

Obstacles to tele-cooperation in engineering networks of the building industry

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ABSTRACT

This report is about an engineering network in the building industry which has been supported by the OrgTech project in its attempt to implement modern tele-cooperation technology. The cooperation of the small and medium sized firms involved is organized by regular face-to-face meetings of their managers corresponding the centralization of decision making within the firms. These regular meetings allow the cooperating firms to organize projects and quality management with some (very limited) flexibility. On the other hand, the over-centralization of decision making is an obstacle to the formation of tele-cooperating teams and to any more sophisticated organizational arrangements.

Keywords

Inter-organizational cooperation, virtual enterprises, de-centralization, information monopoly

INTRODUCTION

According to Aristoteles, the whole is more than the sum of its parts, a thesis which has gained topicality with the discussion about the emergence of virtual organizations (Asdonk et al., 1991). In particular, a growing number of business organizations feel the necessity to react to the increased speed of global market processes and to adopt new organizational forms. Consequently, a growing number of enterprises are organized as "virtual organizations" (Rittenbruch et al., 1998). "A virtual enterprise is a form of cooperation between legally independent enterprises, institutions and / or individuals contributing inputs on the basis of a shared business idea. The cooperating units participate in this cooperation mainly with their core competencies and interact externally like a normal enterprise. Nevertheless, the use of information and communication technology is widely used to avoid the institutionalization of a central management for design, coordination and

development of the virtual enterprise" (Fischer, 1996, trans. B.N.).

Such virtual enterprises allow flexible adaptation to particularities of single market structures, clients' demands and geographical distribution of the cooperation partners without losses in quality management. While this increased flexibility offers more opportunities to the individual partners, it gives the network the possibility of new, more sophisticated products and services, making it indeed more than the sum of its contributors. In this sense, the virtual enterprise could represent a promising model for engineering networks in the building industry.

However, the established organizational structures in the building industry hinder such developments. The field is characterized by the predominance of small, scarcely medium sized enterprises which cooperate only during the specific order. Due to the interdependency of the different construction processes and to the changes of the order itself, managing the building process requires flexibility and is a complex task. In the building industry, engineering networks are (if existing) the results of clients demanding cooperation from the engineering firms contracted: the planning contract demands a regular coordination (for example participation in a weekly meeting of the engineering firms' representatives). However, not every client demands such cooperation in the contract. Cooperation, then, only arises from spontaneous interaction between the managers of the enterprises involved.

In this context, the possibilities for inter-organizational tele-cooperation to be supported by modern groupware is promising. The technical infrastructure needed has become very cheap, even for small and medium sized enterprises. Nevertheless, using modern tele-cooperation technology has not yet become general practice in the building industry. The OrgTech project (organizational and technical development in the context of the introduction of a tele-cooperation system in small and medium-sized engineering firms) has the objective to introduce modern tele-cooperation tools to construction firms and to analyze which obstacles hamper this. Within the project different application fields are examined and the

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attempt of introducing modern tele-cooperation tools has been followed (Wulf et al., 1999).

The next chapter describes the proceeding of the OrgTech project. It will be followed by a chapter about an engineering network in building industry we worked together with. After having sketched the data management practiced, the next chapter depicts our improvement suggestions and the reaction from the engineering network towards these. This will be followed by a chapter dealing with an analysis of the reaction of the engineering network. The last chapter attempts to draw a conclusion.

THE ORGTECH PROJECT

The OrgTech project is based on integrated organizational and technological development (OTD) which combines the introduction and development of information technologies with the demands of organizational and staff development processes. OTD is based on a participation-oriented and evolutionary proceeding (Hartmann, 1994 and Wulf & Rohde, 1995). This proceeding usually begins with a problem analysis. The results are then discussed by the applicants in order to decide together which proceeding to follow. The OrgTech project is about OTD while introducing modern tele-cooperation tools to engineering firms in the building industry.

The project has adopted a variety of methods for analysis. In every participating company of the engineering network at least one person was interviewed (in most companies several people). Half-standardized interviews were used questioning about the position and qualification of the interview partner, about the technical infrastructure at hand, the work process, communication patterns, data management, information costs and typical cooperation problems. We also asked about wishes and ideas for future improvements. The employees were interviewed at their work place for about 45 to 90 minutes. The results were protocolled and taped and later the contents were analyzed.

Informal conversations, analysis of selected data, observation of employees at their work place and during project meetings as well as analysis of material relevant to the network also contributed to research. Through these inquiry methods the OrgTech team obtained an insight on the cooperation problems of the entire cooperation system, which was not even accessible to insiders of the different firms. On this basis we worked out improvement suggestions, which we presented and handed out during a workshop to the engineering network which could be discussed and decided upon our proposals.

THE ENGINEERING NETWORK

During the OrgTech project, a variety of networks has been analyzed. The engineering network described here has the task to plan the extension of a bank's administration headquarters from the drawing up of an appropriate construction application to the partial realization within the framework of planning during actual construction. It is conspicuous that all offices of the engineering network have modern computers, yet many

employees have trouble with CAD and nearly all of them have difficulties with the use of modern tele-cooperation tools. In almost all offices the employees carry out system maintenance and learning of software in passing.

The engineering network consists of a number of companies situated within a radius of about 100 km from Bonn. Not all of them have worked together previously. During the building project (especially at the transition from the temporary construction application to actual building) networking partners change. The architect's office is the most constantly present if it is in charge of drawing up the construction application as well as further planning during building, as in this case. It is followed by the office for structural engineering, where arising changes demand for an adaptation of calculations.

From the moment of the temporary construction application until the completion of the building the site office is the center of communication. In this phase, the planning department and building control office demand for further plans before final approval. The setting-up of building logistics, the invitation of tenders, excavations and the construction of the building's shell take place at the same time. Inter-organizational cooperation is various. While the site office has a key position as interface to the companies carrying out the orders, the building physicist takes part more peripherally in the planning process. The fact that the landscape gardener and the land surveyor are not members of the engineering network proves that roles of the network may be unclarified. This is reinforced by the ad-hoc shifting of cooperation in the course of time.

The engineering network is networking only in the sense that weekly project meetings, obligatory for the firms, take place. These meetings, which have no fixed agenda, permit the firm managers to discuss actual planning problems. The client is represented by the project controller, a representative of interests laid down for large-scale projects. His job is to check the financial and temporal framework during planning (once construction begins, this is the site manager's job) and with regard to the bank's moving. In our case the controller also has the task of transmitting the engineering network's recommendations to the bank and the bank's alteration of orders to the network. This for instance happens when the bank asks for a change of the use of rooms.

The site manager has a special role within the engineering network, being the interface to the undertaking companies. He passes on all questions (and thus the necessary feedback for flexible construction) from the undertaking companies to the respective engineering firms as well as all their corresponding answers or minor changes back to the undertaking companies (major changes always demand for a decision at the project meetings).

Being in charge of the invitation of tenders, billing and controlling the construction progress, the site manager has considerable responsibility. For him, the problem of incompatible software used within the engineering network

is particularly crucial. Since the offices used different CAD programs, the site manager has to do the mass calculations for the invitation of tenders, billing and cost control by hand (measuring blueprints with a ruler / multiplication with a calculator) despite the existing of CAD data. The results are then entered into the computer. This costs a third of the site manager office's work time.

THE DATA MANAGEMENT

In the building industry tenders are invited by sending out floppy disks. These contain tables in which the estimated values of the suppliers are to be entered as well as information about the services demanded for. Contractors are obliged to put their documents into their own archives, as common archive standards do not exist. Paper printouts have a central role within the engineering network. Only occasionally Email is used for data exchange or file transfer. The only means of communication with the undertaking companies are paper printouts and telephone.

Printouts do not circulate among all network members. They are only sent to the person who is believed to need the drawing. Thanks to the expertise of the members this handling of blueprints works quite well as long as no other member unexpectedly needs the blueprint. However, serious problems arise when different versions of a blueprint are used. This is why the architect's secretary stores a copy of the architect's latest blueprints in a local register of drawings - which only he has access to. The other firms do not know about or have access to it.

The engineering network is aware of flexibility in planning as being essential. For example, problems arising while planning the laying of pipes and wires often require a revision. Then a new opening of a wall requires a revision of the structural engineering and sometimes also of the building geometry. In addition, the coordination of sanitary, heating, and tubes for electric cables is a constant source of alteration to plans.

The engineering network takes account for the need for alteration in different ways. For instance, plans remain large-meshed, leaving a certain freedom. For example, at first the architect leaves the concrete arranging of certain component parts open, the structural engineer bases his plans upon rough estimates. At the same time, an active tuning by telephone takes place between the people carrying out the orders. Nevertheless, it is the managers who meet on regular terms and not the people working on the orders themselves. In these meetings changes agreed on are marked on the blueprints with symbols. Thanks to software incompatibilities different versions of the blueprints can exist if the changes marked on paper are not taken on electronically in all files, and information gets lost. Even the continuous numbering of versions cannot definitely settle whether a blueprint is at its latest version. The efficiency of these meetings suffer from the fact that not always all necessary blueprints are at hand and that the people carrying out the orders can only be reached by telephone.

The people working on the orders usually coordinate their work only by telephone, even though their different tasks are highly interdependent. The cooperative planning process suffers from the lack of a common central archive for relevant documents. Because of the necessary flexibility in the course of planning, the multitude of drawings provokes version problems for CAD files and blueprints. The incompatibility of the used CAD programs is another large impediment to cooperation. The poor experience with the given form of data management is the reason for several persons interviewed to favor the setting up of a central archive.

THE ORGTECH TRANSFER WORKSHOP

Members of the OrgTech project present the above problem analysis to the engineering network on a workshop. Foils are shown, which itemize the problems and make clear the underlying causes. Following this, several solutions are presented and discussed. Thus in accordance with the OrgTech approach, the scientific help through the project team functions in a transparent way as an offer to the partners for their efforts for better cooperation. The workshop takes place at the end of an engineering network's project meeting. Besides the managers, further employees of the different firms take part in the workshop.

Our proposal in this workshop is to partially decentralize the coordination tasks. In order to facilitate coordination between the persons carrying out the plans within different companies, we suggest the use of various tele-cooperation tools in addition to telephone. We also propose to support discussions between different firms through application sharing. Even if CAD programs diverge, it is still possible to instruct the cooperation partner acoustically and thus indirectly show the subjects for discussion. As a back-up to tele-cooperation tools, we suggest the use of already existing digital cameras. After having called up the network members, digital pictures shall be sent as Email attachments. The site shown in the picture can then be elucidated by a model and a webcam. The reply is that this cannot replace arrangements and personal presence on site. Nevertheless, in some cases, the suggestion could be helpful.

In addition we recommend to increase the efficiency of the manager's weekly project meetings by using a video-conference application. Thus managers of firms who's contribution to a specific meeting is minor can avoid the journey and be called upon by video conference if required. In the same way individual employees of the represented firms can be called upon.

In order to improve the access to collectively relevant planning documents we recommend the establishment of a central archive which could easily be carried out electronically by using a common workspace from an internet provider. Here the latest version of documents agreed upon is to be stored in a familiar file structure, accessible online to all network members. Further communication software such as automatic Email, marker functions (for changes) and

revision functions can be implemented additionally. By systematizing the archive, the persons carrying out the orders can be included closer into the network, coordination can be improved, and managers relieved. Furthermore, as a solution to the compatibility problems between the different CAD systems, we present a CAD program which supports most of the CAD functions needed by the engineering network's members.

The engineering network reacts rather reserved to our suggestions. First the advanced state of the planning of the bank building would speak against the introduction of tele-cooperation tools. The workshop takes place at a time, where the phase of construction application is in essence concluded, so that soon only the architect, the site manager and the project controller remains involved in the engineering network. Future projects would ask for a new engineering network composed of new members. However, the dynamism of the composition of network members would speak against the introduction of a common CAD system, as well as against high investment costs and the necessary training period.

There are also doubts about data protection. Particularly the site manager fears the necessary opening of his local computer network. The manager has second thoughts about becoming victim of espionage (insight into preliminary appraisals, competitor's bids) or even manipulation and fraud. Therefore, he has asked an IT consultant to configure his firewall computer so that only Email-exchange is possible.

LACK OF AWARENESS OF THE COOPERATION PROCESS

In the process of socially stabilized cooperation, the individuals within the cooperation ensure an acceptable scope (Meyer-Faje, 1999) which make mutual looking after interests possible (Kensing, 1987). Such recursive processes (for instance the constitution and further development of "rules") can only develop in networks which are transparent to the members. The possibility of making decisions and revising them autonomously represents a „closing of the social environment“ (Floyd, 1989) necessary to encourage self-confidential learning. A lack of participation, in contrast, makes the perception of the social interaction to look unstable and amorphous.

Since the cooperation between different engineering firms requires a sensitivity for data and quality management from all employees, the de- and re-contextualization of expertise needs to be ensured (Ackerman et al., 1998). Optimistic managers, therefore, are looking for brilliant tools, highly adapted to their demands and yet open to future changes, while pessimistic ones concentrate their efforts to muddle through while minimizing the consequences of the most important goofs. A more promising alternative seems to be, however, to increase the flexibility of the organizational units involved in the cooperation network and thus its ability to

respond to changing demands by making the units process-near and by giving them feedback information about their work.

Project teams can structure the entire context of their work from the beginning and gather important experience for the offices' work. Yet, in the given engineering network in the building industry, even if employees expedite isolated work processes through the use of telephone or file transfer, the network is still not based on such tele-cooperation but on the decision monopoly of the face-to-face meetings of managers, the engineers remaining their attachments. Process knowledge, for the employees, remains limited and strange. For example, one engineer is able to calculate the amount of work remaining – but he can not calculate the end of his project work, because he does not know about the planning process outside his engineering firm.

At the same time, this monopolizing of coordination leads to chronic overtaxing of managers. The example of one manager, who invested approximately one fourth of his entire work time into the planning coordination of just this one bank project, demonstrates the capacity restraints of decision monopolization. This is a further reason why managers will usually not reflect upon possibilities for improvement of work processes. The lack of awareness for the cooperation as a whole lets decision concentration on the project meetings seem to be the optimum even if contrary facts exist. Alternatives are not even looked upon.

Within our investigations we could not find organizational development based on systematic evaluation in any firm. Given the predominate decision monopoly only the managers could have achieved this, and they are already under too great strain. From the managers' point of view introducing tele-cooperation would demand for an additional effort which they do not feel up to because of the great strain already existing and the lack of technical know-how. Furthermore they fear a loss of decision power if tele-cooperation proves to be a success.

Besides this, the managers' insisting upon their decision monopoly has to do with their protection of their own firm's interests in project meetings as well as their wish to cultivate the firm's business contacts and ensure the quality of the company planning. In addition, clients call for the manager to be present, as they want to have a responsible contact person. Protection of interests, cultivation of business contacts, evaluation and quality securing as well as responsible contact persons are important functions of an engineering firm, yet they are not arguments in favor for manager decision monopoly. On the contrary, precisely because these functions are so important, they should not be settled alongside by a manager who is already structurally overtaxed. Instead, they could be solved together in decentralized teamwork.

However, due to the lack of systematic evaluation and organizational development, the small engineering firms assume the inefficiencies of cooperation to be a given fact making investment in this field look like only a further expenditure. The engineers' remaining unawareness of the planning process corresponds with their managers' unawareness of their employees' potential competence of self-organizing work. Thus, for the managers, their monopolization of process knowledge provokes a hetero-stereotype of their employees as being unable to self-organize their work.

CONCLUSION

Building projects usually change largely in the course of time. Effective handling thus calls for a flexible adaptation of work efforts according to such changes. Small engineering firms believe to have only limited ability to implement such adaptations. It is not that the general result and flexibility is not looked after at all. But the attempt to optimize synchronizing and evaluation stabilizes the monopolization of information. Thus only a sub-optimum is achieved compared to the possibilities modern quality management offers. Remaining the sum of given parts and unable to determine its components according to changing process requirements, the engineering networks cannot develop as a virtual enterprise.

The lack of self-control implies that the systems of interaction remain statically and refuse restructuring. The reason is that inter-organizational cooperation in the building industry is not organized in the form of integrated networking teams, but by regular meetings of the managers. Cooperation is not tele-cooperation, but the working-off of individual orders of the managers, this is: a summing up of separate contributions of the firms. The managers centralize all project decisions to prevent and reduce important errors. This means that the cooperation process is widely intransparent for the individual engineer, who remains dependent upon the orders of his manager.

However, if engineering firms could breach the mentioned impediments and combine the introduction of modern tele-cooperation tools with a systematical organizational development, they would gain access to promising virtual enterprises' marketing elements. However, this would, first of all, require the direct participation of the people involved in the planning process. Today, it is not the resources of the small engineering firms, but the employees' limited awareness of the cooperation process itself which hinders promising organizational development. This lack of awareness has much to do with their managers' information monopoly.

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