RESEARCH MANAGEMENT AT THE INTERFACES

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This contribution presents some lessons learned in the development of cooperation and knowledge transfer across the numerous interfaces involved in managing a corporate research laboratory.

For an industrial research manager, the decade ahead will be quite different from that just passed. Technology has become a global commodity, and intellectual property is now an entity not only to be generated and guarded, but also to be bought and sold. National and corporate interests may become increasingly confused when a company has research laboratories in several countries. Indeed, the concept of sovereignty becomes somewhat tenuous when national boundaries are transparent to ideas and information. New, strong competitors are arising in the Pacific Rim countries, and mega-companies are being formed by mergers in Europe and the U.S. to match those owned by Japanese banks.

The Information Age has truly arrived, and nowadays one is as likely to receive an e-mail from Moscow as from Birmingham. But, while information is readily available, the work force has yet to be educated for an age of "brains-on" rather than "hands-on." Recognition of the need for continuous education for continuing change, and of the likelihood of several jobs per career, is coming but slowly, even to university graduates.

And many otherwise intelligent people still have not grasped the fact that a film of air and water about 0.1% of the radius of the earth in thickness represents the complete life support system for humanity. A variation of a few degrees centigrade in its temperature, or of some modest change in chemistry, and no one will be around to read the proceedings of this conference. It follows that, all industrial processes must be energy and environment conserving, as well as economical.

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Given this situation, what advice might one give an aspiring research manager? For example, what should be his/her technology development strategy?

Well, actually, most companies do not have a technology strategy; planning tends to be finance or market oriented. "Today, our sales are x million pounds, and in five years they will be x+y million." How will this desirable objective be achieved? By increasing market share in existing markets. The company's projections will show steady growth, the underlying assumption being that nothing much will change.

In reality, one can almost guarantee that something that was not expected to change, will. To expect the unexpected and plan for it is a good strategy, and this is an emerging responsibility for the research manager. Developing a technology roadmap that starts from where the company is today and ends where it wants to be a few years hence, that identifies the technical road blocks and recognizes opportunities for being surprised, or for surprising the competition along the way, is one of the principal tasks that a research manager must undertake nowadays.

Increasingly, however, it does not follow that the research organization must itself solve all the problems identified. Indeed, the function of a research organization is not, a priori, to do research. Rather it is to acquire relevant knowledge, and to transfer this in understandable and usable form, to the profit makers of the corporation. Only if the needed knowledge does not exist should the laboratories do (or get done) the research to create it. Research in industry is one means to an end...not the end in itself. Transmitting this fact of life to newly hired Ph.D.'s is crucial, but not easy.

Getting a problem solved, but not necessarily by solving it oneself, provides a segue into the changing world of research management vis a vis interfaces, defined in this context as the cultural barriers between disciplines or operational functions.

Thirty years ago, most major corporations had central research laboratories staffed with young scientists who had the time to browse in the library, and the funds to travel to conferences. They were expected to generate knowledge and ideas likely to be useful to their companies some 5-15 years hence. Today, the time frame is 3-5 years, companies have become lean, mean and decentralized, and the emphasis is on applied rather than fundamental research. The scientist's interface with his or her world has changed from journals and colleagues to computers, databases, and world-wide networks. Young scientists still must be taught to "search, before you research," but the methodology is different. The limitations of today's approach are captured by an advertising phrase used by one company regarding the sophistication of its software, namely, "What you see is what you get." Unfortunately, the converse also is true, namely, "What you don't see...you don't get," meaning that if your computer is not connected to the right database, you cannot get the information you need,...nor will you know that the information actually exists somewhere else. Few people other than computer hackers have the skill to intelligently search another person's database. Thus, at least for now, so-called expert systems...even systems using information-seeking gophers or knowbots...are not as useful as human experts who, using their own experience-developed fuzzy logic, know where to look in their database to find the information needed to solve a particular problem.

This recognition has lead companies such as Martin Marietta to develop not so much an "expert system" as a networked "system of experts." The experts are technical gurus or gatekeepers of databases who can be identified via a simple query software system. Utilizing expert people in the network can help transform data to intelligence.

Given that the nature of the interface between the researcher and the world of knowledge is changing, the research manager must now ensure that his staff are connected internationally, and that they consult with the most knowledgeable people in the world before beginning their own researches, so avoiding wasteful re-invention. Incidentally, the approach of building creatively upon ideas generated elsewhere, practiced so effectively by Japanese industrial researchers, should be strongly encouraged. Indeed, it has been suggested only partly in jest that there should be a prize for the most innovative exploitation of someone else's idea! This notion, however, leads us to another challenge for the research manager, namely protection of the company's intellectual property from unauthorized searchers of its databases, or from monitors of its Internet transmissions. The high speed encryption and decryption of all data will soon be a way of life.

Another factor that has changed the nature of R&D interfaces in the U.S. is the end of the Cold War. Along with the scaling down and re-orientation of corporate research labs has come the need for defense-related national labs to find new missions...or be closed down. One possibility is to provide the function that the old corporate labs used to provide, namely, generation of the knowledge base from which can spring ideas for superior processes and products. For example, Sandia National Laboratories is now adding to its long term mission of caring for the surety of the U.S. nuclear weapon stockpile the new mission of becoming a "virtual" corporate laboratory for consortia of companies from several industrial segments, e.g., semiconductors, textiles, specialty metals, etc.

An emerging modus operandi requires technical representatives from the companies making up a consortium to work with staff from Sandia to develop a roadmap for their industry that is designed to sustain and enhance its international competitive position. Problems requiring solution are identified and prioritized, and responsibility for their solution allocated to various elements of the partnership according to some agreed upon time scale and cost limitations.

This new responsibility is adding another set of interfaces for Sandia's research managers. Whereas previously they needed to be responsive only to the needs of the U.S. Departments of Energy and Defense, now they must learn to work with numerous industrial customers, no two of which are alike! This is because the culture of, say, an electronics company, with a window of opportunity for getting a new idea to market of three years, is quite different from that of an oil company, for whom any significant change in a process is likely to cost hundreds of millions of pounds and be feasible only every decade or so.

Even so, the responsibility of the research manager is to see that his staff gets to know each partner company intimately, not only its products, processes, customers, and marketing strategy, but also its people and corporate personality. From such interactions, one learns that the phrase "order of magnitude" can mean different things to different companies. A computer company may think in terms of increasing the computing power of its machines by a factor of 10^{+1} every few years, but an aluminum company may be more than content to reduce its energy consumption by 10^{-2} per year, saving millions of dollars thereby.

Getting to know a partner company can be accomplished only through extended and frequent visits, and the cost of developing this knowledge is one that the research manager should plan for and bear willingly. It is crucial to laboratory effectiveness.

Still, the fundamental challenge for a research manager is the same, regardless of industry. It is to transform a good idea into a process or a product of superior quality as cost-effectively, swiftly, and profitably as possible. The traditional series of functions involved in creating a new process or product include research, engineering, manufacturing, marketing, and the various administrative functions that interact along the way. The interface between each function is a barrier through which the development must be pulled or pushed.

A better approach to process or product development is, of course, the parallel or concurrent approach. The product development team...research, engineering, manufacturing, marketing, finance, legal, etc., get together as a group at the onset of the program to decide exactly what must be done, by whom, by when, and at what cost. They then collectively develop a plan to meet the objective (the roadmap). and finally proceed, more or less simultaneously, to do what they have promised. The concurrent approach, well-developed in Japan, accelerates the introduction of any development to market and, when used in conjunction with an aggressive forward-pricing strategy, can make the entry of late arrivals difficult.

The challenge to the research manager here is to ensure that the company's effective utilization of its world-wide knowledge base, together with that of its own research portfolio, provides it with a pre-emptive competitive edge.

Some of the elements of strategy for the manager to accomplish this are well known, for example, hiring talented and creative people...including inventors, i.e., people who can recognize in one person's problem the solution to someone else's. Also given that, absent direction, creative people tend to be creative at random, it is always a good idea to make clear to the staff exactly which problems require an early solution. Top down guidance often is not as clear as it needs to be if results are expected in a timely fashion.

The Research-Marketing interface is important because many marketers prefer to keep researchers away from the "real" world, i.e., their customers. There is a good reason for this. In a selling environment, marketers need to focus on the purported advantages of their product, whereas researchers tend to talk about its remaining problems. Keeping the scientists away from the customer is not a good idea, however. Educating them on when to speak, what to say, and when to stop, is a better one. Direct involvement with the customer is important because developing an innovative response to a real market need usually is much more profitable than attempting to exploit a generic scientific advance.

One way to reduce such concerns is to appoint a liaison scientist to each client company or major product line. It is not unusual for such staff to transfer to their client company after a few years and, given their knowledge of its technology, product, and market, rise quickly in their new environment.

Returning to the earlier concern about the adequacy of a company's technical base to generate the understanding and new ideas required to remain competitive, it is now recognized that not even the largest corporations can afford to do this. Consequently, various forms of R&D leveraging are becoming the norm. These involve collaboration with consortia, universities, national labs, etc., and cooperative R&D with other companies at home and abroad. As Robert White (President of the U.S. National Academy of Engineering) has noted, "In today's world, a company or nation must be cooperative to be competitive." Talent is universal and, given opportunity, new knowledge can be generated anywhere. Thus, the search for ideas and understanding must be global, and the exploitation of developments "not-invented-here" encouraged rather than disparaged.

Technology and knowledge also leaks, and there is not much one can do to prevent this completely. Therefore, the research manager must seek to acquire or generate technology faster than it can leak, focusing on opening up the information inflow spigots rather than developing a bureaucracy to minimize the outflow.

Much has been written on the Research Lab-University interface, but the need to activate diffusion across this interface is rarely mentioned. Setting funds aside explicitly for travel to the partner's labs in the budgets of both the sponsored professor and the industrial lab's staff will markedly catalyze interaction.

Another barrier to effective research management can arise within the laboratory itself as a consequence of thinking about the organization in the traditional manner, i.e. as a hierarchy, with the Director at the top, and with the functional departments, chemistry, physics, materials, etc., in some horizontal array. This depiction provides no indication of the way the institution is supposed to operate. However, rotating one's perspective, putting the customer at the top and management/administration on the bottom, and distributing the disciplinary departments in a vertical array related to what they do...as opposed to what they are called e.g., Synthesis as opposed to Chemistry, Structure-Property Relationships as opposed to Materials Science, etc. provides a better appreciation for both the roles and responsibilities within the lab, and of the important need for teamwork. Management's function in this arrangement is to produce a "controlled turbulence," breaking down (making transparent) interdepartmental interfaces, and promoting interdisciplinary thinking.

Of course, the very concept of scientific disciplines introduces obstacles to solution of practical problems. Disciplines do not occur in nature; they are merely artifacts introduced by the academia community to break down knowledge into teachable (and learnable) chunks. Industrially significant problems usually are most creatively solved using an interdisciplinary team. This increases the prospect of an innovative solution not immediately evident to someone from the discipline traditionally thought to own the problem. In the writer's experience, this approach has permitted a mathematician to provide insights leading to significant advances in aluminum smelting, a biologist to propose new approaches for the inhibition of corrosion, and a geochemist to develop today's state-of-the-art piezoelectric materials.

It should be noted, however, that cross fertilization of disciplines does not happen spontaneously. Synergistic operation of an R&D organization is possible...provided that the manager can cause the parts to interact. This is the art of research management; it takes cajolery, flattery, patience, and occasionally even hierarchical persuasion.

The Research-Managing Director (M.D.) interface is another area of concern for a research manager. Trust is very important in this relationship, and this can be enhanced through a variety of actions. First, stay in touch. The research manager must know where the M.D. is trying to take the company, and help him understand the potential impact of emerging technologies on his plans. He must be informed of the significance of technical progress at the labs, but not overwhelmed with the details. The manager should be generic rather than specific in stating research goals, and limit the M.D.'s expectations so that, more often than not, the results actually achieved are similar to but better than what the M.D. anticipated. The research manager should also be prepared to answer the question "What are you not doing that you ought to be?" In other words, what potentially important opportunities are not being addressed.

The Research-Finance interface is always tricky. Because industrial R&D is usually paid for using "overhead funds," the research function is usually perceived by financial managers as centers for present costs rather than future profits. Research managers also spend a fair amount of their time asking for money.

There are several ways of reducing friction at this interface. One is to have the Director-Finance (D.F.) place one of his best people in the R&D organization as Controller, because how research manages its costs can be a cause of for concern. Another is to never ask the D.F. for money, only for advice. The research manager should invite him to visit the labs, and take the time to explain what is going on and why, in non-technical language. His imagination should be stimulated with the lab's latest embryo-product, and he should then be asked for advice on how best to bring it to market. If the research manager has done a good job of communicating, the D.F. might be tempted to say, "Why don't we try...." If so, note carefully the word "we." The research manager has now, as the Americans say, reached first base. The writer's experience is that D.F's can be extremely creative regarding ways of funding projects they consider exciting. So, the research manager should endeavor to get them on the team.

Regarding the Research-Plant Manager (P.M.) interface, when the P.M. calls, the research manager should be responsive, but not believe all he is told. It is a fact of life that all P.M.'s have strongly held opinions. It is also a fact that managerial authority does not necessarily correlate with scientific perspicacity. There are golden rules regarding this interface, namely: To determine if the problem is important, ask the manager...not the involved engineer. But present any proposed solutions first to the engineer, not to the P.M. because, chances are, the research manager has been told only part of the story! Thus, at best, he will have only part of the solution. He should now get the rest of the story, solve the actual problem, and give plant engineering all of the credit. The consequence will be several happy customers, the likelihood of being invited back, and the prospects of having his results actually introduced into practice.

Finally, it is evident that the nature of corporations is continuing to change. Already decentralized, lean-and-mean organizations are moving to a new, non-hierarchical, task-based style. In this mode, teams from a variety of disciplines are formed to solve a specific problem. The team then dissolves, and its members join other teams to tackle new issues. Such an organization exhibits an ambiguous structure with few of the traditional interfaces. Its operation requires both a flexible style and a communication system that permits the whole team to access and act on all the available information. Another development is the virtual company, in which supplier, manufacturer and customer are so closely related that it can be difficult to tell which is which. Not any one of them is in total control; the customer helps design the product and set the specifications; the supplier produces to agreed upon quality and delivers just-in-time pre-inspected components for the manufacturer to assemble or integrate. The risks and responsibility for success are shared, and so is the knowledge. There are few secrets.

How to effectively manage the research function for such empowered and dynamic organizations has yet to be discovered.

For related reading see, for example:

(1) A.R.C. Westwood, Res. Management, 27(3) 23-26 1984.

(2) A.R.C. Westwood and Y. Sekine, Res.-Technol. Management, 31 (4) 16-20, 1988.

(3) A. N. Chester, ibid, 37(1) 25-32, 1994.

(4) A. Deutschmann, Fortune, 17 Oct. 1994, p. 197 et seq.