

MONITORING COMMUNICATIONS IN PARTNERING PROJECTS

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SUMMARY: *This report is a summary of a two year research project carried out by the IT byg group at BYG.DTU for the Danish government agencies Erhvervsfremmestyrelsen and By- og Bolig-ministeriet. The objectives were to collect data on the use of IT by the PPB housing consortia, a development project to test out various innovations, to map communications between the partners, and compare IT usage with their original proposals. Data was collected on communications in housing projects in the period June 1999- Aug 2000.*

The original PPB proposals were made in 1994/5 but there have been breaks in the flow of projects, and information technology has gone through much change since then. Use of Email has taken over from post and fax, and Project Webs have been developed in most consortia.

Consortium members' policies have dominated the choice of management and logistics software, restricted compatibility in the consortia, and limited willingness to share data. Greater involvement by the client, and more sharing of equity, would have encouraged adoption of common IT systems and created more trust for data sharing between partners.

PPB projects have allowed consortium members to test out new technologies but, in general, the IT systems used have been similar to those which the larger firms use elsewhere. Vertical integration has been limited by lack of experience and technology in smaller firms. In future, access to Project Webs from mobile devices should help use by all partners from any location.

In all the projects studied, and in spite of the introduction of Email and Project Webs, the ratio of non-IT communications to IT varied from 0.8 to 4.6. When problems need to be solved rapidly there appears to be a tendency to revert to traditional means of communication – meetings, telephone and fax.

KEYWORDS: *communications, partnering, project web, social network analysis, housing*

1. INTRODUCTION

The research contract between the Technical University of Denmark, and Erhvervsfremmestyrelsen and By- og Boligministeriet, stated that there was to be a systematic collection of data on the use of Information Technology in the Proces- og produktudvikling i byggeriet (PPB) development project, based on interviews with the members of four consortia and a method of measuring information flow. This was to be mapped onto the organisation, IT tools and strategy of each consortium. The result was to be a comparative analysis of the effects of IT on processes, and quality and quantity of information, compared with their original proposals from 1994/5.

This paper covers two aspects of the work: a report on the general use of IT in the PPB Consortia based on their original proposals and interviews with the main partners, which give the background to the second part, a research study of the communications used on active housing projects by each of the consortia.

The overall objective of the PPB project was product and process development to improve productivity in Danish social housing. IT innovations, proposed in the PPB competition to appoint four consortia, included: communications, CAD and modelling, databases, logistics and management applications. Communications was chosen as the main application to study since the technology was developing fast and the vertical integration of the PPB consortia over a series of projects should have provided the ideal environment in which to share information. However, the research team found that there were few PPB building projects under way early in 1999 and that the two-week periods of study would have to take place when it was possible to obtain the cooperation of the project teams.

In addition to the briefing of the project teams before the communications studies, three visits were planned with each consortium: at the beginning of the research, early in 2000 for the interim report (Howard, 2000) on general IT use, and late in 2000 to check the data collected before completing the final report. A seminar was held in May 1999 for each consortium to present its work and for DTU to propose how it wished to collect communications data. The plan was to collect quantitative data by recording all communications over a period of two weeks on the four projects studied, and to collect qualitative data through recording messages resulting from incidents that arose during each project. It was never intended to study the content of the messages, but it was hoped that a measure of relative efficiency of different media might be found if similar incidents arose and were solved using different methods.

1.1 Previous work

The innovations made by the PPB consortia from 1995 – 1997 were studied by the BPS-centret (Hauch, 1995-7). The consortia were then using Lotus Notes and email with attached files, and the use of project webs had not started. Social Network Analysis was first applied in this area to the study of communications in one of the consortia, PPU, in a Master's thesis by Jan Andresen, now a PhD student in the IT byg group at DTU (Brendstrup and Andresen, 1998). This analysed the number of emails between members of the consortium, and the number of accesses to drawing and document databases, and combined these to indicate a total density of communications. Sociograms were produced to show the pattern of communications between each of the consultants and contractors.

Social Network Analysis is normally used in the social sciences for more than just recording communications between members of a group (Scott, 1981). It can also analyse the strengths and subdivisions within a group, although this was not the purpose of the PPB research. The main objective was to monitor the use of both traditional and electronic communications, and present the results in a form that would allow comparison and inform the Danish building industry of the possibilities and advantages of new technology.

Other work on measuring the sharing of information in building includes the benchmarking report from Construct IT on Integrated Project Information (Construct IT, 1999). This was carried out through interviews with members of project teams on seven projects, and allocated points on the basis of the use of electronic transfer between members of project teams as a means of integration. The results ranged from 0.22 (low degree of integration) to 0.78 (high degree of integration) on a scale up to 1.0.

2. THE USE OF IT IN PARTNERING PROJECTS

The PPB development project was planned to be innovative in various ways: vertical integration, industrialisation, building systems, IT integration, intelligent houses and environmentally friendly, low energy houses. Each consortium included an architect, consulting engineer and contractor, and some also included subcontractors and suppliers. Each was expected to build 8 housing projects with a total of 300 units by 1999. These targets have not been achieved yet due to changes in ways of funding social housing.

This paper is mainly about the use of communications but it is linked to other innovations and to developments in IT that have taken place over the last five years. The take up of these was studied through a series of semi-structured interviews with the members of the consortia. The original proposals from the consortia were optimistic about using the technologies described in the TR (technology council) initiative (BPS, 1988), some of which have not moved as fast as expected, while others, particularly the Internet, have made very rapid progress.

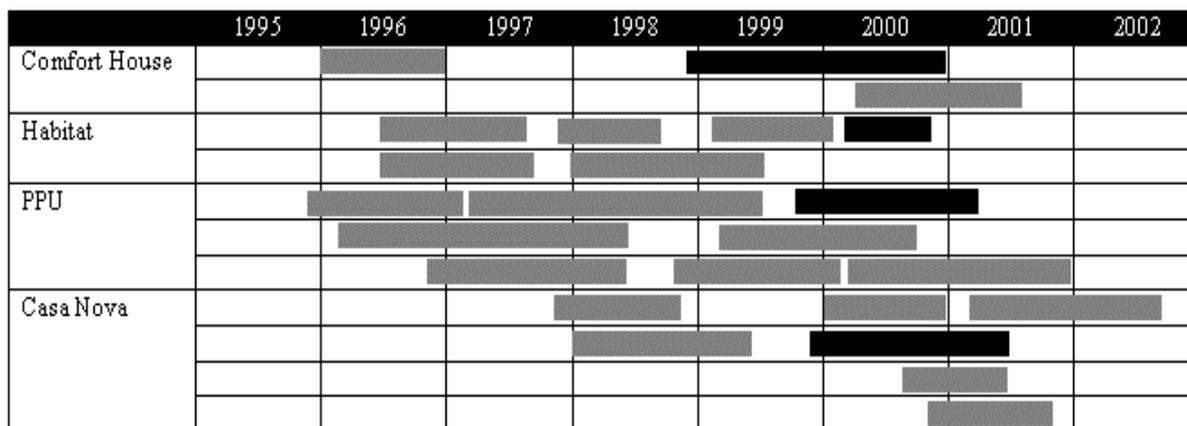


FIG. 1: Timetable of housing projects by each of the consortia

2.1 Changes in IT since 1994/5

While the building process changes slowly, IT changes rapidly. New IT systems have been quickly taken up by Danish companies. In 1995, the potential of the Internet was not apparent and the WWW had only just been launched and had very little information for construction. The latest technology for group working was Lotus Notes. Several consortia adopted this, with PPU the most successful, but it was originally limited for the transfer of graphical information.

The Internet has made exchange of electronic information available to all including smaller firms, and all consortia now use email with the possibility of attaching drawing files. Several consortia have set up Project Web sites for sharing data. In some cases contractors are reluctant to share data and prefer to send specific messages. One factor, which the nature of system building affects, is that there are fewer exchanges of drawings needed. The system or project is designed and, while there is exchange between architects and engineers, the drawings may only be issued to contractors once.

Other changes in IT have helped information exchange in the consortia. Almost all partners now have PCs running under Windows and use the Office package. The same convergence has happened with CAD where Autocad now dominates. Electronic Data Interchange was expected to standardise commercial messages and become widely used, but has not been successful yet. What has grown is use of mobile phones and these will have faster, higher bandwidth, internet connections soon.

2.2 The nature of IT in partnering

IT strategies are dominated by the policies of individual companies in the consortia and, except in Habitat where the consortium is a company, the partners have had to try to maintain compatibility within their firms and with their partners. The original objective of PPB was vertical integration, from client through to subcontractors and suppliers. This has not taken place, but what has been achieved is partnering between architect, engineer and contractor.

2.3 Reasons for change from the original proposals

Some consortia admitted there were too many visions in their original proposals and, as the projects have progressed, they have tended to concentrate on different types of innovation: Comfort House on façade design and energy saving, PPU on communications and sharing data, Habitat on radical changes in logistics and links with customers, and Casa Nova on standard details for building more storeys in timber housing. All these together make up a broad test bed for new ideas. The PPB development project has enabled the consortia to try

out new systems before using them on other projects. A limitation in continuity is that of staff. When projects are in different regions, different people are used, and the experience gained may not be passed on.

IT is mainly a supporting technology for these process and product developments. Apart from some plans to provide intelligence in the houses themselves, which have not been achieved, the use of IT has concentrated on communications, CAD and some shared databases. For management systems, logistics, environment and safety, most companies have used the same systems as on other projects. Use of IT for facility management and maintenance depends upon the abilities of clients to use this. The tool that makes sharing of data, and the involvement of all partners possible, is the Internet, and Project Webs can now deliver many of the original aims. Organising people to adopt new methods of working is the longest part of a change process. Retraining and gaining experience can take a long time and the 5-7 years of the PPB project seems a short time to achieve this.

3. TECHNOLOGIES USED BY THE PPB CONSORTIA

This report follows on from the work of the BPS-centret (Hauch 1995-7) and briefly covers each IT area.

3.1 Communications

Partnering offers the ideal environment for electronic communications and the main part of the DTU research was to measure the level of use of communications, both in normal operation, and when quick solutions to problems involving several partners are required. All the PPB consortia tried out groupware or email with attached files at an early stage, but the technology has now moved on to project webs. Three of the four consortia introduced these in 1999/2000 but usage of these has been limited by several factors:

- The reduced need for exchanging information in a standard form of construction
- Some reluctance, particularly by contractors, to share information.
- Limited access to, and ability to use, the web by all companies involved

3.2 CAD and design

Most of the design firms and some of the contractors had CAD systems at the beginning of the PPB development project and several consortia explored ways of structuring and exchanging data according to the TR initiative and Ibb (Danish CAD user group) guidelines. The building systems developed in PPB would have been ideal for trying out 3D modelling and this is an opportunity which has not been taken up, perhaps through there being few conventions for 3D data yet.

3.3 Databases

The development of databases of components, quantities and prices is another rather disappointing area for IT use in PPB. Setting up such databases is an intensive activity and requires confidence in the flow of projects. Internet based product data is now widely available but in non-standard forms of limited usefulness. Future possibilities lie in attaching data to standard models, independent of computer systems, such as the Industry Foundation Classes.

3.4 Logistics

Contractors tend to have their own systems for logistics. Skanska uses Microsoft Project in Casa Nova for time planning as do several other consortia. In the exchange of electronic orders and invoices, and passing on facility management data, the standards expected to support this at the beginning of the project, Electronic Data Interchange and CIS-CAD (Danish initiative on standard facility management data), have not developed as much as was hoped.

3.5 Management

The large firms involved in PPB have their own management databases. These manage resources across the whole firm. Financial planning typically uses Excel. Accounts systems in consultant firms are used for the whole

company. Except for Habitat, most consortia have kept management responsibility separate. Further integration would require full equity partnering.

3.6 Overall success and future plans

All the consortia have made slower progress than they expected and have only achieved a few of the goals of their original proposals, largely through factors outside their control. Those which made the most rapid progress early on, such as PPU, have had to revise their systems several times, while those, such as Habitat, which concentrated on changing the process before developing their IT systems, are only now building their IT systems. The IT tools used most successfully have been established ones, and the greatest influence on integration has been convergence on Microsoft Office, the Internet and Autocad. It is hard to single out individual consortia, but PPU has put great effort into the flow of information, while Comfort House has pioneered the project web and databases. Habitat is starting to use IT to communicate with its clients, and Casa Nova has standardised the building system and process to minimise the need for data sharing.

The consortia were well aware of relevant standards and guidelines from the TR initiative (BPS, 1988) but not all these were fully developed or implemented. The IT barometer survey (Howard, 1998) showed that levels of awareness and use of standards for organising and communicating data in the Danish construction industry were low. The consortia were more aware and referred to these in their original proposals, but made little use of them. The survey is being repeated in 2001 and should show the general progress made with standards over 3 years.

4. THE COMMUNICATIONS RESEARCH METHODOLOGY

The communications research was to define a method of measuring information flow between those involved in the housing projects, to map this and compare the consortia. Communications was chosen as the most significant application of IT, since it was developing rapidly and consortia working together over a series of projects ought to be able to maximise the benefits of its use.

4.1 Forms of communication

The following media, both IT and traditional, were recorded:

- Meetings – still a vital way of getting the views of groups of people who can refer to documents.
- Post – The usual method of sending design drawings, documents and letters with legal significance.
- Telephone – still the preferred means of interactive person-to-person communication, now mobile.
- Fax – An electronic medium of wide availability but uses unstructured data that cannot be edited.
- Email – messages to which electronic documents such as drawings and text can be attached.
- Project Web – a technology for shared access to project data by any partner over the Internet
- Databases – structured information on a consortium's method of construction or costing
- Others – this might have included groupware, video conferencing or transfer of computer discs.

4.2 Monitoring communications

It was hoped that some forms of message, such as Email, could be monitored through electronic records, but it was decided to collect data in a standard way. A period of two weeks was used for all project participants to record, on data forms, all the messages received and sent, relating to the selected project. Forms were designed to make this easy, and they were explained to each team, but it is understandable that this was not a priority for busy people.

4.3 Method of analysis

Social Network Analysis is a technique developed in the Social Sciences to look at relationships within groups of many types (Scott, 1991). It is based upon Gestalt theory – the relation between wholes and their parts. Vertical

integration, or partnering, over a series of projects involves building a community, and therefore it is appropriate to study the PPB project teams. Computer tools are available to quantify the strength of links between firms or individuals. Various indices are given: the density of the group, its degree of centrality, component parts and cliques, for example. The UCINET program from the University of California (Borgatti, 1996) was used, as it had been by Jan Andresen (Brendstrup and Andresen, 1998) in a previous study of the PPU consortium. Output was sent to the Krackplot program to plot diagrams showing the volume of each type of communication and the strengths of links visually, for quick appraisal.

4.4 Occurrence of incidents

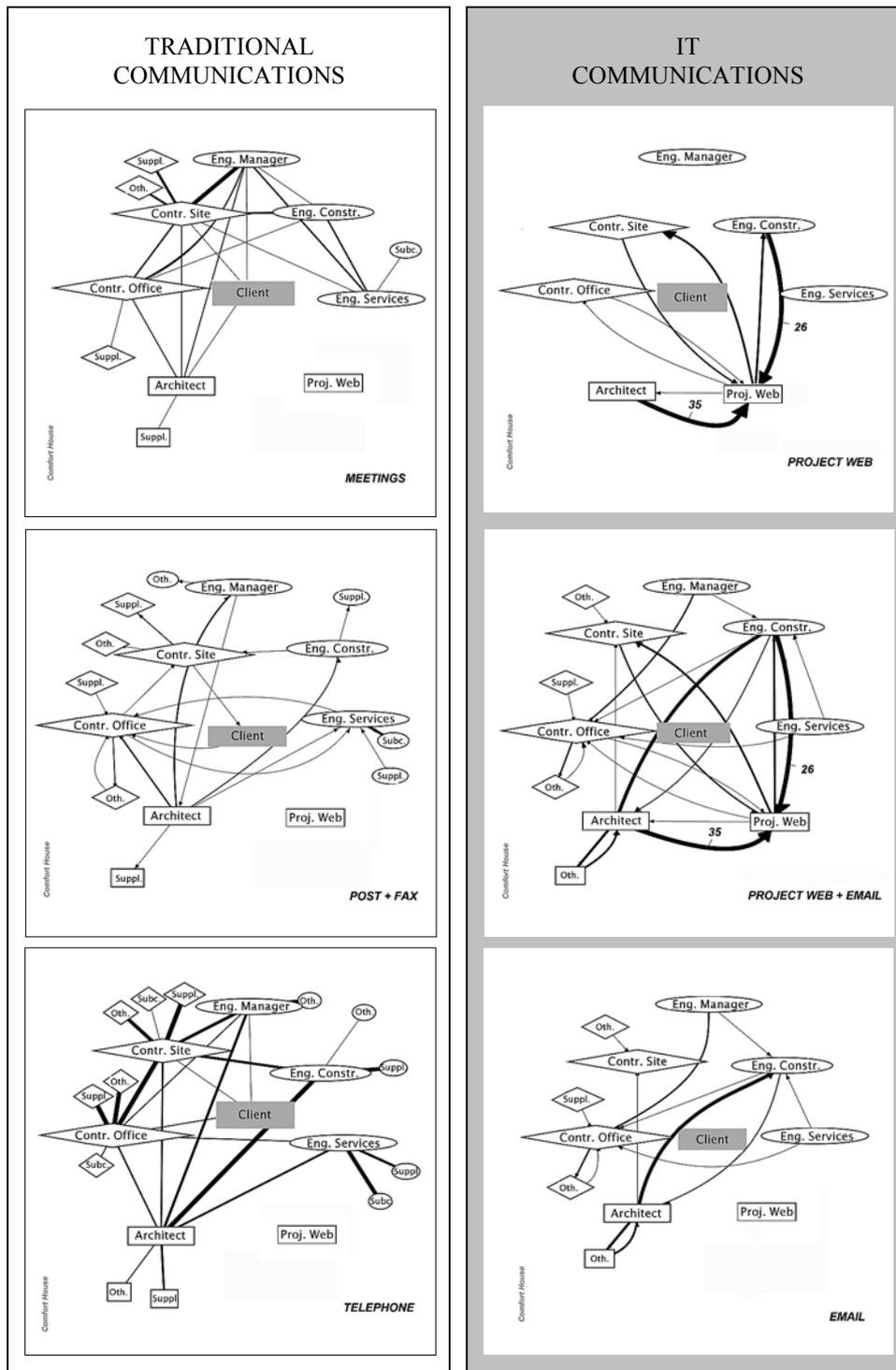
The period chosen for collecting this data varied within the stages of each housing project, but two consortia were asked to complete the forms during the design stage, and two during the construction stage, to allow comparison. The incidents would inevitably arise spontaneously, and forms were provided for all those involved to record the messages sent or received to help solve the problem. The first project studied provided very good data on an incident involving redesign to meet fire requirements, but the other consortia could not produce similar data.

4.5 Incidents arising during the projects

The expectations for this research were that patterns and types of communication between project participants could be recorded over a typical period, and compared with communications used when incidents occurred requiring rapid consultation. In fact the information received, in spite of clear explanations given at meetings with each project team, was very variable in quality. It was also collected at different stages of design or construction. There were, therefore, limited possibilities for comparison, but the level of use of different media does provide useful information, the roles of different individuals or companies are apparent, and the few incidents reported can be related, in their use of communications, to more typical patterns of use.

4.6 Comparison of the consortia

One incident was plotted in linear form showing the messages or meetings involved in solving the problems and the time elapsed between them. (Fig. 6) It was hoped that similar incidents solved using different means of communication would allow more comparison of their relative speeds. This did not prove possible owing to the small amount of data received.



The number of messages is indicated by the weight of the lines or by a number when it is greater than 9. The shape of the boxes differentiates the companies.

FIG. 2: Sociogram of communications on Comfort House project

4.7 Sociograms of the two-week studies of each project

The presentation of the communications between the main participants on each of the projects is designed for quick understanding of the media used, and volumes of messages sent and received, between the different

participants. They should be looked at together with the descriptions of each project and the stage at which it was studied.

The UCINET tables for each project compare the number of messages between each of the main consortium partners over the two-week period studied.

Rank is the order of the frequency of use of each medium.

Medium: meetings, telephone, Email, Post+fax, Project Web. Sums of all IT & non-IT media.

Number of Messages is the total sent by all partners over the two-week period.

Number of groups is the number of the groups of people from the main partners involved at that time.

Density is the ratio between the actual number of messages sent and the number if each group had sent one message to each other group. This allows comparison between one-way and two-way forms of communication.

Two-way – Meetings and Telephone Density = $\frac{\text{No of messages}}{n(n-1)/2}$, where n = number of groups.

One-way – Post & Fax, E-mail and Web Density = $\frac{\text{No of messages}}{n(n-1)}$.

5. COMMUNICATIONS ON EACH PROJECT

5.1 COMFORT HOUSE → AALBORG HAVN → CONSTRUCTION STAGE

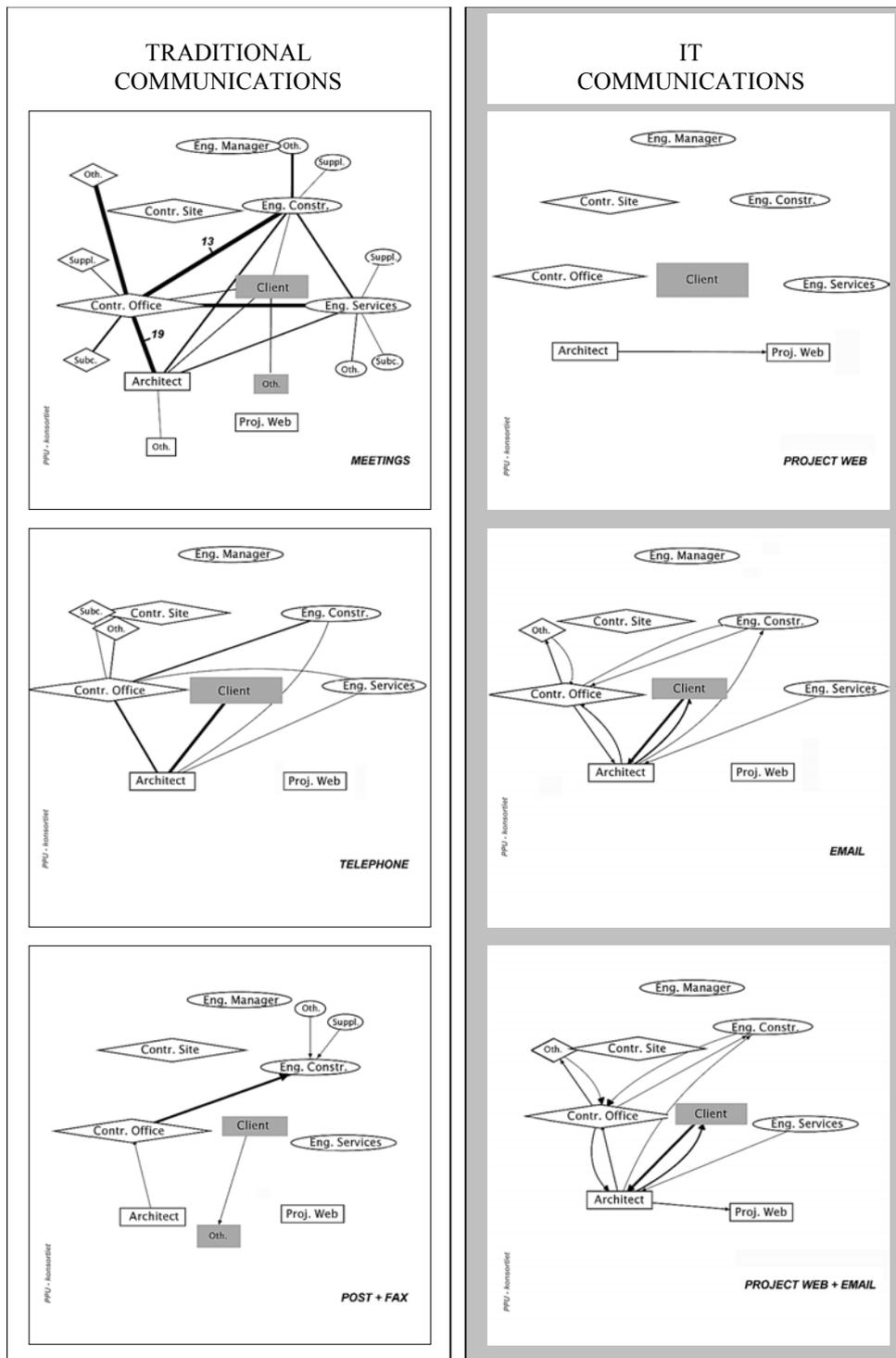
The project studied was only the second by this consortium. It used the same partners as the previous project but the project manager from NCC was different. CAD was used widely and drawings were sent as attached Email files. The capacity of communications available on site was not adequate for Project Web use.

There were relatively few meetings and these mainly involved the engineer's project manager and site manager but most of the team took part in some. The telephone was also used by all and was the main form of communication. Post and Fax were used very little, except by the architect. Data was being uploaded to the Project Web at this stage with the site manager the main user of this data. The Email traffic was mainly from architect to construction engineer. There was a high volume of communication that involved mainly telephone and uploading to the Project Web.

TABLE 1: Analysis of communications on the Comfort House project

Rank	Medium	No of messages	No of groups	Density
1	Telephone	94	7	4.48
2	Meetings	36	7	1.71
3	Project web	65	7	1.55
4	E-mail	17	7	0.40
5	Post + Fax	16	7	0.38
	All non-IT	146	7	3.48
	All IT	82	7	1.95

Although the average number of communications with the Project Web looks higher than that for meetings, more partners were involved in the meetings. The telephone is the main means of communication – that is an average of 4.48 calls for each group of partners with each other group over the period studied. Non-IT media are used nearly 1.8 times more than IT based media (all non-IT/All IT).



The number of messages is indicated by the weight of the lines or by a number when it is greater than 9. The shape of the boxes differentiates the companies.

FIG. 3: Sociogram of communications on a PPU project

5.2 PPU CONSORTIUM → SKEJBYPARKEN, AARHUS → DESIGN STAGE

This was the fifth project in a regular series of eight, but was delayed so that there were nearly three years between its start and the previous project start. The data was collected at sketch design stage when the contractor started to plan the project. This explains why the project web was hardly used. At this stage there were a lot of

meetings. Telephone use was much lower, mainly between architect and client. Post and Fax were little used except between the contractor and the construction engineer. The Project Web was just starting to be uploaded by the architect. Email was used mainly between the client and the architect, and the contractor and engineer.

TABLE 2: Analysis of communications on the PPU project

Rank	Medium	No of messages	No of groups	Density
1	Meetings	57	7	2.71
2	Telephone	21	7	1.00
3	E-mail	16	7	0.38
4	Post + Fax	6	7	0.14
5	ProjectWeb	2	7	0.05
	All non-IT	84	7	2.0
	All IT	18	7	0.43

As is clear from the sociogram in Fig. 4, meetings are the predominant form of communication but not all partners are equally involved. The ratio between non IT media and IT media is about 4.7 but this may be due to the stage at which the project was studied. Meetings were necessary and there was little data in the Project Web.

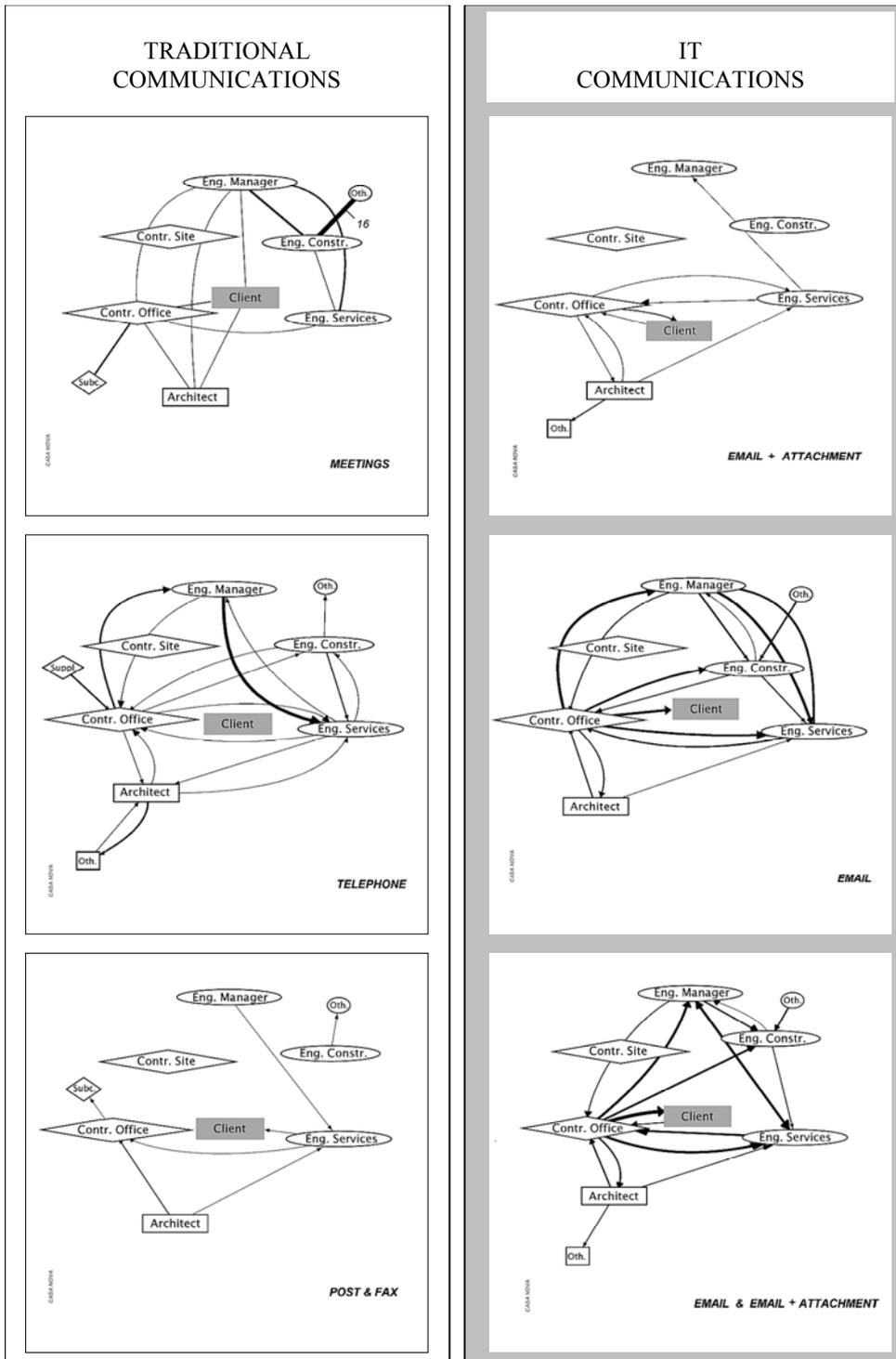
5.3 CASA NOVA → GRØNHØJ, BALLERUP → DESIGN STAGE

This was a project with 46 row houses and it was studied during the design stage in the middle of March 2000, about two months before construction started on site. At this stage there were few meetings except between the construction engineer and people outside the consortium. Telephone was used between all partners, particularly by the engineers. Post and Fax were little used. With no Project Web, Emails with attachments were analysed separately from Emails, and were the main means of exchanging documents. Email was the main form of communication, and like other media, was quite evenly used across the project team. This consortium said that, with standard construction and drawings, it needed fewer document exchanges since there were few revisions.

TABLE 3: Analysis of communications on Casa Nova project

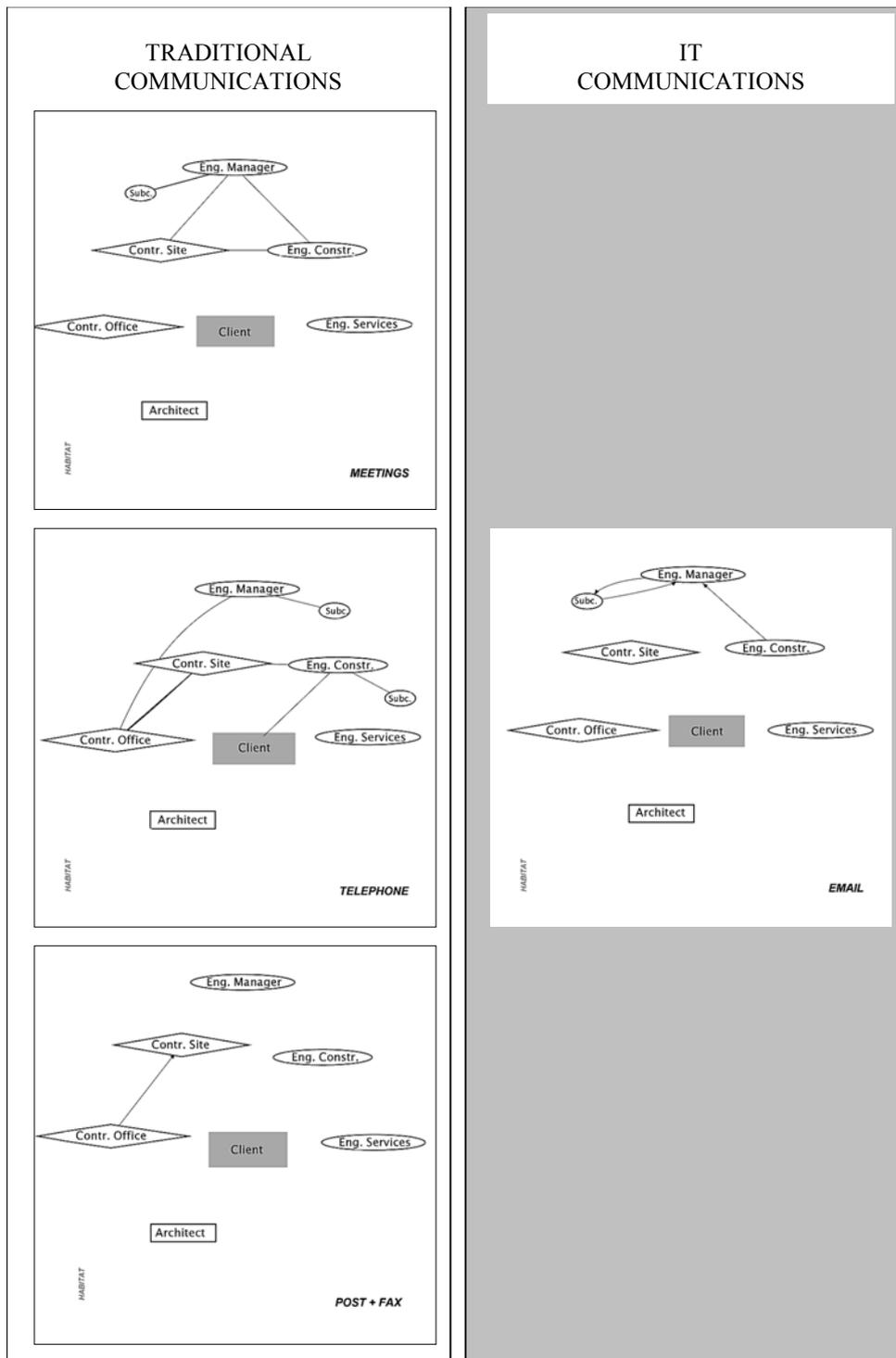
Rank	Medium	No of messages	No of groups	Density
1	E-mail	45	7	1.07
2	Telephone	22	7	1.05
3	Meetings	16	7	0.76
4	E-mail+attachments	9	7	0.21
5	Post + Fax	6	7	0.14
	All non-IT	44	7	1.05
	All IT	54	7	1.29

For a consortium that seems to have placed IT lower in its priorities, it is surprising to see Email as the most widely used medium. Even the telephone is well behind with only 1.05 messages sent on average between each partner over the two weeks studied. The totals show that IT media are used about 23% more than non-IT media.



The number of messages is indicated by the weight of the lines or by a number when it is greater than 9. The shape of the boxes differentiates the companies.

FIG. 4: Sociogram of communications on a Casa Nova project



The number of messages is indicated by the weight of the lines or by a number when it is greater than 9. The shape of the boxes differentiates the companies.

FIG. 5: Sociogram of communications on a Habitat project

5.4 HABITAT → ENGPARKEN, FREDERIKSVÆRK → CONSTRUCTION STAGE

This was the last project studied and, in spite of the cooperation of Habitat a/s, the engineers and the project manager, very little information appears to have been transferred at this stage of the project studied, and it is not possible to carry out any numerical analysis. The sociogram reflects the involvement at this stage of the

contractor and engineer. Most of the communication shown was by traditional means. There were meetings involving the subcontractor for the prefabricated bathrooms, who has a major role in the Habitat process, and much use of telephone and fax. Although NIRAS made their first use of a Project Web on a PPB project, it was not used on the one studied. The engineer made some use of Email during the study period.

With such a small volume of data it is difficult to draw any conclusions but Habitat has redesigned the construction process to involve a major contribution by three main subcontractors. This may have succeeded in reducing the complexity of communication necessary, and the sociogram is probably a fair representation of this simplified process.

5.5 Communications used during incidents

It was the intention to study incidents as they arose and the means of communication used to solve them. This is only meaningful at the construction stage when changes become expensive and decisions have to be taken quickly. Only one incident, described by Comfort House, could be studied and this was reported in detail by all those involved, and showed how this was solved following a series of 15 communications.

An interesting observation is that, for a consortium with a high level of IT use for communication, there were no IT means used for solving the problem. All messages were by fax, telephone and post. It seems that, when a problem arises, the traditional way of solving problems is turned to. This problem took 89 days to solve and involved exchanging information between most of the partners. M = meeting, F = fax, T = telephone

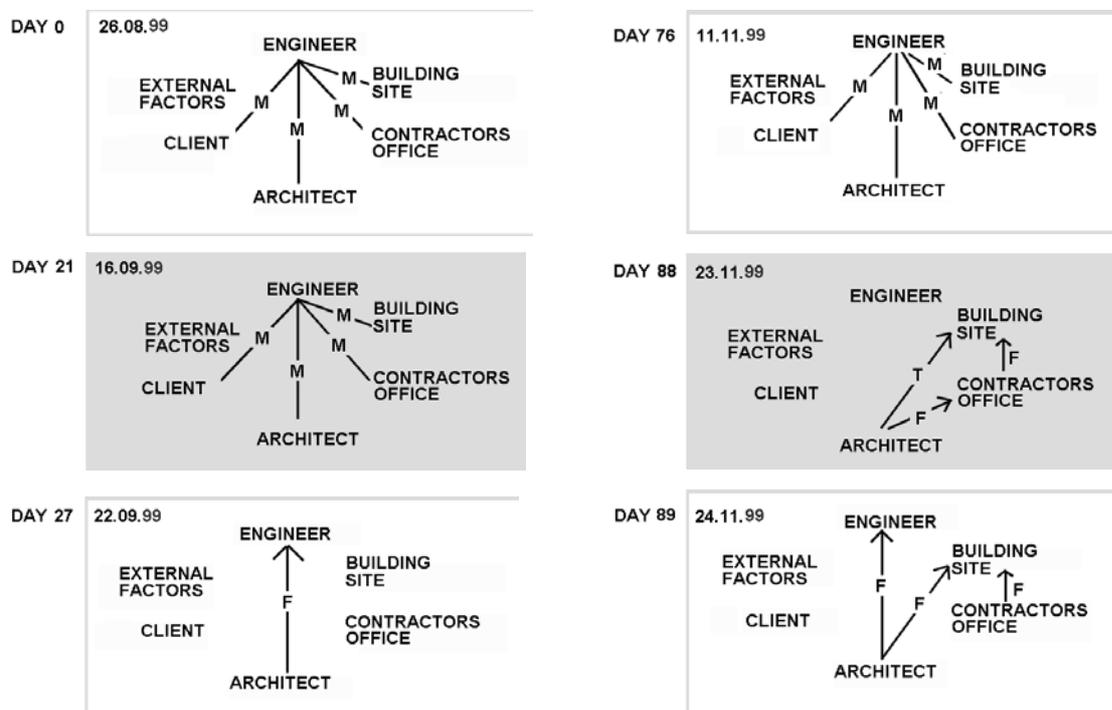


FIG. 6: Messages at the beginning and end of a sequence of 15 over 88 days to resolve a Comfort House incident

6. COMPARISON OF COMMUNICATIONS IN EACH CONSORTIUM

It is difficult to use the data collected to make precise comparisons, largely because it was collected during different project stages. The research team could only study the projects when they became available. A rigorous study to prove the hypothesis put forward that 'electronic means of communication, particularly email and project web sites, will help solve problems arising on consortium housing projects more quickly and effectively' would have required research based upon artificial projects. Real projects were being studied and it would not have been possible, with the resources available, to have researchers on site and in the partners' offices even for the two weeks of the study. The limited amount of data collected and the differences in the stage of each project

studied, means that the results should be regarded as case studies rather than providing directly comparable data. So few communications were recorded in the study of the Habitat project that they are not included in Fig. 7.

TABLE 4: Different communications media used ranked by density for three of the consortia.

Rank Stage	Comfort House Construction	PPU Design	Casa Nova Design
1	Telephone	Meetings	E-mail
2	Meetings	Telephone	Telephone
3	Project Web	E-mail	Meetings
4	E-mail	Post + Fax	E-mail +
5	Post + Fax	Project Web	Post + Fax
All non-IT	3.48	2.0	1.05
All IT	1.95	0.43	1.29

A different medium is ranked first in each consortium, with Casa Nova the only one to use an electronic medium, Email, most frequently. Telephone is overall the most frequently used. Project Web comes quite low down but for reasons which relate to the stage at which each project was studied. Post and Fax are last overall and this is a real change from a few years previously. Users are aware of the limited speed and cost of Post compared with Email, and Fax provides poor quality and cannot be edited.

If All non-IT media are compared, Comfort House shows the highest density but this is largely due to the frequency of meetings at the beginning of the construction stage. The ratio between All non-IT media and IT media varies from a ratio of 1.78 for Comfort House, and 4.6 for PPU, to 0.8 for Casa Nova. Comfort House has the highest density of use of IT media, which may be due to the late stage at which they started their second project and the more advanced use of Project Web by that time.

7. APPRAISAL OF THE USE OF IT IN THE PPB DEVELOPMENT PROJECT

Significance of communications for partnering many of the problems experienced by the construction industry in trying to increase its productivity are due to the complexity of the project team and the changes that take place in it from project to project. The PPB Development Project with its continuity for 5-7 years, was therefore an opportunity to improve understanding between partners. In the same period the fastest development in IT was in communications, with the Internet and faster networks aiding adoption of Email and Project Webs.

Vertical integration or partnering the original proposal for PPB mentions vertical integration between architect, engineer and contractor through a project database, and greater involvement of suppliers and subcontractors. Databases were established for the construction methods developed, but these were not fully shared nor was there any record of them being accessed electronically during the periods studied. They were simple databases of 2D data, but that may be due to standards for 3D modelling not being established.

Conclusions on new technologies generally these do not replace older ones but continue to exist alongside them. One exception in this research is that Email has become widely established and is replacing Post and Fax. Meetings are still important for shared understanding of, and commitment to, a project, and the telephone, now usable from anywhere on the site, is still the most widely used form of communication. Project webs were the major development during the period studied and the partners in the consortia gained useful experience of their use. In future there will be faster connections on mobile phones allowing more use of the Internet.

Limited continuity between projects although the same consultants and contractors were involved throughout the development project, there were gaps in the sequence of projects and different clients resulted in the projects being located in different parts of Denmark. This meant they were managed from regional offices and most projects used different personnel. There was therefore little more continuity in the transfer of IT experience than traditional projects have, except for the use of a standardised method of building.

Solving problems reverts to traditional methods although there was only one incident involving design changes during construction that was fully reported, this shows that, when a problem needs to be resolved quickly, people turn to the traditional methods – telephone, meetings and fax. Meetings to initiate a solution are

understandable since problems require input from several partners, but they do take time to arrange and greater use of Email would have been expected.

Level of IT use disappointing compared with the original proposals for IT use, the consortia have achieved much less, but new technologies have emerged during the PPB project and several companies used their housing projects to test out Project webs, for example. Generally the partners have used the technology they were introducing elsewhere, and in management and logistics this is often different to that of their PPB partners. Levels of IT use in communications compared with traditional means vary from 4.6 times less to 1.2 times more, but this may be due to the stage at which each project was studied. Even 6 years is a short time to change human attitudes to the means of communication used, in spite of impressive new technologies being available.

8. ACKNOWLEDGEMENTS

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