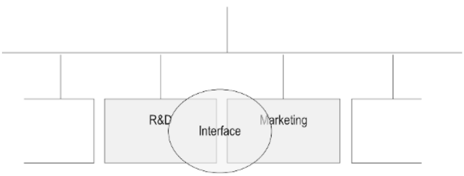
This project management concept converts the traditional procedure of completing the individual phases of product development (functional model, prototype, limited production, full production) in series to a procedure in which the phases are partly overlapping. This means on the one side to take risks, since essential project information may be uncertain during times of overlaps. On the other, however, valuable project time can be gained to the benefit of shortened R&D cycles and accelerated market entry. Concurrent Engineering is often used as synonym to SE.

In practical cases time reductions of 30% and more are not unrealistic. In the Leica case, a theodolite has been developed using simultaneous engineering, resulting in a shorter project time from 30 months to 19 months (Figure 18, right).

3.14 Example 14: Being aware of intracultural barriers and ways to overcome them (operational level)

Recently, one of the major players in the pharmaceutical industry expressed concern about the faltering collaboration between its R&D and marketing departments. Typical in this situation, was for example, the presence of prejudices between members of the two departments: marketing would consider R&D to be “narrow-minded, too specialized, not aware of ‘real-word’-problems, too slow, and not cost conscious." And R&D were of the opinion that marketing was "impatient, incapable of understanding technical problems, exclusively interested in short-term problems, unreliable with respect to confidential R&D-information."

Further investigations focused on the “interface” between marketing and R&D (Figure 19, right) and came to the conclusion that this situation was not the result of any “badwill” of the people concerned but rather the natural consequence of the fact that cultural determinants of the two groups were fundamentally different (Figure 19, right).



Cultural characteristics	R&D	Marketing
Time horizon	long-range	short-range
Feedback time	long	short
Reality	■ technological ■ “objective” ■ empirical ■ “factlogical”	■ economic ■ “intersubjective” ■ consens-oriented ■ “psychological”

Figure 19: The intracultural barrier between R&D and marketing (Wiebecke et al 1987: 5)

Therefore, subsequent research concentrated on the question of how to overcome such internal cultural barriers. The answer was threefold:

- building procedural bridges: joint planning of all aspects of R&D-programs: research, technology, product & process development, joint staffing of projects, pre- and post transfers, common proposals, including product specifications, jointly established criteria for project discontinuance, common base of information;building structural bridges: physical proximity, "organizational" proximity, integrators, process management, specialized transfer groups, internal multidisciplinary venture groups, simultaneous (concurrent) engineering project work;building human bridges: people movement, both upstream & downstream (most effective of all bridging approaches), improve: formal information & meetings, promote: informal contacts, rotation programs, “liaison” personnel, joint problem solving sessions, common training, create: interface awareness and atmosphere of mutual trust.

3.15 Example 15: “Gatekeepers”: usually anonymous carriers of informal communication (operational level)

One of the rare full-scale investigations in technology management, which got an extraordinarily wide acceptance, concerns the “Gatekeeper”-phenomenon. It was carried out by Tom Allen from MIT in the 1980’s and reveal a valuable insight into the dynamics of knowledge transfer in R&D organizations (Allen 1986). Main findings emphasize the dominance of communication and the key role which relatively few people play as carriers of communication processes.

Typical result of the investigations states that the frequency of internal and external and communications is a determining factor for project success (Figure 20).

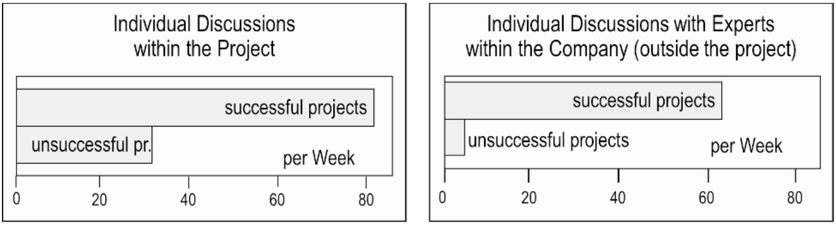


Figure 20: Internal and external communications of successful and unsuccessful R&D Projects (Allen 1986: 112, 114)

Not surprisingly, the contributions from the individual researchers and engineers to this frequency are unevenly distributed. In typical communication networks of R&D organizations which visualize the communication intensity during a given time period (i.e. one month) usually a small number of people attract attention as being "communication nodes" of the network (Figure 21, left). At first these people were called "communication stars". Since detailed analysis of their daily activities showed that in addition to being preferred discussion partners within the company they also were perceptibly above average in fostering external communication and literature study (Figure 1, right).

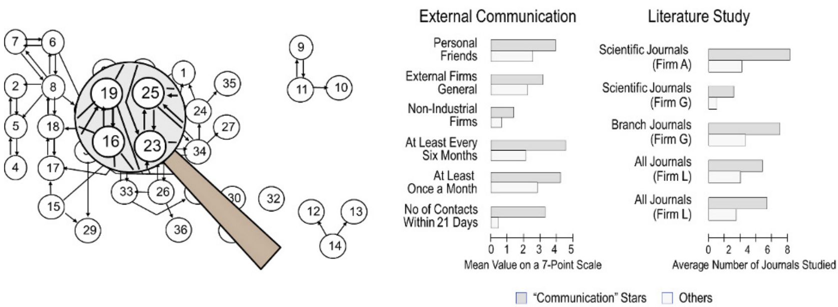


Figure 21: "Communication stars" (gatekeepers) within communication networks of R&D structures (Allen 1986: 146, 147)

Based on these findings the "communication stars" were baptized "Gatekeepers" since these people obviously functioned as gates for channeling external information and its internal distribution (Figure 22). In other words: information flow and thus knowledge transfer into companies occur at the first stage, mainly through the gatekeepers, who in the second stage are also responsible for the dissemination of the incoming knowledge.

The answer to the question "who are the gatekeepers?" revealed that they had above average competence in their professional field, they were members of lower management and their service in the company was neither the shortest nor the longest compared to their colleagues. And most surprisingly: the gatekeepers were unknown to the company management as carriers of roles crucial to the company's survival.

Sometimes when discussing the gatekeeper phenomenon in management seminars it is suggested to introduce something like a "gatekeeper management" in order obtain maximum results from the communication networks. This may not be a good idea. This is because informal communication processes, which constitute the underlying theme of the gatekeeper phenomenon, are not tightly manageable but need to be effectively supported, for example through generously supporting business travel and attending conferences.

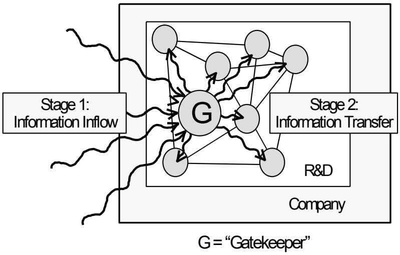


Figure 22: Dominant role of gatekeepers in the two-stage process of information in-flow (after Allen 1986: 162)

4 A model case of technology and innovation management

The following case example (Figure 23) of the Human Tissues Corporation Inc. (HTC) demonstrates the structures and tools of technology management which were chosen in order to build up a strong competitive market position.

The technology management of HTC contains a few centralized and a larger number of decentralized elements associated with the normative, strategic and operational level of management. The *first element* is the CTO-function established at the top management level. The *second element* is the vision "Technology for Quality of Life", which had been developed to express dominating values as a long-term orientation ("polar star"-function) of the enterprise. The *third element* is a technology policy, which had been elaborated in conjunction with an analysis of the enterprise culture in order to reach agreement between the long-term technology goals and the basic enterprise behavior. The analysis led to measures aimed at increasing the flexibility and external orientation of the enterprise.

The *fourth element* is the Technology Intelligence Center (TIC) reporting to the CTO. It represents the technology information pool of the enterprise. Its tasks comprise:

- the worldwide collection of technology-sensitive information,
- the establishment of relations to relevant technology users and suppliers inside and outside the medical branch,

- the preparation of make-or-buy and keep-or-sell decisions,
- the strategic evaluation of key and pacemaker technologies and negotiations on technology collaboration of any sort including the legal work.

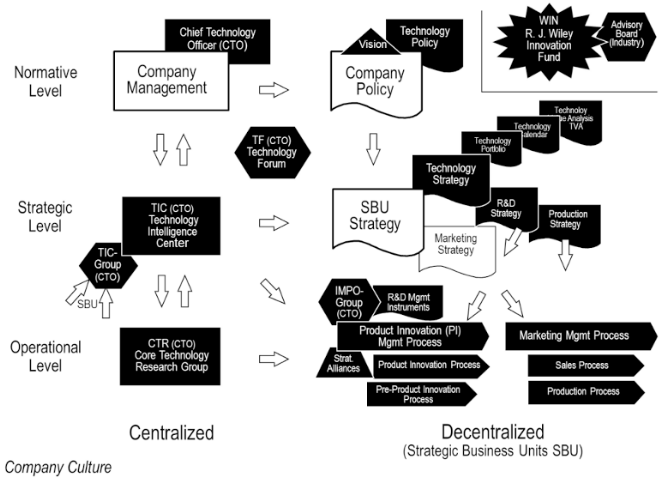


Figure 23: Elements of technology and innovation management of the Human Tissues Corporation Inc. (HTC) (Tschirky 1998: 370)

TIC is also in a position to perform patent analyses and to handle patent application procedures. In collaboration with the SBUs, the technology portfolio's are brought up-to-date periodically and support is provided to the SBUs for elaborating the technology calendars, which determine the sequence of introducing new and/or obsolete technologies. The TIC-tasks are handled by three people including one patent lawyer. The *fifth element* is the interdisciplinary TIC-Group consisting of SBU-representatives from R&D, marketing and production and the manager of the Core Technology Research Group (CTR). This group meets bimonthly under the guidance of the CTO. Main agenda items are news from technology intelligence, ongoing and future alliances, patent situation and licensing businesses.

The *sixth element* consists of the Core Technology Research Group also reporting to the CTO. It is focused on the evaluation and development of strategically significant technologies. It has close relations with universities and institutes of technology such as Caltech, Stanford and MIT. The *seventh element* represents the technology strategy which constitutes an integrated part of the SBU business strategies. Main planning instruments include technology portfolios, technology calendars and technology value analysis (TVA) which allows – as mentioned above - a way of relating the business value of a technology project to the enterprise value based on the free cash flow methodology by Rappaport. From the technology policy, SBU specific R&D and production strategies are derived. The *eighth element* reflects the process orientation and consists of three operational SBU processes, the product & process innovation (PPI) process, the pre-product & process innovation process and the production process. The

PPI process is focused on known technologies in order to keep the risk associated with development time low. The same is true for the production process, which is coupled with the sales process. New product and process technologies are evaluated within the Pre-PPI process. This task is closely related to CTR. The *ninth element* represents two management processes. The PPI management process takes responsibility for the PPI and Pre-PPI processes. This assignment is based on a close collaboration with TIC. The marketing management process is in charge of the sales and production processes.

The *tenth element* is the innovation management process owner group (IMPO). It brings together those responsible for the PPI management processes and enhances the exchange of experience, the coordination technology alliances and the development of suitable R&D management instruments (such as target costing, project management tools, etc.). The TIC and IMPO groups meet 3-4 times yearly in order to discuss basic questions of technology competitiveness. The *eleventh element* is the technology forum (TF). Under the leadership of the CTO, it takes place twice a year and is addressed primarily to the non-technical management those responsible of HTC. The main topics presented include the current technology situation of HTC, the progress of strategic technology projects and technology alliances, aimed at promoting the technology understanding across functional boundaries. The *twelfth element* finally is the J.R. Wiley Innovation fund (WIN). It had been established, by the enterprise founder, to increase the chances of acceptance of attractive innovation projects. This way, within HTC, two entirely separated routes exist to apply for innovation project funds, namely the ordinary procedure within the SBUs and the extraordinary path leading directly to WIN. The evaluation of WIN-proposals is done by an external committee consisting of representatives from industry and academia.

5 Does actively practicing technology management pay off?

As always, when attempting to relate business success to specific variables such as strategy, company culture, leadership or even entire management concepts, it is inherently difficult to come to unequivocal conclusions. A research study carried out at the Swiss Federal Institute of Technology on the "technology management intensity" of 60 SME's belonging to different industries of varying technology levels, identified a group of obviously innovative and financially successful enterprises which are practicing technology management proactively on all management levels, and another group of non-innovative and unsuccessful firms in which technology issues are at best marginally integrated into processes of general management (Kohler 1994).

In addition, an individual in-depth study of renowned technology enterprises as ABB, Siemens, 3M, Canon, NEC, Hewlett Packard, Honda, Hilti, Novartis, Monsanto, Roche and others revealed a high level of awareness of technology and innovation management issues in many forms. Of particular interest is the fact that these companies do not take a singular but rather an integrated approach to managing technology. They simultaneously manage on the normative level in terms of explicit technology policy and innovative organizational culture, on the strategic level in terms of a clear focus on core technologies and at the same time on a high intensity of strategic technology alliances, and finally on the operational level in terms of up-to-date management instruments such as target costing, concurrent engineering project management, process management and the promotion of informal communication.

No crystal ball is required to predict a significantly increasing need for management awareness of technology and its management, as we face the unprecedented challenges of the next millennium. There are "good" and "bad" ways to go about this, using the frameworks outlined above as well as others that follow in subsequent chapters.

Acknowledgements

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