"MANAGEMENT OF COMMUNICATION IN INTERNATIONAL RESEARCH AND DEVELOPMENT"

by

Arnoud DE MEYER*

N° 90/03/TM

* Associate Professor of Technology Management, INSEAD, Boulevard de Constance, Fontainebleau 77305, France

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Arnoud DE MEYER
INSEAD
Bd. de Constance
77305 Fontainebleau Cedex
France
33-1-60724000
33-1-60724242

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Abstract

Multinationally operating companies have no choice but adopting a global technology policy. Several options such as acquisition of existing technologies, partnerships or the development of an international network of laboratories are open to these companies. In the case of international R&D the company will have to pay considerable attention to the creation of an effective communication network. On the basis of data gathered in 14 large multinational companies we propose a portfolio of six different categories of tools that can be used to improve the international communication network

Management of Communication in International Research and Development

1. Introduction

The globalisation of the world markets and the rise of Japan's industrial power have made transnational companies thinking about how to manage its technology globally [1]. No single company is able to master all the technologies needed to respond quickly to increasingly competitive markets. Even the largest companies recognise that they have to get involved in collaboration or strategic alliances with other companies across the world , in order to develop the products which the global market place needs. No single industrial power can pretend, as the United States could do in the fifities and the sixties, to have a quasi-monopoly on high tech developments. The creation of technology happens in more places than Massachusetts or California only, and some European universities or companies as well as some Japanese or Korean companies have become the drivers of technological development.

Companies have developed several responses to the need to develop a global technological strategy. Acquisitions of technology, either by buying laboratories or by negotiating licenses is one type of response. Strategic alliances or other forms of collaboration with companies, research institutes or governments are a second form. Creating an in-house international research and development capability is a third type of response. In this paper we will focus exclusively on this last aspect where companies respond to the challenge of creating a global technological capability by developing an international network of laboratories.

Traditionally one of the most important productivity problems in research and development is the question of how to stimulate the communication between the researchers. How can one improve the flow of technology [2] ? This problem becomes even more difficult in a situation where laboratories are at a large geographical distance from each other. Multinational R&D poses serious problems of communication. Steele observed for instance that in many corporations coordination and communication becomes rather weak outside a one-day return travelling distance, and that in the cases where communication and coordination do work, the corporations have long-standing multinational experience.[3]

We want to report here on the practice of 14 large multinational companies in order to get some insight how this communication problem can be managed in a multinational company. This will lead us to a number of propositions of

how the transnational or multinational company can improve the management of its international R&D operations [4].

2. The role of communication in R&D

An essential element of the work of an R&D engineer is the gathering, diffusion, and creative processing of information. Many studies about R&D have shown that the productivity of an R&D engineer depends to a high extent on his ability to tap into an appropriate network of information flows. [5]

The seminal work by T.J. Allen at M.I.T's Sloan School and his students have supported repeatedly the notion that the face-to-face individual contact form the backbone of an efficiently operating information network [6]. To exchange information, engineers and technologists have to talk to each other, and that in each others' presence. Engineers do read. But they limit their reading mainly to textbooks, to refresh their memories, or trade journals to figure out what the competition is doing, or to see what suppliers have to offer in terms of novel components and approaches. These results have been repeated under several different conditions of technologies or countries, and the core finding has been remarkably well verified in these different contexts.

This result is in fact quite easy to accept. To be able to understand and digest information about new technologies, specific market conditions or competitive developments, the engineer needs more than the raw information or data. He also needs the context of the information. Knowing about the existence of a new micro-electronic component is often insufficient. The engineer needs also to know what the primary application was for which the component was developed. Action upon the new information or rephrasing of the information is often needed to better understand what the raw data means. You want to repeat to the source of your information what you have understood, to check whether you understood it properly. And the engineer often wants control over the speed with which the information is offered to him. Compare the level of understanding of an audience that has listened to the delivery of a written speech, with an audience where the speaker has built up an argument together with the audience. Generally speaking the comprehension will be higher in the second case. Control by the audience over the speed of delivery, or the feedback mechanism through which the observant speaker can adapt the speed of delivery to the level of understanding of his audience, increases the efficiency of the information transfer.

Why do we write individual face-to-face communication ? Would it not be simpler to talk about individual communication ? Well, one of the interesting findings of

studies in the sixties and the seventies was that telephone communication patterns, which are individual but not face-to-face follow closely the existing pattern of face-to-face communication. One only calls the people one knows well, and which one sees fairly often to engage in conversations which are more than a simple exchange of data.

Thus individual face-to-face communication seems to be essential to improve and maintain the productivity of an R&D organisation. It is quite clear that creating geographically decentralised R&D operations does not contribute to an efficient communication pattern of this type. On the contrary the tendency will exist to form efficient communication clusters in the different countries, with a loose coupling between the different clusters. This may be sufficient in the case of development laboratories which have a mere adaptation function. If their charter consists of adapting products, developed elsewhere, to local market conditions, than such a communication structure may be aceptable. As Ghoshal and Bartlett [7] have demonstrated in their empirical study of nine large transnational companies, creation of innovation in local subsidiaries is positively associated with intra-subsidiary communication, though neutral with respect to inter-subsidiary communication. But both adoption and adaption by the subsidiary of innovations elsewhere developed, and diffusion of innovations created by the subsidiary, to other parts of the companies are strongly positively associated with both intra- and inter-subsidiary communication. In those cases where the communication flows have to go in two or more directions, or where truly international developments are started, companies will have to bring in place other mechanisms to replace or support the communication pattern based on personal interactions.[8]

3. The study

To study the question of how multinationally operating companies organise the international R&D operations we gathered data through interviews with fourteen large multinationally operating companies. The number of interviews was dependent on the extent of the international network of R&D operations. In some cases only the R&D manager was interviewed. In other cases several laboratory managers and eventually users of the research or development results (such as product managers and/or production managers) were interviewed as well. The interviews ranged from several hours to several days. Though the basis for the interviews was a checklist of items to be discussed, in most interviews the questions were kept very open, and the interview format was adapted to the specific technology and market presence of the company [9].

The fourteen companies do not form a sample representative for a particular industry or geographical region. Four companies belong to the electronics industry,

one to the food industry, three to the pharmaceutical industry, four to specialty chemicals and two to the automobile industry. Nine companies have a European headquarter, three are North-American, but with a long presence in Europe and two of them are Japanese companies. Ten of the fourteen companies have a long experience with carrying out R&D on an international scale. The number of laboratories ranged from 2 to 17. In each of the cases the companies had several hundreds if not thousands of professionals working in R&D. Each of the companies was at the moment of the interviews considered to be successful to very successful by evaluations in the international business press, and judging from the financial performance over the last five years. This does not guarantee however the quality and success of their R&D performance. In fact in more than one company we were granted interviewing time, because managers were concerned about the performance of the international R&D, and they hoped to get a sort of a bench mark evaluation out of the interviews.

The activities of the laboratories ranged widely on the spectrum from basic research to applied development. We however discarded from the analysis simple process engineering outlets. Even in the definition of what research and development are, we found an enormous variety. What was classified by one company as research would probably be labeled by another company (even in the same industry) as applied development. Consequently it does not seem to be useful to provide here a table with the number of research and development laboratories according to their technical activities.

4. What can be done ?

The literature on communication in R&D has often stressed that communication patterns are highly influenced by the project structure, the structure of the organisation and by the change over time of this project structure. [10] Openness of person-to-person communication is very often a result of having worked together [11]. And the reallocation of personnel to different project teams can lead to the creation of links between the project teams. But communication links can also be destroyed when either the organizational structure, the technical assignment, or the project groups are altered. Also the style of project management can have an important influence on the creation of links between different project teams. Consequently one could expect multinationally operating companies to take organisational measures and to use career planning to manage the communication patterns.

A second constant element in the research on communication patterns is the important role played by what are called boundary spanning individuals or gatekeepers

[12]. The discovery of these roles is based on the observation that information from outside a group into the group is often characterised by a two step process. Particular individuals seem to have the capability of better monitoring what is going on in their environment and translating that external information into messages comprehensible for the group to which they belong. They are different from the integrators or liaison roles which are described in the literature on integration and differentiation. Indeed the gatekeeping role does not integrate tasks and actions, but only improves the flow of information. Would one be able to use a similar boundary spanning role, a sort of international gatekeeping role, to manage the flow of information between the different international locations of the R&D laboratory ?

Recent technological innovations such as fax machines, teleconferencing or videoconferencing have improved considerably the tool kit that can be used to complement the individual face-to-face communication. In the same way as the question was asked for simple telephone calls, one can wonder to what extent these technological means can help the company to support or even replace the face-to-face communication. In particular the addition of images with videoconferencing, or pictures, graphs and tables with fax machines, electronic mail or computer conferencing provide a quantum improvement over the simple telephone call.

In our study we have seen a bit of everything. The companies were all very strongly aware of the need to improve communications and often admitted that breakdown of the communicication lines was the biggest recurring problem in their organisation. We could categorise the solutions they were pursuing in six broad categories : (1)efforts to increase the socialisation in order to enhance communication and information exchange, (2)the implementation of rules and procedures in order to increase the formal communication, (3) creation of so-called boundary spanning roles or assigning individuals to the task of smoothening the communication flows, (4)creating a centralised office responsible for the management of the communication, (5) the creation of a network organisation, and (6) the replacement of face to face communication by electronic systems. Let us go through each of these methods in some more detail. By the way, none of the companies applied them all with equal emphasis, and none of the companies limited itself to only one of these methods.

5. Socialisation efforts

Though every company would recognise that an organisational culture favouring exchange of information and communication was an important tool to improve R&D productivity, some companies emphasized more strongly than others socialisation procedures to stimulate such a positive

culture. This was expressed in ways like :

> "we need a cultural change so that people do not consider information to be a source of power. The amount of information you share with others should enhance your position in the company", " we are like a family, we share what we have. And it should stay that way", or "we share our information in informal meetings. It is important that in such a meeting everybody is equal. Status or hierarchy should not play a role in evaluating the value of a piece of information. Only the factual content is important."

Creating such a 'family' atmosphere was created in four ways. One of the most important tools to increase the socialisation [13] were the temporary assignments in other laboratories. As others have found in the study of sharing goals and values in the Multinational Corporation [14], transfers appeared to be a key mechanism. How long should such an assignment last to have a meaningful impact of the 'family' spirit. No strict rule emerged from the cases, except that the companies which used this socialisation as one of the main elements of their policies expected the engineer or scientist to settle down in the other laboratory, i.e. move in into the new country.

> 'It has to be more than a visit where the engineer operates from a hotel. He has to get over the difficulties of settling in, to increase his loyalty to the company family, which has helped him to overcome these difficulties'.

What one can read in between the lines here, is an effort to turn the company into some kind of a protective environment, which nurtures the engineer who finds himself in a quasi-hostile foreign country. It reminds us of some of the descriptions of Japanese companies, and the way they create loyalty to the company, rather than to other groups [15]. Such an approach can of course only work if the company is effectively organised to support the employee looking for help.

A second element of the socialisation was constant travelling. The number of trips was positively correlated to getting to know each other better. In one particular company the R&D department alone had registered in 1988 more than eight thousand business trips. Travel costs of the R&D department ranged in the companies in the sample from 3 to 7% of the total R&D budget. In some cases there was a conscious attempt to turn visits by representatives of central headquarters to the subsidiary laboratories in more than a work related event, but equally into a social event.

> 'I try each time that I or one of my people visit one of the decentralised research companies, that they have an informal get-together organised.'

Such social events help the creation of informal contacts, which are often the start of a healthy exchange on the task to be executed.

In some cases rules and procedures were used to reinforce the company culture. In one case where the company had two equally strong laboratories in the U.K and West Germany, the differences which exist in the training of a German and a British engineer incorporated a tremendous potential for cultural clashes. In this case strong quality standards and procedures about how the work should be executed, and how it should be documented helped to create a strong sense of pride among the engineers, which helped them to identify with the company rather than with their previous training. Such a sense of pride and belonging was in more than one company linked to the feeling that the company had achieved technological leadership in a particular field.

A fourth method indicated as improving the company culture was the use of training programmes. The difficulty here was to find a training programme which increases the identification with the company. Too general programmes can have the disadvantage of being used by employees to increase their value in the labour market of their local country, and had consequently a negative effect on the loyalty of the employee. Language training was often strongly recommended.

In none of the companies that consciously put effort on creating a company culture to foster communication, this meant that a single or standard laboratory was created. National characteristics and the historical background of the center, as well as its strategic mission were often a reason for strong differences in the way the research laboratories operated. The best summary of what socialisation attempted to achieve was made as follows : 'we want to be a multicultural [family] with common goals and values.'

6. Rules and procedures

Rules and procedures were already mentioned as a mechanism to create a culture amenable to improved communication. But rules about the communication were often used as a means to enhance formal communication. These efforts usually took the form of either a careful emphasis on reporting and documenting the research or development effort, or the use of the planning process to stimulate communication between the different laboratories.

During the study it became quite clear that in comparison with single laboratory companies that we studied in the past [16], these multi-laboratory companies paid much more attention to the reporting process and the diffusion of these reports. Originally we thought that this emphasis on reporting was a consequence of the size of the companies, or

as in the case of pharmaceutical companies that it was due to government requirements during the approval stage by the drug administrations. If this would be the case the reporting structure would probably have been experienced by the researchers as an administrative burden, and the useless production of paper. In several companies however, soon it became clear that the reporting structure was really designed to minimise the burden and maximise the diffusion of the acquired knowhow throughout R&D laboratories. In some cases the company had strict rules and report designs in order to increase the readibility and the speed with which one could get access to the material. In other companies information sheets were organised in treelike structures, which allowed the individual laboratory manager or engineer to scan very quickly the new results obtained or problems encountered by the company. A quick turnaround of highlight reports was another attempt to diffuse information as quickly as possible. And in some companies the job description of the laboratory manager clearly included the responsability to read the reports from other laboratories and distribute them to the appropriate engineers. All these were symptoms of efforts to use the reporting structure to enhance the communication.

In those cases where the development was strongly routinised, or had particular routine test procedures, such as in the case of pharmaceuticals, food, agro-chemical products, or mechanical engineering the reporting structured made extensive use of electronic databases. In laboratories or companies where the activities that we studied were more research oriented, less standardised, or more complex, most of the reporting was still manual. This is probably only a temporary situation. The available commercial databases are perhaps not yet powerful enough to present unstructured information in a standardised and efficient form. The companies utilising electronic databases to improve communication had often carefully thought about the design of the databases to enable access to everyone in the company (eventually with different levels of security), and to improve accessibility for the non-experienced database user.

The second major category of rules and procedures to improve communication was found where companies used the planning process to stimulate the communication. A number of rituals and aspects of the planning process had really more to do with rejuvenating the communication network and opening up new channels, than with arriving at a plan [17]. Typical examples were the scientific conferences which started the planning process, the presentations made to other laboratories, or the broad discussion throughout the company of intermediate planning reports. In one particular company, the planning cycle could be summarised as follows :

> The planning cycle is bi-annual. It starts with a number of mini-meetings in preparation for the bi-annual conference. These mini-meetings are held in the

different regions. The bulk of their discussions is brought together at the main conference, which has plenary sessions but also many syndicate groups. After that 3 to 4 day meetings are organised with the business units or operating groups to discuss major thrusts of the programmes and to have the right balance in the programme. The central research group participates actively in these discussions to ensure that a long term perspective is brought in, to inject ideas, and to show implications for the business of some far out technologies. After several steps of a typical planning process, one obtains a sort of research guide, which are heavily discussed in the laboratories. On the basis of these discussions the research laboratories will provide programme sheets detailing time planning and costs. These programme sheets will be discussed with the business managers and fund providers. Once a final programme is defined the central research staff, in many cases the top R&D manager, will visit each of the laboratories to review the detailed research plans and resource allocation. This whole process takes about one and a half year.

This description has been simplified and it skipped some steps typical for a planning process, as it would be described in standard textbooks. It can be read as a traditional, somewhat elaborate planning process. But the length of it, and the seriousness of the discussion process indicate that something more than a simple plan with targets and resource allocations is at stake. The whole process is used to get hundreds of resarchers involved in the discussion and to spread some of the company's knowhow throughout all the R&D laboratories. Planning has become here a mechanism to force large number of researchers to talk about their results, their knowhow, their technological forecasts, and later on to discuss these issues with the business groups to anchor them in a realistic view of the market. The active role of central R&D staff in fostering the communication and diffusing the results of the planning exercise fits also in this interpretation of the planning process.

Though some companies were very successful in using the reporting structure or the planning process to foster communication, it became also very clear that rules and procedures cannot be a substitute for and not even a trigger for the informal communication process. It probably can be a very powerful mechanism of 'maintenance' of communication flows, complementary to other mechanisms that we describe here, but not a substitute for it. One of the companies, which admitted that inter-laboratory communication was below expectations, had obviously tried to use its planning procedures to create some kind of an exchange, but had miserably failed to do so. They were also in the process of revamping completely the planning procedures. The use of these rules and procedures to stimulate communication has

probably to be built upon an already existing informal communication network.

7. Boundary spanning roles

The pre-eminent role of gatekeepers in the transfer of technology has often been discussed. We were not able to test whether a role like an international gatekeeper exists, i.e. whether a person exists, who would have good contacts with other laboratories and who would be able to translate what is going on in the other laboratories into the jargon of the own laboratory. What was clear however is that some companies had defined the role of the central staff to be one of smoothening the information flow. These people had different (and sometimes inappropriate) job or role titles such as sponsor, liaison men or technology coordinators. In one company for example the sponsor was described as follows:

> 'The goal of the system is that every sponsor would encourage and support worldwide communication of developments and results in his product group. This is mainly done through the organisation of a number of technological conferences. '

In this example the sponsor was defined at a high hierarchical level in the company, and the communication responsability was mainly a responsability to organise the process. In other companies the sponsors or technological coordinators were lower in the hierarchy and had to travel constantly around in order to follow up on the evolution of the technology. They had to be active in triggering the contacts between the different individuals and groups in the laboratories. Obviously the success of such a person was dependent on his personality : a combination of technological credibility and social abilities to listen and to integrate were a minimum requirement.

One of the companies described this role as that of an 'ambassador'. Although the company had not appointed those people officially, the research director commented that the success of the remote laboratories in attracting the attention of the central (and much bigger) laboratory had a lot to do with the ability of that remote laboratory to find somebody to represent them in the headquarters.

> 'There is a great need for intense communication... The solution is, at least partially, to include in the remote groups people from the central site. People who know the important people in the central offices and laboratory, who know the flow of information in the different departments. These people should act as ambassadors.'

The role of individuals to transfer technology was

observable in any of the organisations we have visited. In those cases where they received a higher emphasis, or where they seemed to be the cornerstone of the communication process, the companies either had to cope with a breakdown in their communication structure, or with the creation of new laboratories. The individuals as key element of the communication network seem to be a preferred way to construct or reconstruct a communication network in case of a major structural change in the R&D network.

8. Organisational mechanisms

Two types of organisational mechanisms could be distinguished : the creation of a central coordination staff, with explicit communication responsibilities, and the stimulation of a network organisation. We will discuss these two organisations in the same section because they are both a way to use organistional mechanisms to stimulate innovations. In our research they seemed to be mutually somewhat exclusive : companies tended to adhere to either one or the other. Theoretically we see no reason why they should be mutually exclusive.

In five of the fourteen companies which we studied, there was a perhaps light, but meaningful central staff which could not be identified with a particular laboratory and whose explicit task was to coordinate the R&D activities, as well as to stimulate communication. Of course, each company had a central R&D manager and R&D office, coordinating the total of the activities of the group of laboratories. But in some cases this central staff was an explicit component of the oldest laboratory, or the biggest laboratory. In other cases it was limited to a very small administrative staff responsible for the coordination of planning and budgeting activities. The five companies we refer to here, had more than such a light coordination. A group of people, perhaps small, had no explicit research task, but on top of their administrative and coordinating duties, they got involved in coaching, guiding and monitoring the laboratories. They explicitly managed the communication process. In some cases there was a clear overlap with what was described in the previous section as the role of boundary spanning individuals . But there is a difference : the central staff had as an organisational unit the responsiblity for communication. These organisations looked a bit like spider webs : the central staff, sitting in the middle, monitors all movements of information between the different nodes. Weak internodal communication can exist, but the main force of the communication network is in the middle. The mechanisms were fairly simple : organisation of meetings, a lot of travel, playing the role of go-between when engineers with problems had to be brought together with engineers with answers, managing the technical reporting process, diffusion of reports and results, and carefully monitoring the build up of the database of company knowhow.

A second group of six companies had an almost negligible central staff, but believed strongly in the creation of a network in the company. In this case the R&D directors strongly expressed the wish to develop networks between the different laboratories and this at all hierarchical levels. Here people are supposed to be a node in an extensive network of equals, relaying messages to each other, being able to get into contact with any source of information by going through two or three nodes [18]. In such a network there is no preferred way for the message as opposed to the previous form of organisation where it is often implicitly assumed that the central staff plays the role of the preferred central information exchange. Information can go through any sequence of links, as long as the person with a problem can find a person with a solution and as long as information gets from source to receiver. None of the four companies which explicitly pursued such a system had been able to get to such an ideal state.

As we said in the beginning of this section, the two organisational mechanisms seemed to be almost mutually exclusive. One company only was attempting to do both : creating a network, but stimulating such a network from a central R&D staff. --In the other companies either the central staff approach or the network approach were emphasized.-- Since they had only started promoting the network two years before the interviews were conducted , it was too early to judge the potential for success.

The six companies which attempted to create such a network fell into two categories. They were either companies with a limited number of laboratories (two or three), or were in the communication and electronics industry. It would be an interesting hypothesis to check whether network communications were favoured by those managers who had actually been involved in electronic network design. But the fact that such a network organisation was more favoured by organisations with a limited number of laboratories is not surprising Organisational networks in R&D are not easy to create. It seemed to require the fulfillment of three conditions, which were easier to implement in smaller, less complicated organisations.

First the central staff had to accept, not only at a rational level, but also at an emotional level that information will flow freely in the organisation. Given the secrecy that often is needed in a R&D envirionment it requires that the central office accepts that every individual engineer can make a judgment about what can be shared, or that the company accepts that within the company there will be no secrets. It is easy to propose this, but not all companies are willing to accept the increased risks of leakage of information that exist in such a system.

Secondly it assumes that the individual engineer is prepared to play the role of node, i.e. prepared to share his contacts with others. It requires time on the level of the individual engineer to create and maintain that network, and he will often see this network as a source of individual competitive advantage within the company. Transforming this protective attitude into an attitude where sharing a network is perceived to be a source of competitive advantage is a conditio sine qua non for the success of a network approach.

Thirdly the company had to be prepared to support the creation and maintenance of the network with the appropriate tools. A career planning and job rotation system that promotes the creation of networks, an extensive portfolio of meetings (at different hierarchical levels) and inter-laboratory travel, and an electronic communication system which can help to maintain the network seem to be a minimum.

9. Electronic communication

Each of the companies in the sample that was studied was experimenting in some way or another with electronic means of communication. Though not all of them had gone beyond the stage of pilot experiments, in each of them we have been able to find traces of computer networks, electronic mail and computer conferencing. Needless to say that fax machines were standard equipment six months after their introduction in the market. Nearly all of them had electronic mail systems or worldwide engineering databases if appropriate. In at least four companies serious experiments with videoconferencing were under way. In only one company had videoconferencing become a normal way of communicating between two R&D sites.

The evaluation of these electronic means as support or replacement of individual face-to-face contact was rather mixed. Nobody doubted the value of the communication systems in place to complement the other channels for communication. But the mere fact that videoconferencing has not been implemented with the same sweeping pace that has characterised the diffusion of fax machine indicates that reluctance about new forms of communication media remained very strongly alive.

In the case of computerised communication systems we could observe that most information sent, concerned purely operational matters (time schedules, results of experiments, list of publications). The frequency of use was high, but the contribution to sharing of problem-solving information was quite low. Information shared during development projects has been categorised in problem-solving information and coordinative information [19]. In most of the cases electronic media were most effective to share the coordinative information. This can however not be

generalised. We observed that the capacity to share problem-solving information was dependent on the nature of the R&D work. The higher the analysability and the lower the complexity of the technology, such as in the case of electronic assembly, or simple chemical experiments, the more effective the computer supported communication systems seemed to be. With increasing complexity and decreasing analysability the problem-solving content of the information exchange decreased, while the coordinative content of the information could still be communicated. Nature of the R&D work seems to play a role in the effectiveness of the electronic communication system.

Hope was expressed by the companies which were experimenting with videoconferencing that these real-time picture systems could replace some direct personal contacts. There did not seem to exist a high confidence that these electronic communication systems, even in their most sophisticated form, could be more than a temporary replacement for the direct face-to-face individual contact.

> "Videoconferencing, integrated CAD/CAM databases, electronic mail and intensive jet travel all contribute to lowering the communication barriers. All things considered, however, the most effective communications, especially in the beginning of a project, is a handshake across a table to build mutual trust and confidence. Then and only then the electronics can be really effective, "

commented the senior product development manager of the company that had deployed the comparatively most sophisticated electronic communication system in the sample. In each of the companies that had built up some experience with electronic communication systems, we could sense the same idea as expressed in this quote. Electronic communication can make a valuable contribution on condition that a certain level of confidence between the partners in communication exists already. The 'handshake' is an important preceding condition for the effective use of electronic communication systems.

A similar observation has been made by Karl Weick [20] when he argues that in the electronic world information and representations can loose their meaning because of the loss of a set of assumptions that give them life. He sees a risk that representations of events stop to form a cosmos, and become chaotic. Electronic data are flawed because they are obviously incomplete. Only what can be represented electronically can be transmitted. That excludes sensory information, feelings, intuitions and context. One of the engineers with considerable experience on videoconferencing systems summarised his own relation to the system this way :

> "[Although it is a great system], I have two difficulties with it. I still cannot express emotions

on a videoconferencing system. It seems so silly to become angry, to joke, to deviate from the subject and to talk about your family, to complain about your boss, all those things you need to do to get to know each other. And I am never sure that my colleagues at the other end will not tape me, to use my own words against me. I know it is silly, because I am not scared of taping at the phone, but videoconferencing meetings still create many more formal commitments than a simple phone call."

Weick also argues that electronic data are not only flawed, but the people who manage those data have limited processing capability. When people are forced to make judgments based on cryptic data, they cannot resolve their puzzlement by comparing different versions of the event registered in different media. When comparison is not possible people try to clear up their puzzlement by asking for more data. More data of the same kind clarify nothing, but what does happen is that more and more human-processing capacity is used to keep track of unconnected details. To make sense of what happens around them, people use a variety of procedures. They effectuate, triangulate, affiliate, deliberate and consolidate. And neither of them is possible if they have only electronically transmitted data available.

Two conclusions seem to assert themselves. First, electronically transmitted data cannot be the sole source of information. This seems to be a 'motherhood and apple-pie' statement. But the relative comfort of electronic data communications as opposed to travel, direct contact, and even telephone calls between laboratories in different time zones give people enough reasons to fool themselves, and to be satisfied with the electronically communicated data.

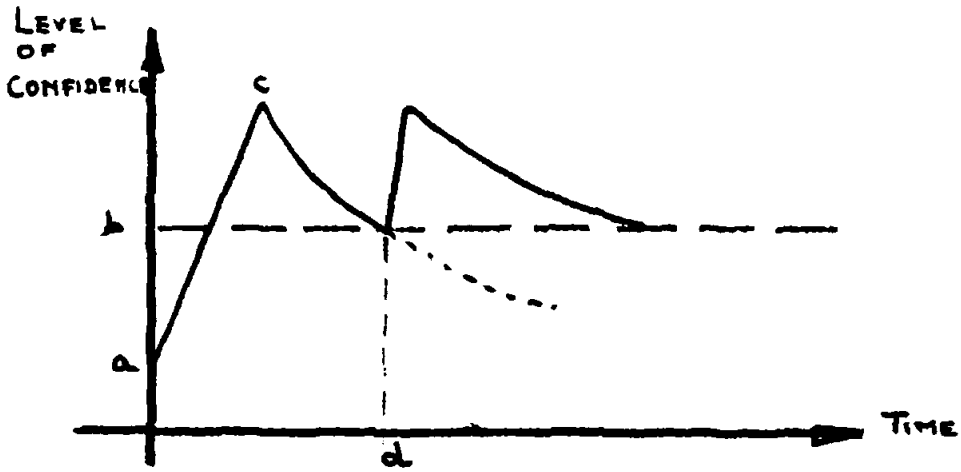

Figure 1 : Half-life time of confidence
a. initial level of confidence
b. minimum threshold of confidence necessary to work together
c. level of confidence after initial face-to-face contact
d. time where a boost of confidence is needed

The second conclusion is that to increase the

effectiveness of that electronic data, there must be some level of confidence in the party at the other side. This confidence is a result of the sensory information, feelings and context--all of which require personal interaction. In the interviews we observed very clearly that even with the best electronic communication systems, confidence between the team members of a development project spread out over the world, seems to decay like nuclear radiation over time. Confidence between engineers, who do not work in the same geographical location, has perhaps, like nuclear radiation, a half-life time. Since a minimum level of confidence is necessary to avoid that the electronic communication has no effect, even a negative effect on the productivity of the development project, one has to avoid that the confidence drops below a certain threshold. Thus regular face-to-face contact seems still necessary to boost that confidence to a level high enough to have effective team work (see figure 1). We have sometimes used the expression 'halflife time effect of electronic communications' to describe this decay of confidence and the need for regular face-to-face contacts to restore the confidence level to its initial level [21]. When one starts a new cross-laboratory project or programme it will be necessary to bring the team members together to create that first badly needed degree of confidence. But once everybody returns to their respective laboratory benches, and starts communicating through terminals, faxes and videoconferences, confidence will decay. A regular face-to-face meeting will be needed to boost the confidence. The frequency of such a confidence-boosting meeting can be lower with intensive use of electronic media than without these electronic information exchanges, but it will not drop below a minimum frequency level.

8. A portfolio of mechanisms

The categorisation of mechanisms to communication is of course somewhat artificial. Companies did not think in these categories and spent consciously or inconsciously efforts in nearly all categories. But none of the companies spent an equally high effort in all the categories neither. There seemed to be a few simple patterns which we want to formulate here as hypotheses.

a. Building up an international communication network is equally important as in a single-laboratory environment. The degree of difficulty to build up such a communication network is of an order of magnitude higher than in the traditional case of a single-laboratory R&D department. Companies use portfolios of mechanisms to create and maintain this communication network.

b. Starting up a new laboratory and integrating it into the existing communication network, or restructuring drastically an international communication network will be heavily dependent on the efforts of individuals

taking up the role of network builders.

c. Procedural mechanisms such as cleverly designed reporting structures which promote diffusion of information, or planning processes which stimulate communication, cannot create a network. They may be efficient complementary mechanisms to do the maintenance of the network or to adapt is slightly.

d. Electronic communication means cannot replace the face-to-face individual contact needed to create effective communication between engineers. But they can help to lengthen the decay of confidence. They have a longer halflife-time of confidence than written exchanges or telephone communications.

e. Organisational design may influence the communication patterns. Two types of approaches were found : a spider web type of network where a central staff gets explicitly responsibility for the smooth flow of communication in the R&D organisation, and network organisations where there are no dominant nodes. Network organisations may be an attractive form of creating a communications network. The difficulties to create such a network should not be underestimated since it requires a serious investment of effort both on the part of the company as on the part of the individual engineer.

9. Conclusion

Though global technology development may remain for the majority of the companies of marginal interest, those companies who want to compete globally have to recognise that such a competitive choice will require them to tap sources of technology across the world. There are several options to do so, of which international R&D is one. If a company chooses to create an international network of laboratories, it will have to pay considerable attention to the creation and maintenance of an effective communication network. This is not a new problem in the management of R&D, but the size of the problem is a magnitude bigger due to the geographical distance between the laboratories. On the basis of company interviews we have found that companies use tools to improve the communication flows, which can be categorised in six groups : socialisation, rules and procedures, boundary spanning roles, organisational measures be it either centralisation or the creation of a network and electronic replacements of face-to-face communication. Companies have chosen different portfolios of tools, and we have formulated here a few hypothesis on the deployment of these tools.

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