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Improving Inter-Organizational Processes with Integrated Organization and Technology Development

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Abstract: The goal of the ORGTECH-project is to improve the cooperation between two engineering offices on the one hand, and a major German steel mill, on the other. An integrated change process has been initiated which combines the introduction of a groupware application with methods of organization development. This change process draws on the framework of Integrated Organization and Technology Development which is presented first. Then we

describe its application in the ORGTECH project. The results of the first project phase are presented and discussed.

Keywords: Groupware, Organization and Technology Development, Tailoring, Requirements Analysis, Concurrent Engineering.

1 Introduction

The introduction of groupware and multimedia applications into organizations holds a lot of promises for improvements [Lloyd (1996)]. Nevertheless, in many cases the full benefits of these technologies can only be realized if their introduction goes along with a change of the underlying business processes [Ciborra (1996), Orlikowski (1996)]. Therefore, an integrated approach is required which combines technological and organizational change [Wulf (1997)]. The framework of Integrated Organizational and Technology Development (OTD) is a participative and evolutionary approach to support changes of work systems. Within this framework instruments of organization development, work psychological guidelines, approaches of software development and tailoring in use are applied in an integrated fashion. It was originally developed to guide change processes within a single company [Wulf and Rohde (1995)]. In the following we will show how this framework is applied within the ORGTECH project where inter-organizational work processes have been supposed to be improved.

ORGTECH (*Organizational and Technical Development in the Context of the Introduction of a Tele-cooperation System in Small and Medium-Sized Engineering Companies*) aims at supporting the cooperative work processes within and between two engineering firms and a steel mill as one of their customers. The two engineering firms take on subcontractual work for a large steel mill in the German Ruhr area, e.g. the construction and documentation of steel furnace components. A construction department inside the steel mill coordinates the construction and documentation, and manages the contacts with external offices at the steel mill. The external offices, however, complain about the specification of the construction orders being vague and due to this several meetings will have to take place before the project is over. The difficulty to gather the documentational data about the actual state of the plants is another problem. This has to do with the way the sketch archive of the steel mill is run. This situation often causes inconsistencies in the final design of steel mill components. This problem is seemingly caused by the huge number of sketches and the organization of the electronic archive, by the complexity of the construction development process, and by communication problems among the engineers and their clients [Iaccuci et al. (1998)]. Besides, the work planning (work preparation) and the production department of the steel mill are not involved in the construction process which often leads to problems during the production process. Given this initial problem description, our key questions are:

- How can the underlying work processes be changed?
- How is the role to be determined which information and communication technology can play within this change process?
- Which applications should be chosen?
- What would be the best way to introduce these applications into the different organizations?

In the following we will describe and discuss our experiences so far. Our approach is based on the OTD framework. First we will describe its roots, explaining its components and how they are integrated into one process. In [chapter 3] the application of this framework within the ORGTECH project is described. In [chapter 4 and 5] we describe the measure taken so far. The paper concludes with a discussion of the findings. The outcomes of the first steps of the project ORGTECH are analyzed and the overall methodology is evaluated.

While this paper focuses on the steel mill / subcontractor scenario with all its specifics, the application base of the ORGTECH project actually comprises a number of other engineering companies (with other customers). Our experience shows that the characteristics exhibited by the scenario discussed here are widely reflected in these other fields of application. Furthermore, we have presented the scenario during a project transfer workshop to an even wider audience and their affirmative responses indicate the relevance of our findings for their respective domains.

2 Integrated Organizational and Technology Development

The integrated organization and technology development (OTD) process is characterized by a parallel development of workplace, organizational and technical systems, the management of (existing) conflicts by discursive and negotiative means, and on immediate participation of the organization members affected. Such a change process is thought to be an ongoing one [Hartmann (1994), Wulf and Rohde (1995)]. The next paragraph introduces the four components of OTD:

- organization development,
- work psychological analysis,
- evolutionary models of software development,
- tailoring in use.

The approach was developed in the context of the POLITeam project where groupware was introduced into single organizations [Wulf (1997); Cremers et al. (1998)]. While the premises of the OTD framework are applicable to other technology-related change processes, it takes the specifics of software technology into account. Due to their immaterial nature, these applications offer a high degree of technical flexibility. Groupware applications are typically very intervinded with the applying organizations.

2.1 Components of the OTD Approach

Organization development can be understood as a initiated and continuously enabled, long-term, organization-wide process of change in the behavior, attitudes and abilities of its members as well as its structures and its processes.

The organizational development process can be characterized by four steps: diagnosis, intervention planning, application of interventions and evaluation. Within this process, methods and instruments of applied social science such as theory of personality, social psychology, group dynamics and organization theory are applied [Huse (1980)]. Moreover, [Pieper (1988)] has proposed to modify traditional approaches of organization development towards a discursive one which offers a wide extend of participation to all members of an organization. Organization development approaches alone do not offer adequate criteria for the evaluation of their results.

To evaluate whether certain work systems are human centered and effective, **work psychological research** seems to be very useful. The *Handlungsregulationstheorie* [action regulation theory; Hacker (1986)] offers a theoretical foundation of several evaluation criteria for human-centered work systems. The theory focuses on psychological aspects of sensomotorical, cognitive, intellectual, and psychological regulation of human work [Hacker (1986), 73ff and activity theory by

Leontjew (1974)]. The *completeness* or *wholeness* of tasks are structured in: preparation of actions, planning of superposed and partial goals, organization of actions, coordination with actions of colleagues, control of action, and feedback about the results [Ulich (1991), Hacker (1987)]. On the basis of this theoretical approach four work psychological criteria of task analysis and job evaluation are derived: the *possibility to perform the task* (Ausführbarkeit), the *harmlessness* (Schädigungslosigkeit), the *avoidance of impairments or interferences* (Beeinträchtigungsfreiheit), and the *promotion for development of personality including social skills and capabilities* (Persönlichkeitsförderlichkeit) [Ulich (1991)]. Concerning single workplaces, we propose to apply these work psychological evaluation instruments (several procedures are available which are grounded on these findings) within organizational restructuring processes especially in the phases of analysis and evaluation of the work system.

Organization development and work psychological analysis take software as a given artifact, which is stable after its production. This perspective was dominating software-engineering for a long time too. Contrary to traditional approaches to software-engineering the STEPS-method of Floyd offers an evolutionary and participative framework which seems to be well adapted to develop software for organizational environments which can be described according to the paradigm of self-organization [Floyd et al. (1989); Floyd (1994)]. In order to keep pace with environmental changes it assigns an iterative development process establishing a system's revision as soon as the functions do not match anymore with the requirements of the users.

Evolutionary and participative software development has to be supplemented by activities performed by end users or local experts of the application environment [Wulf (1994); Stiemerling et al. (1997)]. Approaches of end users' modification of a system have been discussed under different labels [Trigg et al. (1987); Fischer (1990); Henderson (1991); Nardi (1993)]. We want to sum up these activities under the label of *tailoring*. Contrary to the development of a new system version the existing version is adapted by end users or local experts. **Tailoring** allows for adaptation just as far as these needs have been anticipated during system design. If there are requirements for adaptation which have not been anticipated, it is necessary to redesign the system. Therefore the activity of tailoring can become part of an evolutionary approach to software development and usage as it is described in the STEPS-model. As long as users' needs and environmental requirements can be handled locally during usage, there is no need to establish a revision of the system. So tailoring can play an important role in enabling an organization to react to a changing environment [Wulf (1994)].

2.2 Integration towards a holistic approach

In the following we show how the approaches discussed so far are integrated into an evolutionary and participative process model of integrated organization and technology development. First, we will give a short description of the single phases of the OTD process. These phases do not necessarily have to be in consecutive order [Wulf (1995)]:

Establishing the process – A process of integrated organization and technology development starts with the perception of a problem. As a next step the discussion of the members of an organization, who are affected by the problem, must be fostered. They should find out whether there is a need for an integrated process of change.

Analysis of the actual state – First, the actual state has to be analyzed with respect to organizational structure, technology and qualification. The results of this analysis have to be discussed Such a discussion can be prepared by change agents using open interviews or different work psychological instruments for task and work analysis such as the methods mentioned before.

Creation of alternative options – Having clarified the actual state with its problems, it seems important to generate alternative approaches to its solution (organization, technology or qualification measures). The members of the organization should discuss these alternatives and find a solution agreeable to everyone. To judge the human centered potential of the different options, they should be evaluated with work psychologicalmethods.

Planning of interventions – After choosing a development option the members of the organizational unit have to decide on interventions in organizational, technological, and qualificatory dimensions. If in the context of the technological dimension software has to be (re)implemented, the establishment of the software development project takes place in this phase.

Interventions – Interventions derived from organization development play an important role within the wider process of integrated organization and technology development. Their main issue is the change of formal and informal aspects of an organization. Concerning the structures and processes of an organization, decentralization and new forms of labor division may have to be introduced. Software will have to be (re-)designed or tailored.

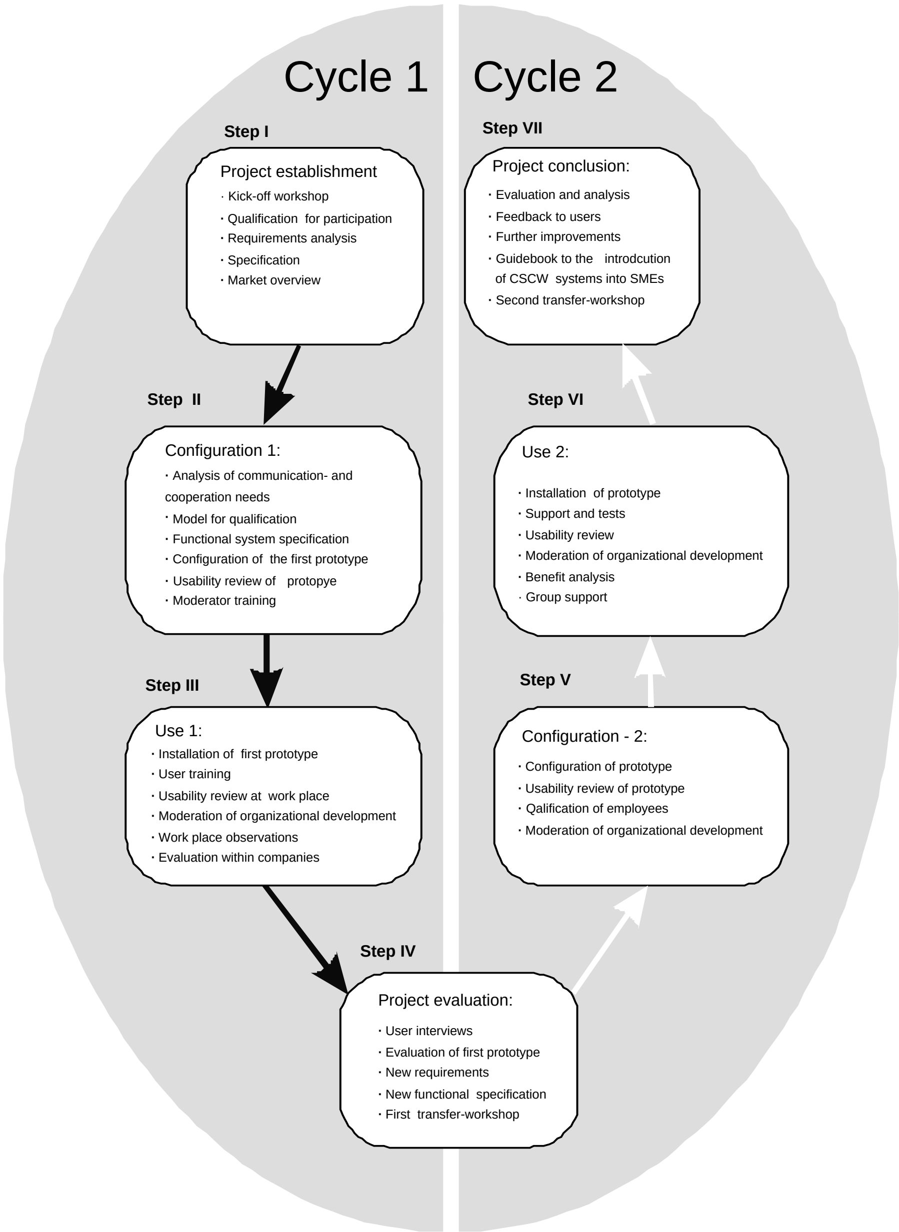

Figure 1: Model for the OrgTech project

Within the process of integrated organization and technology development two different *requirements for qualification* have to be considered: special professional qualifications and social competences as preconditions for participation. Task specific knowledge of organizations' members has to be up-to-date if organizational development leads to new task profiles for individuals or if the introduction of new technologies requires new skills.

Qualification for participation **–** Furthermore, the individuals involved in organization and technology development must be enabled to participate in the process adequately. Therefore, the social competences of the participants have to be promoted. Social competencies in this context are communicative and cooperative abilities for an involvement in discursive development

3 OTD Applied to the ORGTECH Project

In the following we describe the application of the OTD framework in the ORGTECH project which deals with the improvement of a distributed engineering process in the two small engineering firms, we call them here TECHNO and DOKU and one of their major customers the steel mill called MELTIT [Stiemerling et al. (1998)]. The process model defined in the beginning of the project is shown in figure 1.

After the ***project establishment*** (step 1) the process mainly comprises two equivalent cycles which give the project staff the opportunity to evaluate after 1.5 years (the whole project lasts 3 years) and use experiences from the first phase as basis for the second. Each phase consists of an analysis of the current situation in the field of application, the configuration and tailoring of the technical system and - in parallel -the organization development and the qualification of the employees involved. In this model the phases outlined in the previous paragraph are deployed in a form, which is project specific.

During the ***analysis of the actual state*** the current communication and cooperation structures within and between the organizations are analyzed with interviews, observations, and work psychological instruments. Based on these findings ***alternative options*** for cooperation are created participatively in workshops. To support the discussions about alternatives and to encourage the participants we use standard components and early prototypes of the communication system. Also, a qualification program which is aimed to improve the social and communicative competencies of the users involved, is introduced. It is supposed to enable the users to participate adequately in the process. Besides they are trained to moderate discussions and problem solving processes by themselves.

This ***qualification for participation***, will be applied continuously by change agents during the project's phases. We have applied a concept by [Sell (1994)] who proposes an approach to qualify for participation which is directed to analytical, synthetic, and dialectical abilities for problem solving and conflict management. These abilities are practiced by using methods as group discussions, group training, practice of communicational methods, and theme-centered interaction.

The ***planning of interventions*** will consider technological, organizational and qualificatorical aspects. The functions will be specified and implemented, a new concept for cooperation in project structures and task groups will be developed, and a concept for qualification of the users involved will be worked out. In the phase of ***intervention*** there will be an installation of groupware and multimedia systems, a restructuring of division of labor within and among the organizations, an establishment of project groups and a coaching and nurturing of users will take place.

After these modifications the work system will be evaluated by the users in the different organizations. Change agents will collect additional data with methods of observation and user interviews. The data is analyzed and discussed with users involved on the basis of work psychological analysis.

We do not expect that the first development cycle will lead to satisfactory results, and so another iteration of this development process is anticipated. The iteration offers potential playground for evolutionary and participative software development and tailoring in use, all of which has been explained in the previous paragraph. So, based on the data analysis in the discussion with the users, different options for further development will be created. The technological and organizational requirements will be defined, organization and technology development will be oriented again to the changed conditions and problems of cooperation, and the users involved will be qualified for the usage of the redesigned groupware and multimedia systems and trained to perform further development activities by themselves without external change agents. The second phase of the OTD process ends with another re-evaluation of the integrated socio-technical work system and the feedback of the results to the users involved. At this point the members of the organizations should be able to continue the process by themselves, to perform workshops for further qualification, problem solving and conflict handling, to tailor the shared communication system according to their needs, and to restructure task groups, if necessary. Thus, the OTD process is supposed to continue without the involvement of external change agents.

4 The ORGTECH Project at Work

Let us now have a look at the first steps taken in the ORGTECH project.

4.1 The kick-off workshop

The kick-off workshop was intended to give us an idea of the existing work processes inside MELTIT and between the steel mill and the engineering offices. Furthermore, we wanted to introduce ourselves to the project-partners and give them an idea what the ORGTECH project could mean and what services we can provide. From MELTIT there were seven employees and middle managers of various technique-oriented departments present, from each engineering office, the boss and one employee participated. After a short introduction into the institutional background of ORGTECH, we handed out cards to each participant of the workshop. We asked them to note down problems concerning their actual collaboration and suggestions for improvement. Then we discussed the concerns written on the cards.

We discovered three main groups of problems: organization and information, technology and qualification. For the engineering offices two big organizational problems were the missing of detailed terms and easy ways to interchange information between them and MELTIT. Furthermore, the workshops showed lots of technical problems and the participants also had many suggestions for technical improvements. Quite a few cards mentioned problems with the construction data base of MELTIT and suggested an easier access to it for the engineering offices and a better organization of the data. Many participants wanted to use 3-D construction tools, but they had not found any suitable ones so far, and, again, they had no clue how to share the resulting data and how to archivate it. Other cards dealt with CAD-CAM integration and the problems resulting from the rapid development of exchange formats. Under the topic "qualification" the biggest number of cards dealt with special knowledge new employees had to gain in order to be able to work efficiently. Another problem concerned the acceptance of new design methods. The mode the engineering offices were paid by the steel mill was mentioned as a further problem when introducing 3D technology. It became clear that it is not easy to define the value of creative work like a construction, thus it is not easy to find a fair mode to pay the work done. Right now the offices are mainly being paid according to the amount of written lines in the 2D sketches produced.

At the end of the workshop, we gave a broad overview, of what the project is capable of offering to overcome some of the problems. Besides, we used the results of the workshop to develop the interview methodology described in the next chapter.

4.2 The interviews

The objective of the interviews was not only the analysis of the needs and requirement specification. The discussions with managers and employees helped us to gather important information about social and political issues inside and between the organizations. This brought us to understand the political obstacles that we possible were to encounter when proposing or discussing our suggestions.

Based on the results of the kick-off workshop we created a semi-structured questionnaire, covering the following topics: task of the interviewee, communication and cooperation problems, information and communication infrastructure, data and archive management, CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing), 3D-CAD, and teamwork.

The interviews lasted from 70 to 120 minutes and were held at the workplaces of the interviewees. They often involved quite a number of demonstrations of the systems in use. The demonstrations were essential to discern improvement potential. In the following, we will present the results of the interviews of each organization.

4.2.1 The point of view of MELTIT

Only a few departments of the huge steel mill organization are relevant for the project. We interviewed the managers and employees of the following departments:

- construction: manages the outsourcing of construction design,
- production planning: receives sketches from construction department and plans production,
- mechanical workshop: produces mechanical pieces, tubes etc. to maintain the mill,
- systems and methods department: also managing the electronic archive of the sketches used by all departments.

The construction department manages the maintenance of the different production facilities. If an operator of a production facility requires a repair service or a new part, the construction department is contacted. That department decides who will carry out the design and sketch and coordinates that process. Nevertheless, the final decision whether the object being designed will be produced in the company's workshop or by an external supplier is taken by another department.

A typical task of the construction department is to supply the external engineering offices with documentation and sketches, and discuss the design with them. From the commission of the order until the final acceptance , the external engineer may meet quite frequently with the construction department. Sometimes an on-the-spot visit is needed or a discussion with the operator, but most of the meetings have the sketches of the external office as point of interest. On the basis of seven on-site interviews we were able to reproduce the typical development of a construction order from the point of view of the different actors of the steel mill (Figure 2).

The information infrastructure allows all departments mentioned and all operators to access the central electronic archive of more then 100,000 sketches. The archive system allows for searching, viewing and ordering of sketches. The system allows multiple users to simultaneously view the same sketch in read only mode. An employee from the construction department and one from the production planning department said that they used this viewing functionality to discuss design or manufacturing problems over the telephone. Such an improvised solution of *computer supported cooperative work* has been tested by those employees, who were very interested in such a new technology. This attempt was seen as a clear demonstration of how application sharing or whiteboards would improve communication within MELTIT or between the construction department and the external offices.

In general, employees and managers were doubtful at first, being concerned about potential benefits of groupware application in their daily work. The arguments against the application of new technologies for collaborative work were the following:

- real face to face is necessary to discuss problems,
- normally not just one but several sketches are of interest,
- some of the meetings involve more than two people.

Another relevant problem area of the steel mill is the archive system of the sketches. The system presents only the latest version of each sketch. If anything is altered then saved, it is no longer possible to obtain the older version of the sketches for the remaining parts of the same type. Besides, the key number that allows for

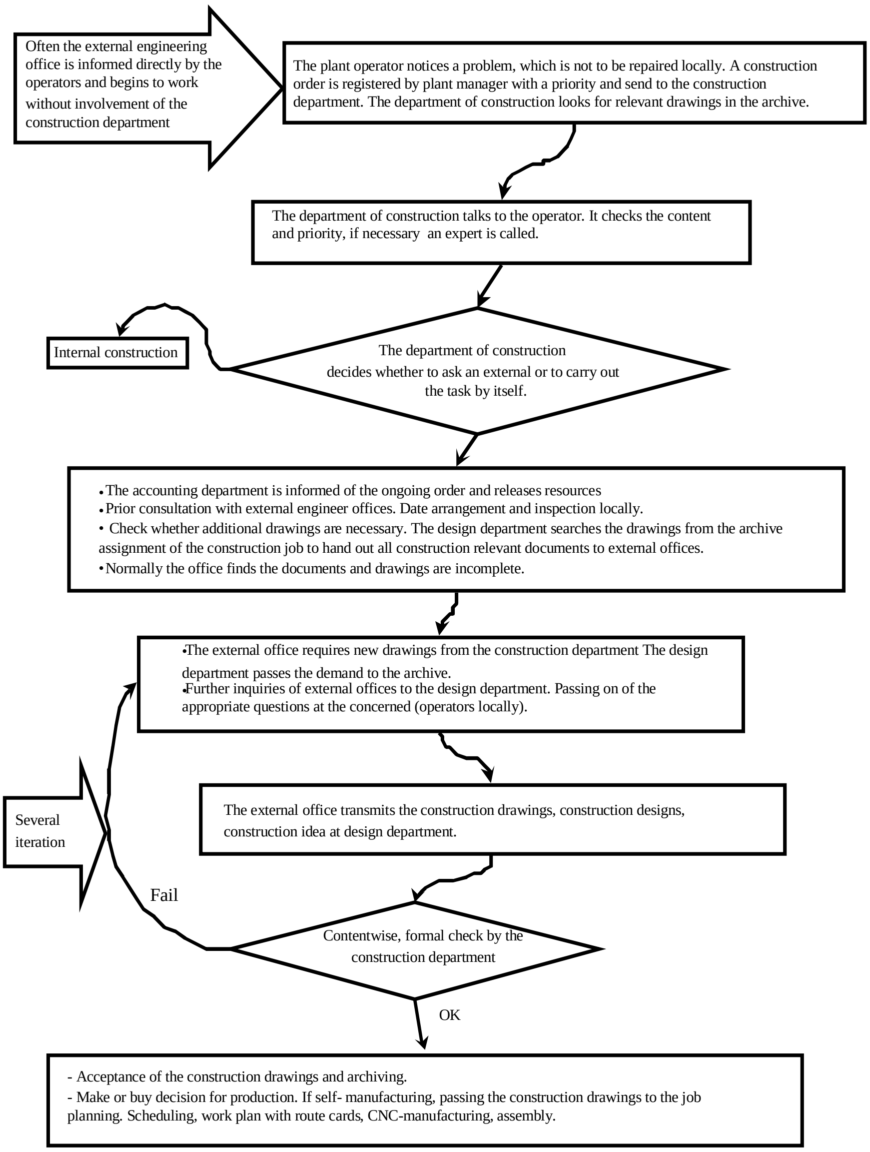

Figure 2: Typical process when constructing

searching the electronic archive is too unspecific. This causes difficult search efforts.

The production planning department complained that often the sketches are not ready for the workshop and that considerable alterations have to be made before the sketches can be used as a base for CNC programming. In general, they felt that they did not have a possibility of sufficient participation in the construction process. This causes additional efforts during the production phase. Three dimensional CAD is not used in production planning at the moment. It would be, in the opinion of a technician of this department, useful for three reasons:

- to communicate better with the workshop since the workers sometimes have problems reading 2D sketches,
- to improve the quality of the construction design by eliminating errors,
- to automatically create lists of the parts.

4.2.2 The point of view of the engineering office TECHNO

The engineering office TECHNO offers services for planning, execution, change, or capacity increase of conveying systems in heavy industry. TECHNO possesses various patents in this area. The office employs about a dozen engineers. The manager had founded the office about 10 years ago. AutoCAD 14 is applied on a Novell network with 12 CAD workstations. One of the workstations has an ISDN connection and is used to exchange files with the steel mill.

The typical design project (compare figure 3) requires first of all to get the sketches and documentation on the actual state. This need for sketches and documentation remains during the whole order cycle. The sketches are normally ordered by fax from the construction department, and after the print out they are stapled at MELTIT to be collected by the engineers. Although normally every day someone from the office drives to MELTIT (about a 30 min drive away) and checks if there are sketches to be collected, the waiting time can be up to one week.

When a project is finished, the sketches are delivered to the steel mill on a disk in an AutoCAD file and in an image file, ready to be saved in the archive. This could be done by sending the files via ISDN, but at the construction department only one of the group leader has a PC which supports ISDN connections. Unfortunately, the recipient of the files is most of the time someone else.

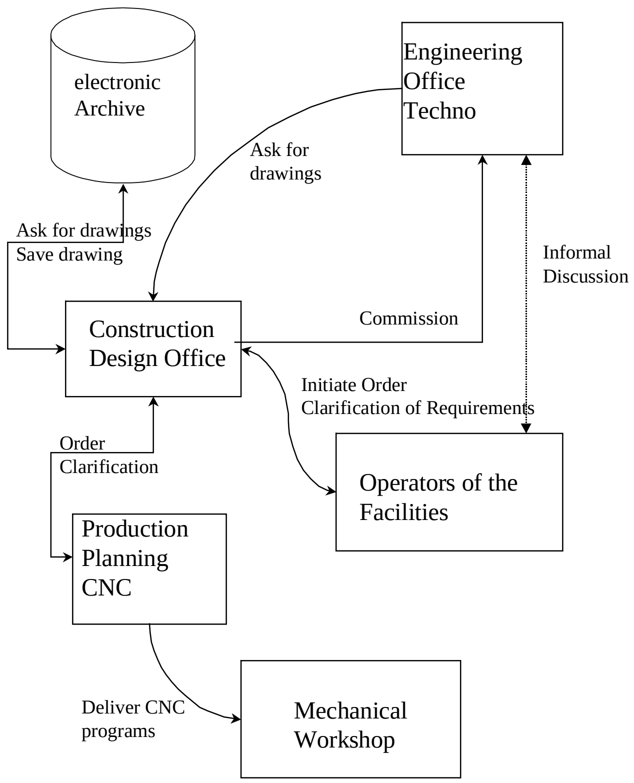

Figure 3: Information flow between TECHNO and the steel mill

The office has rather intense contacts with the construction department, and the engineers meet the plant's operator only on few occasions. They appreciate the high level of expertise of the construction department. Contrary to the plant operators they are technically able to value the prepared design.

Concerning future perspectives, both engineering offices would like to have permission to search and download sketches from the steel mill's archive via ISDN. On the other hand, MELTIT does not want to grant such a permission for obvious security reasons. Besides an engineer explained that he visits the steel mill every week There, sometimes a brief teleconference could be enough. He can also imagine discussing some of the problems with a shared viewer. The introduction of groupware technologies by TECHNO would be a long term strategic choice considering that the office has many foreign customers, as well. For instance, an engineer maintains contact with a steel mill in the USA, currently using e-mail and telephone, and he said that in this case groupware would have a greater potential.

The 3D design has been used but only for new constructions. The head of the office is skeptic about introducing the 3D CAD mainly due to the high costs and due to the maintenance construction a 3D model of the environment which would be required.

4.2.3 The point of view of the engineering office DOKU

The construction office DOKU offers planning and documentation within the area of pipe lines and plant construction In the sector "pipelines and plant construction" the construction office DOKU offers planning and documentation tasks). The office has a dozen employees and one manager who is also the owner. They have a network of 10 CAD workstations running AutoCAD 12 and 14. The office supplies the steel mill mostly with plant documentation. The documentation is necessary in case of failure or breakdown, but in the daily work the plant operator and the construction department of MELTIT have more important things to worry about. Thus, the work of the DOKU office is surveyed much less by the construction department. More frequently than in the case of TECHNO, DOKU has informal meetings with the operators and often starts the job before it is officially commissioned by the construction department. Compared to TECHNO, DOKU depends more on its tight relationship with the plant operators.

Like TECHNO, DOKU would like to search and download sketches directly via ISDN. Regarding the possibilities to apply videoconferencing one of the technicians explained that visiting the factory is necessary and that tele-cooperation would not improve the situation. This is due to the fact that most of his communication partners on the shop floor of the plant operators would probably not take the time to apply the new technology. To provide information for DOKU is not their main job but rather a service they provide due to personal contacts. Moreover, these people need quite some explanation to be able to understand the 2D sketches.

Three dimensional design is considered by the manager as a competitive advantage that could change his business. The employees also consider three dimensional design a useful technology, especially in documentation to facilitate the work of the plant operators in case of a breakdown If they had to locate the right pipe or valve fast.

4.3 Workshops introducing technological options

Having carried out and analyzed the interviews, we invited all the interviewees to the Fraunhofer Institute. During a one day workshop we presented different groupware applications and multimedia systems to five participants representing the three organizations. Based on the results of the interviews, we chose ten different applications which offered a potential to overcome the existing problems. Some of them were directly available for the project, while others were in the state of research prototypes, indicating future technological developments. In a first block, we presented a smartboard, a video conference with application sharing and whiteboard functionality, a workflow system, and an electronic calendar. In the following an application converting photogrammetric data into 3D models, a distributed 2D CAD application, a high-end 3D CAD application, a shared 3D viewer, a distributed 3D CAD application, and a 3D animation of a factory hall were presented.

Each of the presentations started by an introductory statement of the presenter referring to some of the existing problems. As the group was rather small, the participants were able to ask and get explanations instantly. The workshop ended with a round table where the potentials of the different applications were discussed. applications of those technologies, which were ready for usage, were introduced and discussed. The interest of the participants focused on the video-conference and different applications of 3D CAD. Moreover, the integration of these applications in the existing technological infrastructure and the investments necessary for hardware and software were discussed. For administrative reasons, one manager of the steel mill found it difficult to authorize these expenditures from his current budget. Nevertheless, the workshop resulted in a certain preselection of technological options towards video conferencing and 3D CAD applications.

4.4 Feedback Workshop

Shortly after the workshop on technological options, we had a second full day workshop in which nine members of the three organizations participated. The main goals for this workshop were:

- to present and feedback our understanding of the distributed engineering process,
- to develop a common perception of the existing problems,

- to find a common focus for the intervention phase of the project, and
- to establish joint work-groups to implement the interventions necessary.

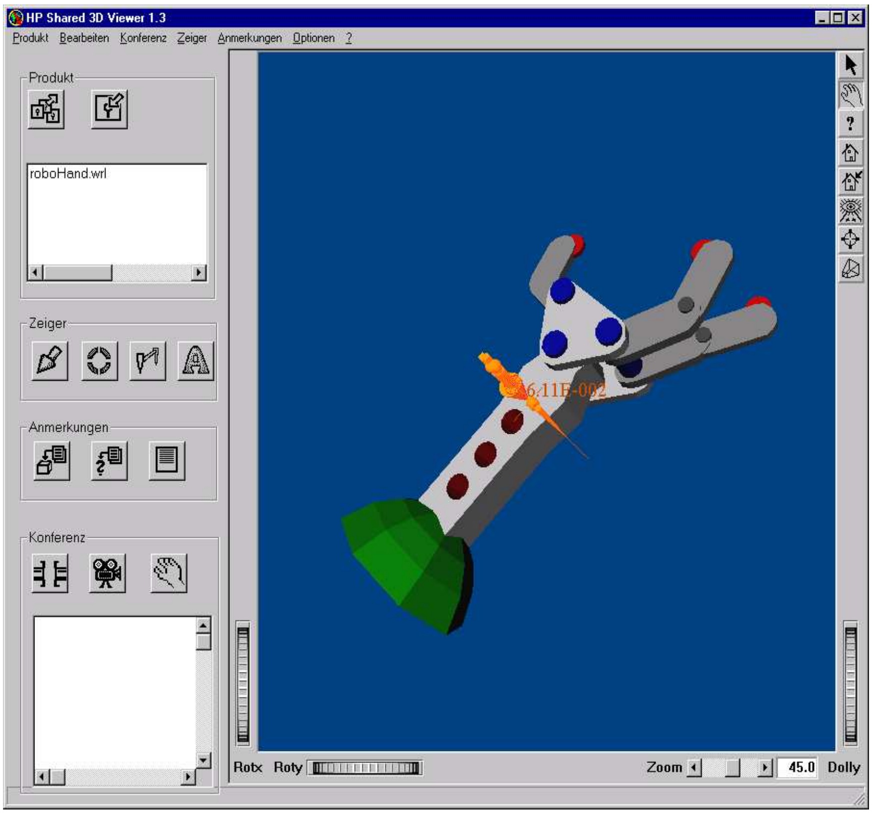

Figure 4: The 3D Viewer developed by the Fraunhofer Institute [Kress and Anderson 1996, Kress 1997]

The workshop started with presentations by two project members. Based on a graphic image similar to the one presented in figure 2 the different steps of the distributed engineering process were presented [chapter 4.2]. In the discussion following the presentation, some misunderstandings concerning certain details of the engineering process were clarified and missing information were collected. It became clear, for instance, that the operators of the plants decide whether an object which has already been constructed will be built. Thus, within the construction process it is not sure whether it makes sense to consider the particularities of the internal production department. Concerning the „appropriate“ mode to start a construction project and the role of the plant operators, the members of the three organizations expressed slightly different opinions without discussing these differences openly. The head of the DOKU office pointed out the importance of the plant operators in this process several times, because they have final budgeting authority.

In the following a project member gave a presentation summing up the problems faced with in the interviews. This list of about 20 problems covered the following aspects of the engineering process:

- the cooperation of the plant operators with the internal and external construction units,
- the cooperation between the internal and the external construction units,
- the access to the sketch archive,
- the cooperation of the internal and external construction units with the internal production-planning and production department.

Most of the problems presented were commented extensively by the participants from the different organizations. Some of them had to be rephrased due to the results of the discussion. Nevertheless, the discussion resulted in a rather homogeneous perception of the existing problems.

For those who did not participate in the previous workshop, one of the managers from the steel mill gave a survey on the system presentation and summarized the results of the final discussion round. Especially concerning the relevance of 3D CAD different opinions were expressed. While the founder of DOKU regards it as a strategic choice for his office, the head of TECHNO pointed to the lacking 3D model of the steel mill. That made it very expensive to apply 3D on a broader scale. An agreement could not be reached during the workshop.

Finally, we agreed on a project structure to guide the upcoming phase of interventions. The project team had suggested to implement four parallel task groups dealing with the following topics: 3D-CAD, synchronous tele-cooperation, conventions for the storage of sketches, and production-oriented construction. These task groups should have been coordinated by plenary workshops taking place every two months. Due to capacity restriction especially on the side of the steel mill, we decided to deal with the second and the third (group A) and the first and the fourth topic (group B) jointly within one task group. The task groups were asked to develop a concept on how to improve their aspect of the distributed engineering process and test it out during their daily work routine.

4.5 The task groups in practice

Each of the task groups consisted of five to seven members all three organizations being. Some participants took part in both groups. Contrary to the plenary workshops, the heads of the offices and members of MELTIT´s middle management did not participate in the task groups. Both task groups were moderated by project members who also provided a variety of services for the groups (e.g. facilitating the discussion, protocolling, information gathering).

4.5.1 Task group A: Synchronous tele-cooperation and conventions for the storage of sketches

Since we had assumed that the usage of video-conferencing and application sharing systems would affect the mode in which sketches were stored and accessed, task group A decided to allow for synchronous tele-cooperation first. Having carried out a market survey, NETMEETING by Microsoft [Microsoft (1998)]was chosen to be introduced. It provides video-conferencing, application sharing, whiteboard, and file transfer functionality. And as the software is free, the organizations just had to spend money for the audio/video equipment of the PCs. Concerning the network infrastructure the task group had to decide whether a RAS (Remote Access Service) or an Internet-based solution should be realized. At the moment of decision none of the organizations was equipped with firewall technology, so the Internet-based solution seemed to be too insecure. Thus, the NETMEETING applications were connected via RAS servers and ISDN lines.

Actually six NetMeeting applications are installed at workspaces in the construction and production planning department of the steel mill, one centrally in the DOKU office, and two at the workplaces engineers in the TECHNO office. To reduce initial investment some of MELTIT´s workspaces are not equipped with audio/video hardware. They use the telephone to discuss shared sketches. Figure 5 depicts the actual installation (a/v means full audio/video equipment). The new communication structure was to be used in 3D-CAD and production-oriented construction projects.

Task group B decided to tackle both of its foci in parallel. Concerning the 3D

CAD the project members carried out a market survey and provided the information for the three organizations. The construction department of MELTIT decided to introduce Mechanical Desktop - a 3D package, based on AutoCAD. It allows to parameterize the design components. While TECHNO followed this decision, DOKU made its own additional inquiries and decided to introduce Plant-4D – a 3D application which supports the planning and animation of production facilities. To gain experiences with the new applications three of the current construction projects were selected by the group to try out the 3D applications.

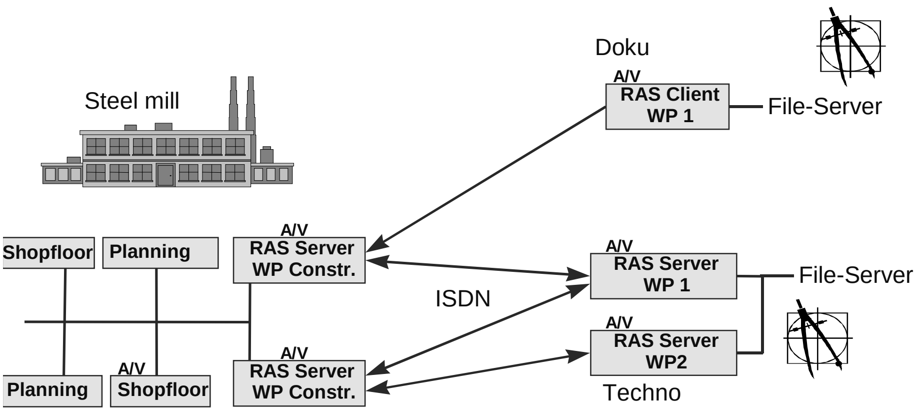

Figure 5: Communication infrastructure

4.5.2 Task group B: 3D-CAD and production-oriented construction

In these projects the communication between the external engineers and the production and production planning department should be established, as well. To encourage mutual understanding the TECHNO engineers visited MELTIT´s production planning and production department. MELTIT was not informed about the visit beforehand. Even though production-oriented construction requires additional efforts on the side of TECHNO, its engineers wanted to proceed, because they thought that would improve the quality of their design. They especially appreciated the video-conference and application sharing tools, because these would reduce the communication effort considerably. On the other hand, one of MELTIT´s CNC programmers said that he would use the video-conference to directly contact TECHNO in case problems occurred on how to use one of their sketches currently worked on.

5 Discussion

In the following we will discuss the experiences gained when improving distributed engineering processes by introducing groupware and multimedia applications in an integrated manner.

5.1 Improving interorganizational engineering processes …

The ORGTECH experience indicates that different actors in interorganizational engineering processes have very individual perspectives on how to define the relevant business processes and how to define quality measures. For instance, from the perspective of the external engineering offices their business process finished when delivering the final sketches. Thus, there was little awareness concerning the production processes and their specific requirements. Moreover, it was unclear to the external offices which ones were the relevant quality measures for their services, because the competencies in the steel mill were unclear. For instance, concerning the layout of the final sketches the construction department focused on DIN and company standards while the plant operators focused on understandability. These differences in perspective have to be understood and tackled when trying to improve inter-organizational business processes.

Beyond different perspectives on the business processes, we have to deal with different long-term company strategies. Different strategies may even lead to the introduction of incompatible technical applications which endanger cooperation. For instance, the head of the DOKU office decided to introduce a widely incompatible 3D application, because he believed that its functionality would open new markets for other companies. A similar problem arises concerning security standards for video-conferencing. Right now MELTIT's central IT division builds up a firewall system to link their local network to the Internet. Our approach of RAS-based ISDN-connections is somewhat contrary to their centralized approach. Nevertheless, Internet-based video-conferencing will require additional security efforts on the side of the engineering offices.

Improving interorganizational business processes, we have to keep the underlying power structures in mind. For both engineering offices, MELTIT is a major client. Concerning the ORGTECH project, MELTIT was able to define the relevant business processes, and thus, influenced the project's goals considerably. While acknowledging the given power structure, facilitators in change processes need to balance their impact on operative decision-making to avoid suboptimal solutions. For instance, being confronted with the incompatible 3D CAD decisions of MELTIT and DOKU and an angry reaction of MELTIT's construction department, we still tried to initiate a discussion on the advantages of each of the two systems.

5.2 … by means of Integrated Organization and Technology Development

Regarding integration, participation and evolution as the main characteristics of an OTD process [chapter 2], they have proven valuable within the ORGTECH project. An integrated approach is required to draw on the interdependencies of organizational and technological change. On the one hand the change in the construction processes, which require the external engineers to discuss their designs more in depth, asked for technical support to overcome spatial barriers. On the other hand, the new communication infrastructure is impacting the construction process already in unpredicted ways. We did not apply instruments of industrial psychology yet. To analyze the given problems in cooperation, we preferred to apply semi-structured interviews because they provided us with a broader picture of the actual work process. Due to capacity restrictions of the application partners – especially in the engineering offices we did not apply these instruments additionally. Nevertheless, they are still an option for the project evaluation phase.

The participation of the employees in the different organizations proved to be invaluable. Without the detailed knowledge of their daily work routine the analysis of the actual state of cooperation could not have reached sufficient depth. The employees' participation in the selection of different technological options and in the planning and implementation of the interventions secured a high level of motivation. Nevertheless, the participation of the employees in the improvement project takes considerable time resources. This causes problems - especially for the smaller engineering offices. Therefore, the project team provided quite a lot of help to the task groups. We had to reduce the speed of the project and became selective with the measures applied. Moreover, up to now we were not able to integrate MELTIT´s plant operators into the project. This is mainly due to inner-organizational rivalry between different departments of the steel mill in the context of a broader reorganization. Thus, an important part of the overall engineering process did not yet get actively involved.

Being still in the first part of the project, evolutionary development of the software and of the organizational interventions did not yet occur. Nevertheless, the usage of the video-conferencing application has led already to some requirements which will be implemented via the application programming interface (API).

While the basics of the OTD framework seem to be sound, the anticipated process model (see figure 1) needs ongoing revision. We had to change the temporal order of certain measures and abandon or redesign others. The market overview, for example, was carried out just after the feedback workshop, because the focus of the task groups had not been well defined before that. Moreover, we have not yet carried out any qualification for participation measures, since the participants involved so far were fully able to articulate their interests during workshops and interviews. The qualification concerning the new computer applications was not provided within a workshop, but by supporting the individual users at their workplaces, via a telephone hotline and by handing out written documentation. Thus, the project had to adapt itself in an evolutionary way.

6 Conclusions

Even though this paper has a look at just one specific case study, we believe to have presented a scenario which is representative for many interorganizational engineering processes and – to a certain degree – also for other cases which concern the outsourcing of non-core activities. Any organization deciding to go this route faces two primary problems:

- How to define “outsourcable” activities with enough sharpness in order to precisely specify the interfaces between the outside organizations and the relevant groups on the inside. Part of these interfaces are, for instance, measures of performance which are exact enough to serve as basis for legally binding cooperation agreements.

- How to integrate the outside organizations into the overall business process. This problem not only concerns “official” communication with entities on the inside, but also the support of informal exchanges, perhaps not anticipated by the management.

At the beginning of the ORGTECH project the first problem had already been addressed and the main point of the project initially was the participatory design of a computer-based tele-cooperation system to address massive difficulties with the second problem. However, the two questions could not be completely separated, because, for instance, the introduction of the 3D technology created problems in putting a price on the engineering efforts of the outside firms. This clearly shows the intervening of technological and organizational change and the need to take both into account.

While the technological solutions designed in the ORGTECH project can only be applied within the rather narrow focus of outsourcing engineering work, the organizational questions raised and addressed within the project and the general process model have a far wider applicability.

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