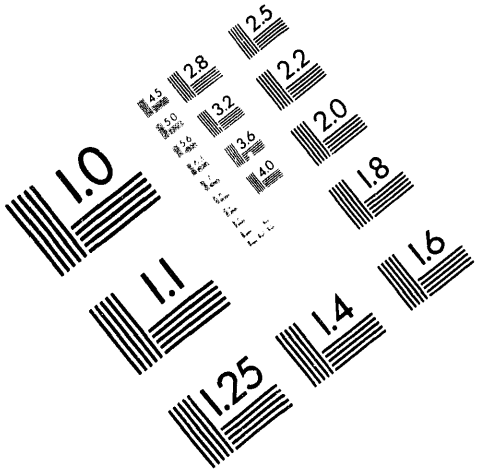

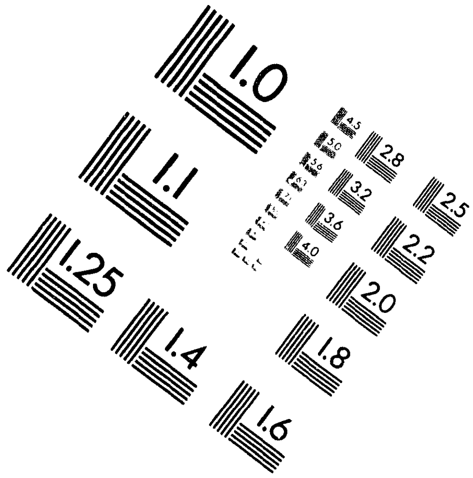

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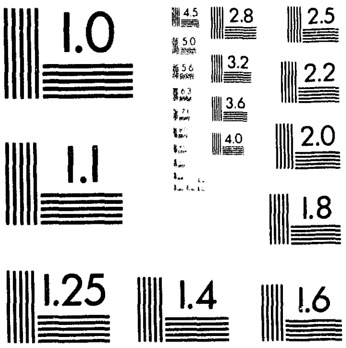

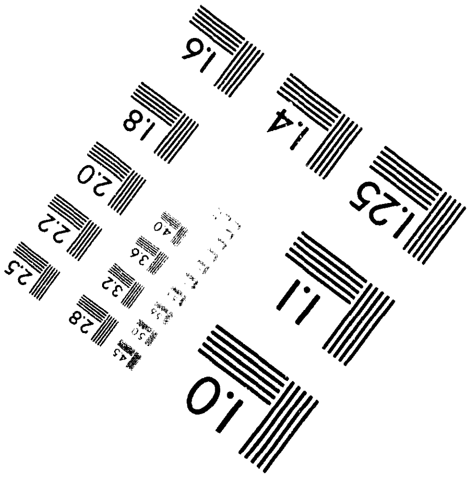

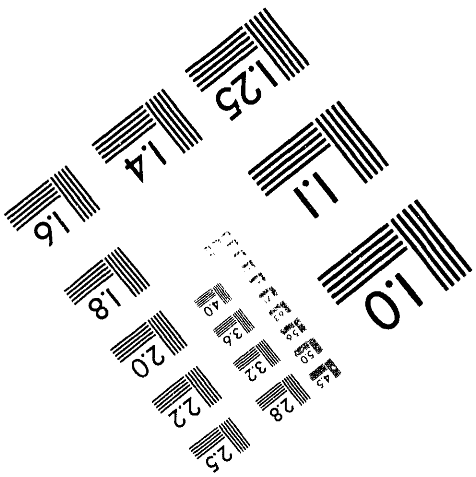

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MONITORING SCIENCE AND TECHNOLOGY FOR COMPETITIVE ADVANTAGE

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MONITORING SCIENCE AND TECHNOLOGY FOR COMPETITIVE ADVANTAGE

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Abstract:

In this age of rapid technological innovation, firms that do not stay abreast of the latest advancements in science and technology (S&T) stand a greater chance of missing opportunities than firms that maintain vigilance over the ever-changing technical environment. As a result, a resurgence of interest in technical intelligence for business is occurring in companies around the globe. Many firms now have formal technical intelligence programs to gather, analyze and use S&T information to watch their competitors, to track emerging trends in technological development and to anticipate significant technology-based changes in key markets. Careful managment of technical information that affects a business can have a vital influence on corporate profitability and long term health.

This paper describes the main features of technical intellegence operations in business, drawing on the experience of several companies that develop and use intelligence information. The steps of gathering, analyzing, evaluating and using information for business decisions are described and examples are given to illustrate how intelligence concepts are implemented in firms from several different industries. Practical issues such as understanding user needs, ethical data collection, effective analysis methods and using intelligence results are covered in the paper.

Key Words: technology intelligence, technology management, technology strategy, innovation, product development, R&D investment planning, technology monitoring, competitive analysis, technology transfer.

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Monitoring Science and Technology for Competitive Advantage

by
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In this age of rapid technological innovation, firms which do not stay abreast of the advancements in technology are more likely to miss valuable opportunities than firms that maintain vigilance over the technical environment. This was highlighted in the late 1960s/early 1970s when a group of scientists, engineers, and economists released the results of the SAPPHO Project on the processes of scientific innovation. The SAPPHO Project compared the characteristics of both successful and failed attempts to innovate. The researchers found that one of the keys to all successful projects was the innovating company's linkages with external science and technology networks.[1] This linkage was brought about in part by tracking developments in other firms and industries in a process called science and technology (S&T) monitoring.

S&T monitoring refers to the practice of searching out and disseminating relevant information on technical events and trends to provide continuing awareness of current activities. This paper discusses how S&T monitoring can contribute to the success of an organization and describes the elements of effective monitoring programs.

I. The Importance of S&T Monitoring in Business

Technical monitoring can help companies detect scientific/technical or socioeconomic events having an impact on a firm's business; it can identify potential threats to the firm's success; and it can lead to new product, process or joint venture opportunities for the organization made possible by changes in the scientific or social environment[2]. Monitoring is a part of a larger set of technical intelligence activities undertaken by firms to keep track of and interpret relevant events and trends in science and technology as a basis for actions to maintain their competitiveness. As shown in the definitions below, monitoring emphasizes continual tracking of technical items or areas of interest.

- *S&T scanning* - routinely surveying, identifying and screening a broad set of data sources to identify items of further interest.
- *S&T monitoring* - regularly searching, interpreting and disseminating relevant information on selected S&T activities to provide continuing awareness of current developments and emerging trends.
- *S&T assessment or evaluation* - analyzing the characteristics, performance, impacts or potential value of scientific area or

technology to determine if some form of management action (e.g. further attention, acquisition, investment or transfer) is warranted.

- *S&T acquisition or transfer* - taking possession of S&T materials or obtaining rights to S&T property generated outside an organization to begin exploitation of potential application value

- *S&T integration or internalization* - assimilating externally-generated S&T knowledge or property into the routine operations, policies and culture of an organization to capture its application value.

Scanning and monitoring are the two components of *S&T surveillance or watching* activities for an organization. Specifically, S&T monitoring helps firms maintain their knowledge of current or future developments external to their own organizations in targeted S&T areas, thereby taking advantage of emerging technical developments and avoiding technological surprises.

Monitoring-acquired technical intelligence regarding important external technical activities provides a foundation for informed internal choices and actions. Monitoring results, for instance, can help managers decide what direction their own R&D programs should take and what strategies should be employed to undertake R&D efforts. Shortly after the Fanuc company spun off from Fujitsu in 1972, the company analyzed the computerized numerical controller market to determine opportunities for market share. At that time MIT's numerical controller, invented in 1952, was still state-of-the-art. With 2,000 mechanical valves, MIT's controller was extremely large and very expensive to purchase and operate. Consequently many small and mid-sized firms were not able to afford it. Fanuc thus targeted this niche and developed a controller that was cheaper, simpler, and smaller than the current generation.[3]

Sometimes S&T monitoring can result in a firm's decision to terminate R&D on a particular project. For example, on learning that competitors were considerably ahead in the development of TPA, a drug to dissolve blood clots in heart attack victims, the pharmaceutical company Searle decided to discontinue its own TPA research. Although terminating an ongoing R&D project can be both costly and unpleasant, it usually frees up resources for more valuable investments when it becomes clear that the project will never bear fruit.[4]

Another reason why monitoring is important is that it enables firms to incorporate new technology advances into their own products. Hewlett-Packard was able to do this in the 1980s when it found out about the emerging Cannon laser for electronic applications. After learning about the new technology, HP moved quickly to establish an agreement with Cannon, whereby HP could use the Canon technology in its newly designed Laserjet printers.[5]

Technology monitoring can help firms identify opportunities for technology investment, including commercialization. In 1985 one of Japan's leading daily newspapers reported that a major semiconductor firm had decided to drop out of the 64k D-RAM market. Because the company had been losing market share for some time, many of its competitors failed to take note of the announcement and hence were not aware of the motivation for the company's decision, which was to switch its R&D to the next generation 256k-bit D-RAM. Although this D-RAM did not fare well on the market, it was really the <u>next</u> generation of bit--the 1M-bit D-RAM--that the company was aiming to develop. As a result, this firm came out way ahead of the competition, with half of the 1M D-RAM market. Currently the firm is considered the leading 1M D-RAM producer, owing to its yield ratio, which is estimated at double that of its competitors.[6]

Monitoring technology also makes it possible for firms to identify potential threats which can cost market share. Whirlpool Corporation in the 1970s monitored developments in the chemical and textile industries, where it learned about the recent innovations in the area of permanent press fabrics prior to their commercialization. Using this information, Whirlpool was able to produce the first washer and dryer with permanent press cycles, beating competitors by about a year and cornering a large share of the appliance market. Thus Whirlpool, through its monitoring efforts, was able to turn a potential threat into a major technological coup.[7]

A final reason for developing a technology monitoring program is that it helps companies identify possible partners for collaboration, thereby leveraging investment dollars and avoiding duplication of efforts. In 1990, for example, the U.S. pharmaceutical company Searle and the French firm Synthelabo joined forces to produce a new drug called Kerlone, which is used for the management of high blood pressure. Searle contributed marketing and drug development skills, while Synthelabo contributed research and drug development expertise. This joint venture, a result of monitoring other firms in the industry, allowed Monsanto, Searle's parent company, to acquire both research skills and new products. Both the U.S. and French firm reaped the benefits of this collaboration.[8]

II. How to Conduct S&T Monitoring

In order to maximize effectiveness, technical monitoring activities need to be carefully rationalized and designed prior to implementation. There are usually far more requests for information than can be handled with available monitoring resources. This means that monitoring efforts must be organized and conducted with specific objectives, resources and products in mind.

In general, there are six basic steps, summarized below, involved in carrying out monitoring activities:

1) define user needs
2) prepare a monitoring plan
3) acquire source materials
4) analyze results
5) disseminate monitoring products
6) review monitoring performance

These steps are displayed in Figure 1 and summarized below:

1) **Define User Needs**--In technology monitoring efforts, the essential first step is to clearly identify the needs to be served by the information gathering and analysis effort. The customers for the information are the ultimate beneficiaries of the work, so their requirements and interests are basic guidance for the monitoring effort. Table 1 indicates that different types of monitoring users have different needs; a marketing manager, for example, will have considerably different information needs than will a technical manager or a CEO. These information requirements in turn will impact key features of technology monitoring program, such as the sources used, level of funding and types of analysis.

Successful needs assessment usually involves a series of direct interactions with potential users of monitoring products. These meetings should cover questions regarding the type of information sought, the level of detail, potential uses of the information and possible sources. It is also useful to identify some of the underlying concerns or issues that drive specific user information requests. Sometimes users are not able to specify their own needs well in early monitoring meetings, making follow-up discussions and trial information products essential to a final set of clear needs.

2) **Prepare a Monitoring Plan**--Once user needs have been identified, a monitoring plan is important to manage the collection, analysis and dissemination efforts. Undoubtedly, the range of subjects and areas of interest to users will be extensive and, inevitably, too vast to cover with limited resources. Thus, a monitoring plan is developed by choosing which technical areas or technologies to monitor, deciding how to monitor them, identifying general S&T information targets, selecting sources of information to use, and organizing the monitoring staff in terms of budget and staff time commitment.

Most efforts to decide what to monitor center around the concept of the *core technical competencies* in a company (Prahalad 1990). Core competencies are those technical capabilities which are essential for the business to be competitive; they should be the focus of considerable company attention, investment and, therefore, monitoring efforts. Identifying core competencies is a difficult exercise for most firms; the core capabilities tend to be either very apparent or very difficult to describe. Historically, two basic approaches have been used to identify core competencies. One is to examine the range of existing products, processes and service delivery systems and list the technologies essential to provide competitive advantage in these business units. This can be done in many ways, but one recent method is to model company operations in a "value chain" for major products and focus on the technology used in the high value-added segments as candidates for the core capabilities.

By combining information on technologies across all these activities, the company can identify the technologies that are both the most pervasive and which give the business its unique character (the core technologies). This uniqueness might be either in how the business operates, as with the logistical system created by Walmart and LL Bean, or in its product technology, as with Mazda (rotary engine) and Coca Cola (the drink formula). The scientific and technical components of the core to monitor can be elaborated by reference to basic and related patents and to relevant scientific literature and related publications.

Another approach is to first identify the services that the technology of the company provides and then forecast the future market needs for those services. In this manner, critical technologies can be identified and future information needs established. It is then possible to search for the S&T developments now that might provide those services in the future. This approach was used by a major "white goods" manufacturer in the United States. They first identified the services (e.g., clean clothes, food prepared to eat, clean dishes) that the current products provided. The need for these services was extrapolated to the future. Then, the company searched for S&T ideas that could provide alternative modes for the delivery of the services (e.g., closed chemical clothes cleaning systems, self-heating frozen pre-prepared meals, non-stick or throwaway dishes and utensils). Ideas such as these became the basis for deciding what S&T areas to monitor.

In addition to specifying what to monitor, the monitoring plan should address whether the monitoring program will be of short or long-term duration. Often companies choose to focus information-gathering on a specific development in a given industry in order to meet a one-time need. However, some form of long-term monitoring system is often desirable for situations where technology is changing rapidly or where many competing technologies are available to provide a service.

3) **Acquire Source Materials**--Choosing sources for a technology monitoring program depends on a variety of factors, including the technical area involved, the needs of the users, the level of funding available, and the level of effort to be applied to the project. Sources can be internal or external to the company, formal or informal, personal or electronic. Below is a sample listing of several potential sources:

- reverse engineering and benchmarking of competitor products
- personal contacts/networking
- hiring individual specialists or consulting firms
- sponsoring research or endowing chairs at technical and academic institutions
- buying minority interests in firms with R&D programs
- acquiring small high-tech companies or hiring knowledgable staff from these firms
- locating facilities near external sources of innovation (including overseas)

- entering into joint ventures
- attending trade shows & conferences
- subscribin to trade journals and other literature, including sources from public clearinghouses
- using internal electronic mail and databases
- accessing commercial computerized data bases

These information sources vary considerably with respect to cost and effectiveness for certain types of data. Those monitoring methods with the *lowest time and funding requirements* include personal networks, databases, trade shows, and trade journals. Although these are comparatively inexpensive methods of gathering data, one must not underestimate their potential effectiveness. Xerox, for example, used newsletters, trade shows, and government databases to obtain useful information about competitors' activities in the area of photocopier development. Consequently Xerox was prepared when Cannon announced a new deal with Kodak to develop and market high-speed, low-end copiers. It was also ready when Ricoh and Cannon announced a joint marketing partnership in Japan in 1988. Because of its monitoring activities, Xerox learned many useful things about the Japanese philosophy regarding design, maintenance, the manufacturing process, and pricing. This knowledge helped Xerox increase its market share in Japan and worldwide.[9]

Monitoring methods which require *significant financial investment* include sponsoring university research, sponsoring endowed chairs at universities, acquiring small high-tech firms, and locating laboratories domestically or overseas where competitors are active. By sponsoring computer research at universities, for example, Digital Equipment Corporation maintains access to major research developments and leading scientists who perform research of interest to the company. As of 1990 DEC sponsored more than 240 projects at over 100 universities around the world.[10] Similarly, in 1988 Fujitsu Limited, Japan's largest computer maker and one of the world's largest manufacturers of telecommunications equipment, gave a $1.5 million grant to MIT to establish the Fujitsu Professorship of Electrical Engineering and Computer Science. As a result, the company benefited from the results of MIT's research in that field.[11] Likewise, Kodak, recognizing the need to learn about the technology of its Japanese competitors, opened a facility in Japan in 1987. The head of Kodak's Japanese operations states that it's easier to collect information on Japan inside the country, since both the popular and trade presses have write-ups on new technological developments faster and more consistently than American companies do. In addition, staff are able to pick up useful information from previous employers, customers, and competitors, or while socializing.[12]

Another method organizations use to monitor technology is hiring consultants to conduct monitoring activities, rather than creating a program in-house. The Japanese have a particularly sophisticated network for technology monitoring, making extensive use of trading companies, called *sogo* *shoshas*. These companies provide information, usually free of charge, to clients. Information-gatherers at the sogo shosha are stationed in 180 overseas offices. They daily send as much as 100,000 pieces of information back to the home office, where it is analyzed and put into a mainframe computers as part of a larger database.[13]

Figure 1 also shows a Data Storage function in the monitoring process, closely related to source acquisition efforts. Storage of S&T data and information refers to the traditional technical library repository function and, like other types of data processing, monitoring materials can be stored in four basic forms:

- primary physical storage - library-type repositories of original source material

- intermediate physical storage - library-type storage of conversions of original material in abstracted or reduced form (e.g., microfiche)

- electronic storage - retention of information or sources on computerized data bases.

- human storage - retaining information through memories of experts or knowledgeable user individuals.

An important aspect of the storage function is the need for organized structures for efficient information access. This means attention must be paid to the catalog structure and the approaches to indexing (cross-referencing).

4) Analyze Source Data--This step involves analysis of the data sources to interpret their meaning in light of monitoring objectives or user needs. The specific analytic approaches used depend on the specific source material and needs addressed. Analysis gives context to the data and helps users determine areas where additional research is needed or where future resources should be allocated.

The analysis activity is the most difficult monitoring step to describe. There are few standard ways to perform monitoring analysis, but a wide range of tools to assist the process are potentially available, depending on characteristics of the source information and user needs. This paper describes some of the general functions that the analytic process should perform to develop useful monitoring information:

- providing technical descriptions of emerging technology capabilities, events or developments; for instance, developing a technical brief on applications of fuzzy logic to process or equipment control

- recognizing when developments are important to the firm--when resources or activities of the firm may be affected or when an organization could become a potential technical partner

- identifying when an emerging capability in a competitor, supplier or customer could affect a firm's business

- identifying when substitute or competing technologies for a firm's products or processes are becoming available

- recognizing patterns of activities with potential consequences for a firm's competitors, suppliers or customers. Examples include competitors, customers or suppliers forming joint ventures, university research program announcements; announcements of new R&D contracts; or new high technology product releases

- identifying significant shifts in the rate of progress in an area or the occurrence of technical breakthroughs that will make a new capability technically or economically feasible

- comparisons of technical state-of-the-art between external and company product/process lines

- comparisons of current data with past data to discern trends that may be important in the future

- judgment-based forecasts of the implications of events or trends for future directions and efforts of the firm.

Many tools can assist analysts in the above monitoring activities, many of them computer-based, but most of them are not designed specifically for monitoring work. Moreover, selecting analysis tools is highly problem-specific. Many firms have developed proprietary computer databases, with unique data search, acquisition, comparison and display features, for their monitoring programs.

Among the unique S&T analytical tools being applied and improved are three very exciting ones: *patent analysis, bibliometrics and content analysis*[14]. These types of tools usually require some expertise for use and may apply only in limited business situations, for instance, in industries like pharmaceuticals or electronics where patents are important.

5) Disseminate Monitoring Products---Products can be distributed in many ways, ranging from formal reports or presentations, electronic mail and one-on-one conversations. Preferred methods depend on the nature of the information to be distributed, the intended audience, cost, urgency and user preferences. In general the dissemination step suggests simply making products available to users and other interested parties; however, in S&T scanning and monitoring, some one-on-one discussion of key results is usually desirable. Personal conversation provides the opportunity for analysts to help educate users directly, for highlighting particularly important findings and for users to ask questions and probe at issues.

Monitoring information in the form of technical reports, newsletters, databases, and staff briefings are most common distribution methods. Electronic mail systems and other forms of computer networking are on the increase because they are efficient as a means of distributing summary-type information. Most users indicate that no matter which method is used, it is important that communicating S&T monitoring information with users be a two-way dialog in order to get maximum benefit from discussing the implications of the findings.

In addition, user feedback at this stage is crucial to successful monitoring efforts. Comments from users help improve the types of information being produced by the program, as well as the methods of communication. User feedback provides both short-term direction to the dynamics of the monitoring program, as well as long-term input to program design.

6) Review Monitoring Performance---After information has been disseminated to the appropriate users, the monitoring process and results should be evaluated with regard to whether it met user needs and whether it ultimately had beneficial impacts for the organization. These evaluations can either be quick and informal, often in connection with a particular situation being studied, or in-depth and structured, where an entire monitoring program is periodically evaluated before decisions regarding continued support are made. The purpose of the evaluation is to improve future monitoring operations by making them more responsive to user needs, to further clarify those needs and to adjust monitoring practices appropriately.

The six steps above are all-important to successful monitoring efforts, but may not be discernible as individual steps in the organizational environment. Thought they appear in different forms depending on the situation, they are each important for well-integrated S&T monitoring over the long term.

III. Using the Results of S&T Monitoring

The payoff from S&T monitoring systems occurs when the monitoring intelligence is used by the firm and the organization benefits as a direct result. These benefits occur when the results of monitoring are used to make technical/business decisions--particularly those which involve resource allocation for technology development or commercialization. Table 2 shows several types of company S&T decisions where information on external S&T trends can have value.

Use of information obtained through technology monitoring can be crucial to making and implementing these types of decisions. The key to using S&T monitoring products well is to focus on the intelligence findings or "*ideas*". Ideas are bits of high priority information which can have an impact on the use of some company resource. Monitoring products in the form of reports, briefings or electronic mail messages are not sufficient to ensure an impact on these decisions by themselves. If these products do not present or stimulate ideas in a user with authority to act, then monitoring efforts are likely to have only limited effectiveness.

Developing ideas often requires the efforts of an "intelligence champion," someone sensitive to company needs who recognizes the significance of the monitoring information and sees how to apply it in a useful way. This process usually requires interaction between the monitoring staff and decision makers or other business parties in the form of focussed and probing discussions, challenging or "mulling" over the analysis results, looking at related information or persuading key persons that the consequences of acting (or not acting) on the intelligence are worth attention.

This aspect of monitoring is the most important, since it represents the payoff from all the previous data collection and processing efforts; however, it is also the most difficult activity to undertake. There are no prescriptions for drawing attention to new developments or for having influence on company decisions. Thus, assigning the "right" people (e.g., gatekeepers and champions) to the intelligence process is the best way to ensure that it works.

IV. Characteristics of Successful Monitoring Programs

The most successful technology monitoring programs are those which are able to influence high levels of the organization, and that usually means being attached to those levels. Management support for monitoring activities gives the program maximum credibility and helps ensure the commitment of users to the program, even if program resources are relatively modest. However, at the working level, successful monitoring programs also account for several features that make the daily functions work. Below are discussed gatekeepers, reward systems and information exchange. Several problems to avoid in monitoring programs are also raised.

Gatekeepers

The success or failure of a monitoring program often depends on the role of "*gatekeepers*", or individuals responsible for gathering, screening and alerting others to key data. The ideal gatekeepers have a good understanding of the needs of the user as well as the overall goals of the company. They should be very knowledgeable regarding the technology under review and have access to technical information, both from written and oral sources. The most effective gatekeepers are also good networkers with strong connections outside the firm. In many cases they are not "created" by their managers, but rather tend to emerge out of the organization because of their abilities to find, filter, and analyze information.[15]

Another characteristic of successful gatekeepers is their ability to think laterally, e.g., to see various angles of an issue and be able to judge possible implications to the firm of new technological developments. Good communication skills are likewise essential, as gatekeepers will need to both speak with individuals outside of the organization and with the users of the monitoring program inside the firm. The gatekeeper should also be given latitude to produce ideas that fail, since not every monitoring strategy will succeed; imagination and innovation should be encouraged in this position.

Rewarding Success and Tolerating Failures

Successful monitoring programs usually incorporate some form of reward system to reinforce desirable performance. The Italian firm Olivetti has a program to offer *an annual prize* to external inventors and innovative companies. Candidates submit their suggestions to Olivetti indicating how their idea could be of value to the company. The firm has received up to 200 applications for the prize. These are screened down to about 10 to 20 which represent those with the most realistic possibility for success. Each of these candidates makes a more detailed presentation of their ideas and Olivetti chooses a winner. For the winner, development support is offered in exchange for compensation, often including a degree of ownership in the small company by Olivetti. By this means, Olivetti is able to survey the scientific and technical developments related to its products and processes and, at the same time, take partial ownership of the attractive developments at an early stage.

As is the case in any creative endeavor, tolerating failure is an important aspect of the monitoring process. Because monitoring involves uncertainty and creative judgment, there will inevitably be more failures than successes. A commonly acknowledged ratio is about one successful idea for 20 to 50 which fail. This means that most people involved will usually "fail." People must be "allowed to fail" and continually reinvigorated. Businesses that recognize this and encourage a continued flow of ideas have significant success in new and innovative products and processes.

Exchanging Information to Stimulate Ideas

Monitoring programs that work usually involve planned forums for interaction among analysts, R&D staff and technical managers. In a large European electronics company, for instance, the concept of *an idea fair* is used to disseminate information about ideas that have been developed in watching scientific and technical developments. This consists of having a semi-annual event at which people with ideas can present them to top level management directly. This allows all people with ideas to offer them to the company and, at the same time, provides the advantage that the lines of communication between the people with the ideas and the people with the resources to use the ideas are direct. There is no intervening screening process. The fair is set up in a large room with space for displays by people with the ideas. Management participates and circulates freely to see the ideas and discuss them with their originators.

One packaging technology firm circulates *a newsletter* for the purpose of stimulating the reader to generate new ideas. This newsletter is short and well illustrated with color. It is not designed to explain all of the scientific and technical developments that have occurred. Instead, it is designed to encourage the reader to have new ideas. This successful newsletter is based on the concept that the purpose of the communication is to generate good ideas, not to report all that has taken place since the previous newsletter.

A computer company links staff by a *computer mail network*. This is a secure network which records the questions, issues or problems faced by people in the company. Using the network, people can browse the problems, build on ideas of others for solving the problems, and suggest solutions. Since everyone is linked by the computer, the communications are rapid and direct.

Problems to Avoid in Establishing Monitoring Programs

Monitoring activities often are ineffective, but the reasons for their shortcomings vary. One of the most common problems is that S&T monitoring is given a *low priority* by management. It is well known that the absence of management support often spells doom for planning and analysis efforts in technical business settings. Thus, for these activities to be successful, they must be give time to mature and respond to user needs. This is especially true in tight financial times for a company. Monitoring activities are often among the first items to be sacrificed in budget-cutting or down-sizing actions.

Sometimes *insufficient resources* are allocated to monitoring, even though the efforts are considered important and given top management lip service. This can show up when firms *rely simply on their own in-house staff.* Some firms expect their professional staff to stay abreast of emerging technology developments as part of their job responsibilities. However, this may result in the staff treating monitoring as a low priority, especially if their efforts are not recognized and their successes not rewarded.

Monitoring efforts can also be limited in their contributions by creating *a process which is too mechanical*. Relying only on technical literature or on computerized data bases, perhaps because they are less expensive, at the expense of other monitoring components, can lead to poor results. It is usually desirable to cross-check important findings with other sources, especially by first-hand site visits or by talking with expert consultants.

One of the biggest problems is *lack of integration* of monitoring into ongoing operations. Competitive intelligence (CI) is fully developed as part of the R&D decision process in leading Japanese firms. In Japan, CI activities for each R&D project are integrated under the control of an "R&D champion," who works with qualified staff in the technology information office, technical librarians, patent specialists and senior researchers. When the champion uncovers a serious issue, a more intensive CI activity with an appropriate budget increase and a corporate-wide project team is proposed, reviewed and implemented. Senior R&D managers receive only analytical results prepared for decision making. Japanese firms excel at combining formal reports and exploiting the daily company grapevine to disseminate interesting technical details gathered in the intelligence processes.

Another difficulty with monitoring, as with many other information system activities is *too much data - not enough information*. At the heart of successful monitoring are ideas that affect company actions--not a vast array of reports, messages or files. Nevertheless, many firms inadvertently emphasize building or maintaining large systems of records. There is no easy solution to this problem, except to continually monitor the data repository situation and regularly seek user feedback as to what monitoring products are most useful.

V. Conclusion

This article shows that S&T monitoring represents an important means by which businesses can stay abreast of advances in science and technology, internationally as well as in their own countries. An effective monitoring program can help a firm avoid duplicative research, respond to competitors' moves, take advantage of breakthroughs by others and enhance overall business competitiveness. Recent trends in the increasing cost of R&D, in continued reductions for many product cycle times and in the increasing numbers of firms with high technology skills, all suggest that S&T monitoring is likely to remain an important part of the technology strategies in many parts of the world.

Table 1. Common User S&T Information Needs

Type of Information User	Typical key information needs
Scientists/engineers	Detailed technical data - technical objectives of R&D - R&D approaches--product/process design - manufacturing methods - R&D results or progress - technical contacts/researchers
Technical Managers	S&T Funding data - funding plans by technical area - R&D or acquisition strategies
Marketing Personnel	Competitive product features - product sales - cost/price data
Senior Executives	Technical management or business news - technical contacts/researchers
Policy-makers/Regulators	Science/technology policy - national S&T goals & funding - new S&T directions

Table 2. Common S&T Decisions Affected by Monitoring

- *Evaluation of technical business areas for further attention and interest in an organization*
  - whether to enter a technology-based product or market area with strong competitors

- *Technology development strategies*
  - whether to invest further in technology being pursued by others
  - priortizing technology needs

- *R&D program management and portfolio decisions*
  - allocating R&D funds to projects
  - terminating or delaying work on a project or in an S&T area
  - re-evaluating technical objectives for R&D

- *Technology acquisition and divestiture decisions*
  - whether to purchase or license technology from outside
  - whether to license technology out or sell to others

- *Technology collaboration choices*
  - whether to enter into a joint technology development venture with another organization

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14. Examples of patent analysis tools may be found in (Ashton and Sen 1988), (Narin 1990) and (Mogee 1993).

15. Porter, et. al. p. 132.

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