VIRTUAL ENGINEERING TEAMS: STRATEGY AND IMPLEMENTATION

Line L.[1] and Syvertsen T.G.[2]

ABSTRACT: A medium-sized and distributed (16 regional offices) Norwegian engineering company (ASPLAN-VIAK) has started a transformation to exploit information and communication technology as a potential for organising knowledge work in new modes. The effort does not only challenge technology, but also organisational systems and social constructs. The paper provides a philosophical, technological and social context for a full-scale experiment, and also summarizes some experiences.

KEYWORDS: Virtual Engineering Teams, Knowledge Work, Coordination

1. INTRODUCTION

It is commonly believed that technological developments will provide a digital environment for collaboration in virtual groups, leading to new ways of conducting projects. However, current solutions are still relatively complex, inflexible, unintelligent and support only low bandwidth communication. Despite its shortcomings, commercially feasible technology offers a lot of functionality.

For companies which regard virtual groups as a means of value creation, there is no reason to wait for the advent of more sophisticated tools and technology. Personal computers, local and wide area network technology are more than adequate to support considerable virtual teamwork. (Netscape Communications has recently released Navigator 3.0, which includes audio and whiteboarding as standard plug-ins, http://www.netscape.com/).

Engineers were among the first to utilise computers. At first computers were used for advanced calculations and analyses. Today we have tools to assist us with almost any task and most engineers produce their own reports and drawings by means of a computer. The use of computers and networks as a medium for communication is yet not common. Table 1 illustrates this history (based on personal experiences) and the conceivable future based on the extrapolation of current trends.

A question could be to what extent can we utilise the experience from the "tool revolution" to meet the "communication revolution", which represents a paradigm shift. The immediate reflection is that we will overestimate importance of technology, process automation and work flow support. Social scientists has coined the word "*technology determinism*" as an expression of the naïve belief that technology is the solution to all problems. The core of virtual teamwork is communication, and communication is not a technical matter but a social and organisational one. We expect team members to work close together and develop social and professional relations even if they are not physically colocated. Communication technology will not replace social proximity and it will still be needed to establish trust and confidence in a social, face-to-face surrounding. On the other hand, technology is the key enabler for virtual teamwork. It becomes imperative to take a cross-disciplinary approach, without underestimating neither technical nor social issues .

The challenge to virtual teamwork is to minimise the disadvantage imposed by physical distance. Solutions must be found within the available economical and technological boundaries and we must balance the effort between technological and non-technological issues.

[1] PAKT, and assistant professor at Agder College (lars.line@hia.no, ll@pakt.unit.no)

[2] PAKT, Program on Applied Coordination Science and professor at The Norwegian University of Science and Technology, Trondheim, Norway (tgs@pakt.unit.no)

	1985	1996	2000+
Source of Information	Customers Colleagues Product catalogues Books, articles and journals Skills and knowledge	Customers Colleagues Product catalogues Books, articles and journals Skills and knowledge	Customers Colleagues Network Skills and knowledge
Equipment	Calculator Drawing board	PC and software LAN	Multimedia, portable computer Global network
Methods	Manual calculations and drawings	Automated and semi-automated computer calculations. Computer drawing and modelling	Modelling and simulations
Media for communication	Face- to- face Telephone Paper (drawings and documents)	Face- to -face Telephone Paper (drawings and documents) Data files	Face- to- face Multimedia network
Information items	Paper (drawings and documents)	Paper (drawings and documents) Data files	Data Models Multimedia, compound documents

Table 1: Engineering with Computers

In the following, we will describe a strategy for companies who want to organise virtual teams. The last part of this paper describes how such a strategy has been adopted by a Norwegian engineering company with 300 employees located throughout 16 regional offices.

2. A STRATEGY FOR VIRTUAL TEAMWORK

The basic elements of virtual teaming has been:

- Rationale - why and what;
- Infrastructure - a house of information services;
- Work structure - a project information model;
- Competence - coaching and continuous learning;
- Empowerment - an open philosophy for collaboration.

Explicit formulation, understanding and acceptance of a rationale is imperative for motivation and guidance. The rationale has to be discussed and understood not only at the executive level but also at the group and personal level (what's in this for me).

Computers as a medium for communication and cooperation is a rather new area, flooded by systems and services and new concepts. The presented house of services is intended as a guidance for a basic infrastructure to support virtual teaming.

The project information model is an aid to highlight barriers for both formal and informal communication.

Coaching and training is always important to change processes. By inclusion in the strategy, we address principles and attitudes regarding the initial phase and continuos development.

Empowerment, boundarylessness, and trust are basic factors for true teamwork.

2.1 Rationale - why and what

A rationale should be established since virtual teamwork in the first place will impose extra cost and inconvenience compared to co-located teams. The involved personnel should know why they are doing this and what the company want to accomplish. The rationale has to be discussed and understood not only at the executive level but also at the group and personal level.

The executive level rationale is the overall or strategic reason why the company wants to organise work in virtual teams. To ensure resources and support during implementation, the rationale should be discussed and promoted by the management.

The rationale presented below, is taken from the case company. The company strategy contains four objectives where the ability to conduct projects using virtual teams is important.

Acquisition and dissemination of competence; The product of a consulting firm is competence and the ability to apply it to provide solutions and value for customers. The ability to develop and disseminate new knowledge is therefore crucial. Virtual teamwork is considered as a central arena for this process.

Capacity; Virtual teams is a way of increasing the capacity and thereby enable the company to take on larger (and possibly more advanced and better paid) projects.

Extended area of service; Extend the market by enabling all regional offices to take on projects requiring expert knowledge only available in other offices. The need to be part of a larger professional- and resource network will therefore become even more important.

Resources; The workload varies over time and is often out of phase among the offices. Virtual teams could be an option to balance workload over time.

Successful completion of the project (budget, quality and schedule) is the primary concern of a project leader. To ensure enthusiasm the selected project leaders and staff should “confess to” the overall rationale. To ensure personal motivation, the rationale should be transformed and expressed at the personal level, for example

> *Successful completion of this project will give me an opportunity for several new and interesting assignments.*

2.2 Infrastructure; a house of information services

The house of services is a way of putting together technology to form an infrastructure for virtual teamwork. Most engineers know how to set up a traditional office or engineering environment. Networked computers as a medium for communication and collaboration is a novel and not comprehended concept. The IT vendors offer a continuos flow of bits and pieces but there is little assistance in creating a working, digital environment tailored to the needs of virtual teamwork.
Even the CSCW literature do not provide much support, because the majority of research have been focused on specialities like "collaborative writing", "work flow support", video conferencing or group decision systems.
The house of services described in the following is targeted at a small to medium sized (SME) Engineering or Consulting company. We focus on services that are important to virtual teamwork and we realise that this is not a final solution, just a draft for a digital environment where we can move in and start virtual team work.
Engineers are basically *information* workers. We collect and process information and produce new information as basis for decisions. In the process we are in a constant interplay with others. We receive and convey information and knowledge. We use a wide range of theories, methods, tools, and services.

The House of Services is a way of relating a set of needs to a set of information services, where we feel professionally comfortable and efficient. The composition and use of these services are based on our physical environment, available resources, competence, physical distance and organisational and human relations to the persons with whom we interplay. If we alter some of these conditions, we will try to adopt to the new situation and change the range of services.
The difference between virtual teams and co-located teams is the physical distance between team members. One immediate consequence of the distance is the speed by which we can exchange physical (information) objects. The obvious answer to this is to exchange digital information. By that we move from the Newtonian to the Einsteinian laws. By moving from atoms to bits, the speed of information processes are changed by orders of magnitude. This will impose technical difficulties that must be solved in the available services.
The second consequence of distance is that we can not have rich technical discussions assisted with broadband physical aids (drawings, white boards etc.). We hence need new types services to support this kind of communication.
The last, but perhaps most important consequence is that we reduce the quality of informal human communication. Direct informal communication is an important channel for both technical information, coordination of activity and social interaction. We have services like telephone and video conferences and there is an intensive technical development and research in how telecommunication can sustain social proximity and interaction. Still, we feel that this is an area were present technology does not provide the required support and we should seek other solutions.

From the above discussion we deduct the following communication needs:

Technical	• Access to project information (objects). • Access to common reference information. • Support for rich technical communication.
Human	• Support for coordination • Support for rich human communication and social interaction

Before discussing a link between needs and technical solutions we will make some general considerations regarding service quality. Quality is in many respects a relative and subjective measure. However, if the following factors are not satisfied, it is not realistic to expect people to use computers and networks for everyday and critical communication:

- Ubiquity
- Concurrency
- Stability
- Conceptually simple and user-friendly

Ubiquity; The communication tools must be easily accessible for all users. Desktop or mobile personal workstations are considered as a prerequisite.

Concurrency; A communication session is often triggered by a phone call, an impulse or some other reminder. The need for a time consuming procedures in order to start the session is not acceptable. This calls for a multitasking, GUI operating system.

Stability; Stability and robustness is essential to trust. Enthusiastic users can tolerate some problems, but generally the system must be as reliable as the power supply.

Conceptually simple and user-friendly; We have many modes of communication and we use a lot of tools. When we introduce new tools for communication it is essential that the concepts of these tools are easily understood.

Groupware is software and hardware for shared interactive environments (http://www.consensus.com/groupware/definition.html). The unOfficial Yellow Pages of CSCW [TOYP95] comprise 11 categories and over hundred products for Computer supported co-operative work. We have defined seven categories of services. In the matrix in Figure 1, the solutions are linked to the communication needs.

	Filing system	Messaging	Conferencing (news)	Application sharing	Video conferencing	Web	Work Flow support
Access to project information objects	x	x	x			x	
Access to reference information	x		x			x	
Support for coordination		x			x	x	x
Support for rich technical communication				x	x	x	
Support for rich human communication					x		

Figure 1: Communication needs vs. services

In the following we will describe the services, and discuss how or if they should be implemented in the house of services

Filing system is a basic service that, with acceptable capacity and functionality, must be accessible for all team members. A filing system can be regarded as a storage for different types of information objects. Software applications as well as operating systems are moving in an object oriented direction. We already see a lot of general functionality inspired by object oriented philosophy and we expect the next generation of network operating systems to be “truly” object oriented.

A filing system may be built on top of the functionality embedded in the operating system, or a specialised system might be developed or procured. Many groupware products offered today are in fact filing systems with added functionality. Typical added functionality is work flow information or routing, improved access control, revision handling or linkage of objects, annotations and other extra information. The choice of a specialised system must be counterbalanced by the loss of general functionality and the classic problem that proprietary solutions excludes the general technological development.

The basic functionality is storage and retrieval. Structure and naming conventions are the normal mechanisms to serve this purpose. An interesting option is the ability for the users to build ad hoc alternative structures to access the filing system (the shortcut feature in Microsoft Windows 95 is an example of such ad hoc alternative structures). The possibility to search for information (by content, type or attributes) is constantly improving and may make us less focused on predefined structures.

A distributed filing system that interconnects several Local Area Networks poses new demands on functionality and the system metaphor. The disk letter assigned to a network area is no longer sufficient. We must access the resources through unique identifiers. The functions that accesses remote resources must be aware of the capacity and attributes of the connection. A user that (perhaps unconsciously) starts an operation that can take considerable time, should be given a clue that something is going on and an option to cancel the operation.

The filing system implemented in the case company is based on a local area network in each office. The data area is structured according to engineering discipline and project. Guidelines for file name conventions is distributed to all employees. Inter office access is provided by preconfigured ftp client applications.

Mail is a simple service to implement and manage. The standardisation of the mailing protocols and the maturity of the client applications has reached a level were it is easy and quite problem-free to use mail and attachments. Convenient address lists lower the initial barrier and raise the quality of the service, and easily configurable post lists extends the applicability.

We already see a massive development on several areas; increased selection of available object types in the message body, agents that automates and performs intelligent operations on incoming and outgoing messages, encryption, verification and signatures. There is no general accepted standards for this extended functionality. To avoid problems, we recommend that mail at present is regarded as an informal and efficient service to exchange messages and information objects.

The mail system in the case company is based on Internet standards.

Conferencing: In principle a conference is a structured database of threaded messages (discussions). The difference between the conferencing offered by groupware products and the original Usenet News service is primarily the available object types in the message body. This added functionality may be decisive for whether conferencing is considered to be an efficient service. However, the basic characteristics of conferencing are not changed. A number of studies have pointed to the difficulties of successful application of conferencing [Orlikowski92], [Cole95]. There are also examples of conditions under which conferencing has been successfully applied [Orlikowski95], [JITOL95]. Commitment to contribution by key personnel and importance of the discussed subjects are central factors. Professional networks candidate for support by conferencing. For the case company, a news server with the possibility for MIME attachments is available.

Application sharing: Application sharing is in this context used as a generic term to describe a class of services that shares the screen windows among two or more users. Several techniques are used to implement this functionality. The main difference is between bitmap and graphical command oriented solutions. The former is more stable and can cross operating system borders but the available options are reduced and in most cases the refresh rate is not as good as with the graphic command technique. Application sharing is easy to use and easy to understand. The experience so far is that it can dramatically increase the quality of a technical discussion. Other interesting areas of application are support and remote control (see Chapter 3).

Workflow technology: *Workflow is about defining and executing a series of tasks in the course of executing a business process* There is no clear cut between work flow technology and the other types of groupware. The split is somewhere in between the generic, ad hoc procedures and the totally captured and automated procedures.

Work flow technology spans from simple forms routing to advanced environments with intelligent agents that monitors and notifies team members about important design changes [Londono91], [SHADE93]. Advanced work flow technology is interesting but it does still not address the coordination needs of small and informal teams of knowledge workers. Knowledge intensive work processes are open, and have to be defined and executed simultaneously. Formal creative techniques are focused on the process structure, not on the information flow or content. Simple work flow technology may be used to optimise "back office" routines and it may contribute to formal project coordination.

Except for standard project management and economy, no dedicated workflow technology is implemented in the case company.

Video conferencing: VC is marketed as the technology that imitate social proximity and enables rich human communication. In many ways this is the weak link in our chain of services. It would have been a real pleasure to say that VC is the perfect solution. The answer is unfortunately not that simple. Cost is the first major barrier. VC at every users desk is presently beyond the acceptable level for most companies. Our general impression is that the technology not offers enough added

value compared to the available alternatives. There are however, examples of projects claiming that VC is the key to success for virtual teaming (British Petroleum Virtual Team Project). VC certainly adds a dimension to communication and it is a clear candidate for inclusion in an extended house of services.

Web: Web is a set of communication protocols and a standard for hypertext documents originally made for sharing of information in heterogeneous environments. The web is in itself an interesting phenomenon. The potential is, however, in the huge economic impact in developing web (and Internet-) based technologies for media and entertainment. The technologies may provide mechanisms for 'playing any kind of game', and even be used for engineering business purposes.

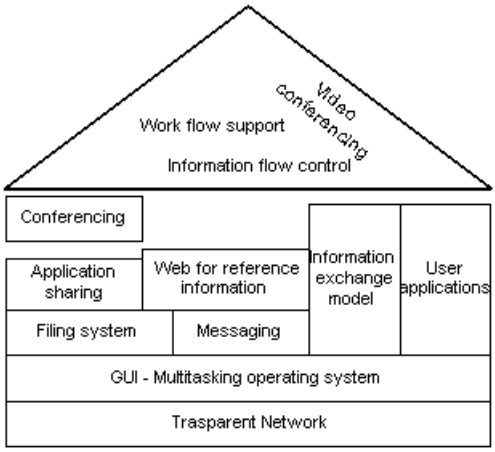

Figure. 2: House of services.

The proposed house of services is illustrated in Figure 2. The foundation, transparent network and GUI operating system is argued mainly from the service quality.

For the case company the network is implemented as TCP/IP above ISDN. This is a solution with relatively low initial costs, acceptable and extendible capacity. There are some conflicts between the virtual line switched nature of ISDN and the packet switched TCP/IP (frequent, small packets must be avoided). Workarounds can be configured but the users should be informed about the "all lines taken" situations so that they dont experience this as error or instability. ISDN is a short time cost efficient solution. Extension of the services to high capacity, multimedia communication and improved connectivity calls for high capacity packet switched networks with priority demand like ATM or broad band ISDN.

The information exchange model is the link between the user applications (the object types) and how the objects fit in to the information process. We must address this in order to be able to exchange, inspect and annotate object and not sub optimise processes by introducing incompatible object types.

Some months ago the word Intranet was coined as an expression of a company wide network based on Internet technology. Our proposed house of services is built by Intranet services, in fact we are heading steadily towards the "Full Service Intranet" as described in a recent Forrester report [Forrester96]. As argued above, this is partly because we see the available services as core services for virtual teamwork, and partly because we se this solution as the key to future open and cost efficient solution. Another important issue is that this set of services is rapidly becoming generally available.

2.3 Work structure; a project information model

The model serves two purposes. Firstly, it highlights the formal information exchange that could hinder virtual teams. Secondly, it highlights informal communication needs and relations based on a match between the required type of competence and the individual competence profile.

Tasks, information flow between tasks, and the need for access to reference information is important to the formal (planned) flow of information. A model describing the formal flow of information can be extracted from an ordinary project management model. The dependencies among the tasks must be identified and described so that they characterise the flow of information.

In addition it may be important to describe dependencies to (physical) reference information (catalogues, standards etc.). Data flow diagrams with annotated flows may give a good visual picture of the process. In some cases it may be relevant to sub divide the activities and describe the formal flow of information between the different roles.
The informal flow of information is mainly due to one of the following:

- **Tempo:** Direct contact awaiting formal information "beta information".
- **Clarifications:** Direct contact to clarify issues in the formal information.
- **Competence:** A team member needs support or education to solve the task he is assigned to. A junior/senior relation represents the clean or extreme version of this situation.

The informal aspect of the model focus on competence because tempo and clarification to a large extent will follow the same patterns as the formal information.
Roles (responsibilities inside a task), The required competence to fill a role and the competence profiles of the employees are central elements in this model.
A data flow model were the persons are representing the objects may visualise the situation. A role model showing competence mismatch and available support personnel may also be informative.
The object structure of the model is shown in Figure 3, using OMT notation [Rumbaugh91].
The mode assumes that all extra information (like person<->office) can be extracted from the project management model or a personnel file.
In its simplicity, the model illustrates that a task receives and produce information (that in turn can be received by other tasks).
A dependency attribute on the input information and a type attribute on the out information is included to characterise the information flow.

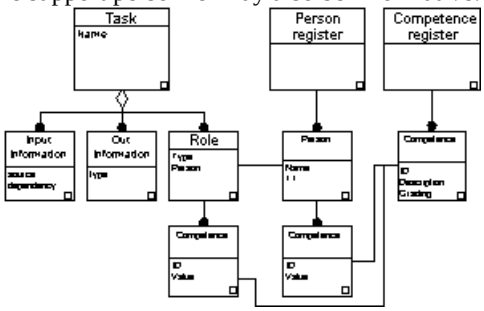

Figure. 3: Formal and informal flow of information.

The role object is assigned a type attribute and a reference to the person register. It may be relevant to have restrictions on the type attribute (a task must have one and only one responsible, etc.). The competence objects are linked to the competence register by the ID attribute. The value attribute is a scale referring the grading defined in the corresponding competence register object.
Competence in roles represents required competence, while competence in the person register represents competence profile. Negative mismatch represents a need for support or education and a potential informal flow of information.
Heuristic rules is used to calibrate the model. Examples is given below:

- Exchange of physical object is negative (cost and time) if it occurs often and in both directions.
- Exchange of complex information that calls for rich communication is negative.
- Safe and established procedures for digital exchange of information is positive.
- Need for access to the same physical reference information is negative (requires duplication and replication)

These rules may also be used for ad hoc queries:

- Show all tasks that are performed on separate locations and requires exchange of physical objects.
- Show all tasks where the roles are assigned to persons in different locations
- Show support requirements where the assigned support personnel is in a different location

It is probably not realistic or necessary to employ this model to all split location projects, but we hope that it, after calibration with experience, can give valuable information of potential problems and that it will indicate considerations to be taken when planning virtual teamwork.

2.4 Competence; coaching and continuous learning

We have adopted the terms and the key elements from the EC research program JITOL [JITOL95] (Just In Time Open Learning): flexible learning, responsibility for own learning and continuous development.

It is easy and "by the book" to prescribe thorough education. Time and attention is a valuable resource and the content must be carefully selected. The basic training is indisputable, We must establish a level where everybody feel comfortable and performs core operations without problems. This coaching must not only convey tool skills but focus on concepts and use.

It is important to consider the different types of users. We have categorised them in three groups:

- The early adapters and creative users
- The normal users
- The late adapters

The early adapters are "self propelled". They understand the concepts and learn the tools on their own. They are an important resource both in the initial phase and the continuos development. They should be encouraged and credited for giving support. On the other hand it is equally important that they understand that other users don't need or want the advanced options and that they don't use advanced techniques that causes trouble for the others.

The normal users understand when being told and with some exercise. They use the services straight forward but without curiosity, and they do not "research" in new possibilities.

The late adapters needs attention. It may be hard to uncover whether they have problems grasping the concepts or whether they resist using it for some other reason. Resistance may be caused by fear of not being able to adapt (and thereby expose themselves by doing silly things), fear of their own work position or maybe they don't agree that the company should use resources on this new technology. To uncover and discuss the problem is often the key for solving it. The most difficult (but often cutest) are the users who are firmly convinced that computers have soul and own will. As replied from a senior engineer (just before retirement): *It's no use, I've tried everything, but the computer decides what to do*

In addition to a competence network as indicated above, we must as facilitators provide systematic and easy accessible reference information, models and examples of effective communication and use of the services.

2.5 Empowerment; an open philosophy for collaboration

The basic principle is that all information is available to all employees. We require an argument as to why information should be restricted, not as to why you need access to it. This is based on trust and we need guidelines on how to inform and give credit for the use of others information. Suitable reactions to misuse of this trust should be established in order to avoid jeopardising the system when such situations occur.

We also address the problem of whether co-operation and information-sharing are rewarded or penalised by the incentive system of the company. Competitive individualism is counter cultural to group technology and virtual teams [Orlikowski92], [Singh92].

3. IMPLEMENTATON OF THE STRATEGY

Asplan Viak a.s is a Norwegian consulting company organised in six independent subsidiaries. The Group has 280 employees in 16 regional offices throughout Norway as well as several staff members working on projects abroad. Anchored in Norway's leading circles within the fields of municipal engineering, geographical information technology and environmental planning, the Group offers a broad range of products and services.

The rationale for establishing a company network is given in section 2.1. The project started late 94 and in January 95 six offices in the southern region was connected with ISDN lines and TCP/IP protocol. The initial functionality was file transfer utilising preconfigured graphical ftp clients and Windows NT ftp servers. Based on the experiences from this project it was decided to connect all offices with this technology. Simultaneously we experimented with an Internet gateway, mail- and web servers. We started to build arguments as to why we should have an Internet connection with mail and web service. The argument that "closed the sale" was an incident were the manager in the Southern region was working on a tender for a water supply project in Zambia. He asked if we had e-mail and it was confirmed that we had a test configuration. A mail with an attached draft of the tender was sent to the local partner in Zambia. An annotated version of the tender was returned shortly after. In this way the two companies worked in parallel with the tender and the manager was astonished by the simplicity and efficiency of the communication.

The configuration of the Intranet is show in Figure 4. Each office is equipped with a TCP/IP router with ethernet and ISDN port, ftp- web- and mailserver. The Internet gateway has a router with several ISDN channels and TCP/IP filtering. A common Internet server is situated outside the filter. (www.asplanviak.no).

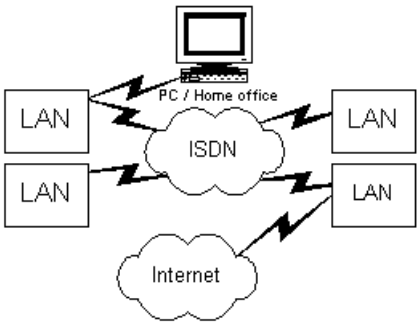

Figure 4: Intranet configuration.

The process of installing and configuring the servers took longer time than expected due to lack of commitment from some of the offices and that the effort needed to coordinate and instruct the IT responsible from 16 offices was underestimated. In the middle of the process, a new group manager was employed. He put forth a date for completion of the installation. Application sharing software was installed on all the servers (easy to install and configure). We then completed the installation and configuration of the server software within a week. The experience from this remote installation and configuration is that it is extremely efficient both for getting the job done and for educating the person at the other side. Another interesting observation is that you, at least in a project oriented company, need to have commitment and deadlines in order to get thing done.

The installation was completed in March 96. The basic training of all personnel is scheduled for April and May. Two disciplines are selected for further research and application of the strategy. Both groups are represented in all regions and they have expressed a need for cooperation.

The road engineering and transportation planning group have all their project information i digital form. They see a trend towards demand for expert competence and larger projects with tighter schedules.

The landscape architects are on the doorstep of digital production. They foresee a need for a professional network to sustain this process. They also perceive the professional network as a way to strengthen their identity and expert competence as a small group in a large engineering company.

In the following we will report and comment typical feedback and experience from this initial phase. Finally, the experiences is summarised in some general reflections that we will carry on to the work ahead.

The following quote illustrates the reactions from employees who have awaited the solution and starts extensive use as soon as it is available.

> *This is the best that has happened to this company for several years. There is no longer a problem to cooperate with and assist the junior engineers at the district offices. We send*

documents back and forth in seconds. It's just like they were sitting here. The only shame is that we cant go out for a beer afterwards.

Other incidents illustrates emerging possibilities that allows efficient ad hoc solutions. For example:

I was contacted by a colleague from the eastern region. They had received a dataset for the GIS system but were not able to import it to the PC version of the software. They were under pressure and didn't know what to do. He transferred the data and I read it into the Unix system. The data was formatted according to the old standard. I exported it in the new format, notified him, explained the problem and told him what I had done. Shortly after I received a notification with "all problems solved, thanks for the assistance".

Open and general tools may, when used with creativity, sustain processes that not are built into the tools. The following illustrates how the filesystem and mail by means of simple agreed procedures sustained both workflow and coordination.

Three of us, all from different offices, were working together on a report. We were sceptical about how to coordinate and cooperate when not co-located. We started with a kick-off meeting where we decided a rough outline and an initial division of responsibilities. The report was divided in one file for each section and the responsibility and status was indicated with initials and a code postfix to the filename. In the early phase we coordinated by occasional e-mails and telephone calls. As the deadline approached and we had to work more intensive with the report, we decided to start each day with a short e-mail telling current work status and the schedule for the day. Together with some telephone conferences, the annotation feature in the word processor and a meeting to finalise the report, this worked surprisingly well.

After a presentation of the Intranet and the available services to a meeting with all the landscape architects, one of the senior architects replied:

This seems very interesting and promising, but how can we expect to utilise this efficiently when we have daily problems with internal standardisation and the robustness of the LAN?

This is a classical conflict. We resist taking the next step and use new and unknown tools when we are unconfident with the foundation. Such problems should be addressed and cleared as far as possible.

The following incident, reported by a junior engineer, underpin the need for training if you expect new tools and methods to be used in stressed situations:

I was working on a letter to a customer and needed a second opinion from a senior engineer at the main office. I phoned him and said that I had mailed the letter and asked if he could comment on it. He was stressed and not in the best mood, he replied: "Fax it at once, I have enough problems to cope with, I can't fiddle with that mail thing"

After a demonstration of file transfer and E-mail with attachment, the following question is often raised:

What is the need for file transfer when we can mail and attach a document?

Orlikowski, [Orlikowski95] refers to this understanding of concepts as *technological frames*. When someone is presented to two new and overlapping concepts, where one is simpler and more appealing than the other, they hope that they can forget the "complex" alternative. The principle advantage of the "complex" method must be stressed.

These observations illustrates some planned and emergent results of new technology. At the same time, some of the problems related to introduction of new technology are shown. Regarding the case company, we have a clear opinion that the adoption of virtual teaming at the moment is not constrained by technology or available services. The challenge is to convey a technological frame or understanding of the concept and basic operating skills. This is the foundation where we have

achieved a common house of services. From this foundation we can work to assist individuals and groups which regard virtual teaming as a mean of value creation.

4. CONCLUSIONS

Information technology is approaching a level of connectivity and sophistication where it provide a digital medium for distributed knowledge work. Successful application of this technology is not a pure technical matter any more, but more a matter where organisational and social issues play a major role, even in engineering work.

A Norwegian engineering company has started to implement virtual teams based on networked computers providing standard services, and plan to extend both the bandwith of services and the connectivity by transformation to intranet technology.

The future of the company will rely on being a part of the open, information society, doing business by providing high-quality engineering work in a social and virtual environment of the winning team.

5. REFERENCES

[TOYP95] The unOfficial Yellow Pages of CSCW: http://www11.informatik.tu-muenchen.de/cscw/yp/

[Cole95] Paul Cole. The Impact of Group Context on Patterns of Groupware Use, CCS WP #182. *http://pound.mit.edu/ccswp/CCSWP182.ps*

[JITOL95] Just In Time Open Learning EU DELTA project; http://www.edb.tih.no/kurs/nitol/english/jitol.html

[Londono91] - F Londono et al - *Coordinating a Virtual Team;* CERC-TR-RN-92-005 West Virginia University, Morgantown, 1992

[Orlikowski92] Orlikowski W.J; LEARNING FROM NOTES: Organizational issues in Groupware implementation. CCS TR # 134, Sloan School WP # 3428-92. *http://pound.mit.edu/ccswp/CCSWP134.ps*

[Orlikowski95] Orlikowski W.J; Evolving with Notes: Organizational Change around Groupware Technology. CCS WP # 186. *http://ccs.mit.edu/CCSWP186.html*

[SHADE93] - Daniel R. Kuokka, et al: SHADE: 1993 Annual Report; Lockheed Palo Alto Research Laboratories

[Singh92] - Kamar J. Singh, Concurrent Engineering Pilot Project at GE Aircraft Engines - Concurrent Engineering in Review, Volum 4-92

[Forrester96] - Thomas J. Pincince, David Goodtree, Carolyn Barth; The Full Service Intranet - The Forrester report, Volume Ten, Number Four March 1, 1996; http://www.forrester.com/hp_mar96nsr.htm