TECODIS. The experience of teleworking for software developers

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Because of the increasing competitive pressures from globalisation, organisations are looking for better ways to face this challenge based on more flexible and effective working methods. Teleworking has been identified as one possible answer to this problem.

Management of big software development projects, distributed among several design centres, has also already taken place using well-established applications (eg e-mail, file transfer, remotely accessible databases) but using basic platforms and supported mainly by narrowband networks.

These applications have not proved to be effective nor have they been able to avoid the costly relocation of resources. That is to say, either short trips for meetings for co-ordination, review or clarification purposes or medium term (eg weeks or months) relocation for longer lasting tasks that require close involvement of key experts.

To achieve a more effective and cost-efficient implementation of distributed software development projects by large multisite and multicultural organisations a new telework project, TECODIS, was launched in September 1995. TECODIS uses a technological platform capable of supporting remote synchronous human-to-human communication.

After developing its own teleworking methodology and successfully performing sufficient industrial trials under real life conditions, it can be stated beyond any reasonable doubt that TECODIS has managed to prove its case. That is to say, it has been able to demonstrate that telework can be a useful tool to improve industrial software production in a multisite and multicultural corporation. The benefits are shown in the reduction of project lead-time, while keeping cost and quality under control.

Although, by any criteria, the experience can be considered a success, it has also revealed considerable minor concerns, and even unexpected fears, amongst some participants about the possible organisational impact and the change of working conditions in general, and in particular on employment.

The importance of this message cannot be overemphasised because it came from an organisation that was already familiar with telework and is beyond the scope of any one culture.

It is, therefore, a serious call for attention to the need to carefully plan this type of experience, particularly in terms of its possible communication strategy, to avoid the participants feeling threatened by the prospects of an experience that it is already challenging enough in itself.
NEW FUNCTIONALITIES FOR THE USER

The Project Platform

From the beginning of the project it was considered important to have a communication platform with advanced facilities, like the ones provided by common PC based videoconferencing systems, mainly for the purpose of project management and internal project communication. These platforms allow users to communicate using audio and video and, with some additional features, to share applications.

Additional equipment is necessary to support anything more than point-to-point connections. These units are called Multipoint Conference Units (MCU).

A survey of various videoconference systems available at that time was performed and the systems were evaluated with respect to functionality and interoperability. The following systems were examined:

- TELES Vision M and MTM (PC-based)
- ELSA Vision (PC-based)
- TANDBERG Grand Vision (Studio)
- Picture Tel PCS 100 (PC-based)
- VTEL 127 S (Studio)
- CLI Eclipse I (Studio)

From those results it was concluded that the ELSA system offered the best price/performance ratio. It offered a full H.320 compliant PCI-based system using state-of-the-art DCI display technology over the PCI bus. It could interoperate with all of the systems tested without major problems. The characteristics of the system can be summarised as follows:

- Single BRI ISDN PCI board providing integrated voice, video & data communications
- H.320 compatible
- Support for Application Sharing
- Operating system: Windows 3.x, Windows95

To support meetings using this system, access to an ISDN MCU ("Multipoint Conference Unit") was needed to allow for the simultaneous connection of more than two partners in the same videoconference.

Service definition and requirement specification

To facilitate the collection and clear description of the requirements that teleworking would place on the TECODIS Teleworking Platform (as well as on the organisations in the Demonstration project), a Teleworking Model was prepared. This was based on the analysis of the User Business Processes and was used as a base to capture the Teleworking Requirements Specification.

The following definition of a ‘Project’ will be used: ‘A set of non repetitive activities with clearly defined goals and synchronising decision making points, with a limited duration, a fixed budget, to be executed by an ad hoc assigned temporal organisation’.

In a project, there are usually several units, business areas or companies involved. The
necessary co-ordination and/or co-operation requires a consistent project methodology.

The related processes of projects were studied, whose main phases were identified as: Pre-study, Feasibility Study, Execution and Conclusion. As a next step, the main actors involved in the different project phases were also identified. The most important roles in a project are: Line managers, Project and Subproject managers, Project staff, Designers, Testers and Technical experts.

The interaction model was then developed, taking into account the interactions of the previously described project phases and roles. A subsequent step in the model was to identify the communication/interaction scenarios that could be supported by teleworking. These scenarios are:

- Resource Assignment / Joint Detailed Planning
- One-way Person-to-Person Communications
- One-Way Communication with Data Base
- Information Clarification / Technical Consultations
- Reviews / Inspections
- Project Meeting / Project Follow-up
- Project Planning and Problem Solving
- Performance Evaluation and Career Planning
- Unit Meetings and Teletraining

The scenarios referred to above were elaborated by studying the basic content, the needs and requirements of a possible teleworking platform, the users involved, the frequency of usage, set up procedure and whether or not a moderator would be needed. These scenarios were later validated with the actors who participated in the first round of interviews. This led us to specify two sets of requirements: The Basic requirements and The Platform requirements.

**OVERVIEW OF THE ENABLING TECHNOLOGIES**

**Project Teleworking terminal**

After having identified the requirements, the ISABEL application was selected from the most suitable applications available as the main component of the teleworking terminal. Two main aspects were considered in that decision: it was being developed by one of the project partners, which gave the project total control of it and it represented no additional costs, and it was an open application that was already used in distributed experiments all over Europe.

But, some changes had to be made to the application. The main change was the need to port the application to the Solaris 2.5 operating system from the previous SunOS 4.1.x. The main problem to solve was the correct operation of the Parallax drivers in the new operating system. During the project the teleworking terminal was constantly updated. The main improvements were:

- **Addition of Data Flow Control** mechanism in order to have the Teleworking Platform work properly and efficiently on the public ISDN network. This provides for constant bit rate
connections and additional mechanisms needed to control the way information is delivered for transportation by the network. With these mechanisms, the traffic generated by teleworking terminals presents a less bursty profile, which can be handled more easily by network elements.

- **Addition of multicast mechanisms** suitable to be used on the ISDN public network. The addition of multicast to the network was needed in order to make efficient use of network resources. In a multipoint-to-multipoint network configuration, multicast is of great importance to reduce the traffic being sent to the network. Without it, a fully meshed network would have to be set-up and a copy of each piece of information would have to be sent to all the other partners. With the mechanisms adopted, based on the concept of a flow server, terminals only have to send one copy of the information they generate to the flow server. In the TECODIS environment this means a lower number of ISDN B channels being established between remotes, which means lower communication costs.

- **Inclusion of new components and refinement of others**: Application Display Sharing, a new Whiteboard and a Document Camera tool were added to the TECODIS Teleworking Platform to meet the previously identified requirements. Other components, like the Telepointer and Audio tool, were changed to be more stable and provide more functionality.

- **Integration of the Quality Support Services**, related, mainly, to security aspects.

**Network aspects**
In the first phases of the project, an evaluation of the available technical solutions was made considering the constraints related to the entities involved in the experiment. Several possibilities were considered, such as public ISDN, ATM, leased lines, GSM and corporate networks, besides the local area networks at each of the premises (see Figure 17).

![Figure 17](image)

The main requirements were the need to support group communications, connecting more than two sites and optimising bandwidth usage to transport audio, video and data flows with the required quality. The technologies available at participant sites and the mechanisms to
set up network connections also played an important role in the final decision.

In the following table a cross comparison of the solutions is presented, summarising the main factors the project considered. GSM was automatically excluded due to the reduced available bandwidth. In the end, the project concluded that public ISDN presented the best solution at that time, mainly due to the necessary compromise between geographical coverage of the adopted solution, costs and flexibility. ATM, the most appropriate technology to be adopted, was not available at the industrial partner premises.

<table>
<thead>
<tr>
<th></th>
<th>Leased Lines</th>
<th>LAN</th>
<th>ISDN</th>
<th>ATM</th>
<th>Corporate Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Costs</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Communication Costs</td>
<td>Null</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Null</td>
</tr>
<tr>
<td>Availability</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Null</td>
<td>High</td>
</tr>
<tr>
<td>Geographical coverage</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Reliability</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Available bandwidth</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Additionally, the flexibility of ATM was very low due to the fact that network operators only establish ATM connections on a PVP basis and need some time (hours or even days) to establish connections. This was impracticable when it was not possible to schedule the teleworking platform usage in advance and when the intention was to use it with the same frequency as a normal phone. Corporate networks were excluded due to the limited bandwidth available. The disadvantage of the Leased Lines solution lies in the high fixed costs.

**QSS integration in the teleworking platform**

The QSS is the part of the Teleworking Platform supporting the quality related (ISO 9000) teleworking requirements. These requirements are mainly data authentication, data integrity and data confidentiality, applied mainly to the secure interchange of electronic mail messages and document management.

- To provide these services it is necessary to rely on a TTP (Trusted Third Party) service as a basic part of the system, incorporating the RA (Registration Authority), the CA (certification Authority) and the KPGA (Key Pair Generation Authority).
- The **TECODIS** TTP is based on the latest standards in the field—mainly RSA for the asymmetric encryption, MD5 for the hashing, DES for the symmetric encryption, X.509 for the certificate formats and PKCS#7 for the file formats. Compliance with standards was vital to achieve the desired level of integration with commercial products (browsers and mail clients).
- Secure document management was implemented as a new application that performs the
necessary operations, basically document signing and encryption. Secure mail management (again, signing and encryption) has been achieved by integrating the TECODIS CA with a commercially available tool (Netscape Communicator browser and mail client).

**THE TRIALS AND RESULTS**

**Model definition**

TECODIS’s first approach to evaluation was based on a questionnaire to capture the users’ needs and opinions. The questionnaire was organised in two broad chapters, *Users’ and Managers’ Perspectives* covering the following subjects:

**Users’ Perspective**
- Functional suitability
- Usability and acceptability
- Quality of Life

**Managers’ perspective**
- Human resource allocation
- Productivity
- Economy
- Decision Making and Lead time
- Quality
- Overall management perspective

The questionnaire was redefined to separate the subjects to be evaluated through Cross Impact Analysis (CRIMP) and Organisational Impact.

The second step took place simultaneously with the teleworking platform development and consisted of a search for a model to cover three main purposes:
- To communicate the rationale which supports the TECODIS model
- To make the relationship between all variables explicit in a systemic way
- To quantify as much as possible the effects of all variables on the Project results in accordance with the Project objectives.

With all these elements we developed a simulation of the model covering two broad lines:
- To build up alternative scenarios of the future, and to simulate the behaviour of the different trend variables, to assess the possible and actual impact on project objectives (cost, quality and lead-time)
- To gather information on actual organisational processes and climate in order to assess the organisational impact

The first purpose is met for TECODIS by a Cross-Impact Matrix (CRIMP). To create such a matrix, a TECODIS Systematic Model (TSM) was built, including major trend variables and their interrelation for simulating different project behaviour.
The Cross Impact Analysis (CRIMP)

CRIMP is based on a mathematical cross impact analysis. This model serves to generate future scenarios, which take into account possible developments and the interrelation of all the variables of the model. A change in any of the variables will impact the others and consequently the final results.

This tool takes into account three main driving forces that affect the output: trends of the system, external events and actions that will influence the course of trends.

The construction of a Cross-Impact model is impossible without the introduction of a time dimension. The time span of a model must at least encompass the planning interval, extending from the present to some future time horizon.

The TECODIS Model

TECODIS, as any other complex project, has several interrelated processes of a sociological and technical nature, which eventually may impact on business results as well as on organisational life and culture.

All these processes aim at three major results in industrial software development, which we therefore consider to be the Result Variables: Lead-time, Cost and Quality.

The rest of the variables were selected in three stages starting from three core variables and deploying them until we arrived at a satisfactory level of insight.

Finally, we set the interrelation and the expected impact (positive or negative) between variables and results, which is shown in Figure 18.

![Figure 18](image)

The Demonstration Phase

The last phase, called Project Demonstration, was defined to provide feedback in terms of the functionality that the teleworking platform should provide for it to be fully useful in the industrial environment.

The trial ran among the three initially planned sites (Madrid, Aachen and Stockholm-Kista), plus an additional site, also located in Stockholm but in another metropolitan area (Älvsjö). This additional site required extra technical work in order to have the four sites connected. It was motivated by the need to connect the TECODIS network (private IP network on top of an ISDN network) to Ericsson's corporate network. This connection had some security implications, which were solved by call screening based on ISDN's CLID (Calling Line Identity) in the routers' ISDN interfaces. Besides this, a tunnelling based solution was
put in place to connect the two Stockholm sites to the ISDN router.

The trial covered all the scenarios contained in the Teleworking Model for distributed software development along all the software development process phases. The coverage of all phases was achieved by running the trial on three development projects, running among all the four sites involved. Since the three projects were scaled in time, all development phases could be covered. The need to use more than one project came from the fact that a development project takes much longer than the trial’s planned duration. The four trial sites are responsible for different parts/roles within the GSM systems development unit in Ericsson.

In parallel to the industrial experiments, a field trial with users—designers—working from home was performed in the R&D Centre in Aachen. Users at home used PCs with Windows 95, Windows NT and Linux, Sun workstations with Solaris, ISDN boards, analogue modems and GSM phones. This was used mainly to access mail servers, databases and to perform low quality videoconferencing on a point-to-point basis. Remote access to the company network was identified as a critical issue in several respects.

However, these experiments were only used to improve and develop performance on the technical part of the platform. The reason we could not take advantage of the users’ feedback about this different teleworking concept was that few experiments were performed, due to the restrictive conditions the German law applies for the teleworker’s environment at home. For this reason, there was no further analysis of these experiences, as planned in the project proposal, and we had no time to modify the schedule to perform this kind of trial in other countries, or even to check what the law specified in other European countries.

**Final results**

All evaluation activities were oriented to identify to what extent the project’s objectives had been met in terms of business and organisational impacts.

Every user was asked to quantify his/her perception of the impact on each relevant variable after using the Tele-work platform. The questionnaires included two responses for each question (before and after using the Tele-work Platform) for each variable. Users were also asked to express their opinion on the probabilities that the reported impact was actually going to take place.

A total of 288 users were involved in the three projects considered, covering different organisational levels and functions as follows:

<table>
<thead>
<tr>
<th>User Type</th>
<th>% Of Total Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managers</td>
<td>22</td>
</tr>
<tr>
<td>Project Managers</td>
<td>10</td>
</tr>
<tr>
<td>Project Staff</td>
<td>19</td>
</tr>
<tr>
<td>Designers &amp; Testers</td>
<td>22</td>
</tr>
<tr>
<td>Experts</td>
<td>27</td>
</tr>
</tbody>
</table>
The most relevant variables, called Results Variables, show a positive impact from the implementation of Telework for distributed software development in a multisite and multicultural organisation. Lead-time shows an average reduction of 17%, Cost also shows an average reduction of 14% and Quality, measured in terms of fault density, shows an average increase of 8%.

With regard to lead-time, all the users reported a positive view of the Telework impact. However, Experts, Project Staff and Designers were more optimistic in their perceptions than Line and Project Managers.

In the case of Cost, there was also a strong correlation in the overall orientation of the answers and the model. Here too the experts appeared to be more confident in the enabling power of the technologies used than did managers and staff; probably due to the fact that experts and designers are more used to working with new technology and subsequently more able to detect its potential power.

For Quality, there appeared to be considerable consensus on all the answers, with the only exception being that Project Staff seemed to have a slightly pessimistic view of the expected impact. To a certain extent, designers and testers appeared less optimistic, probably due to the fact they are afraid that, with the introduction of teleworking, more restrictive personal goals on quality could be imposed on them.

In addition, the comparison between the model and the reported results showed that in general real users answered in the same orientation as the model but with a lower level of accomplishment. This may be due to several related factors. Chief among them is the fact that the original model was primarily built with the input of experts who were very aware of the enabling power of the technologies to be used. Consequently, they managed to make their case about the impact of incumbent variables. As the result of that, the addition of all these variables may tend to add up to more than the overall sum likely to be seen when all the variables interact in a real world scenario.

In summary, from a user perspective, the comparison between actual results and the model clearly shows an improvement in Lead-time, a small reduction in the forecast Cost impact and also an improvement in Quality (measured in terms of lower fault density). All the three Results Variables are in accordance with what was originally forecast by the model. The following figure shows a comparison of the forecast results from the simulation model, the perception of the users in the initial step of the industrial project (early results) and the final results.

<table>
<thead>
<tr>
<th>Users' Perspective</th>
<th>Managers perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional suitability</td>
<td>Human resource allocation</td>
</tr>
<tr>
<td>Usability and acceptability</td>
<td>Productivity</td>
</tr>
<tr>
<td>Quality of Life</td>
<td>Economy</td>
</tr>
<tr>
<td>Decision Making and Lead time</td>
<td>Quality</td>
</tr>
<tr>
<td>Overall management perspective</td>
<td></td>
</tr>
</tbody>
</table>

Figure 19
The multicultural dimension of the problem was also exposed by the evaluation questionnaires. Although it was originally thought that the prevailing strong corporate culture was going to be enough to offset any possible impact of the other cultural filters, experience has shown that these differences are still there. It became apparent that the participants from Germany on one side and Spain on the other seem to have the most extreme perceptions of changes, whereas their Swedish counterparts tend to position themselves in rather more balanced positions.

Regarding the possible organisational impact, the results coming from the actual trials have largely confirmed the initial presumption that no major change could be perceived in the short term. Furthermore, even the most enthusiastic participants have shown a certain degree of scepticism as to the extent by which the organisation may be affected in the short term by the introduction of telework.

By the same token, it is also worth mentioning that no negative impact has been reported. This may be considered as a very positive outcome, taking into account that, in private discussions, some people have expressed considerable concern over the possible negative impact that these technologies may initially have on their physical work place (hot-desk syndrome) and later on their actual employment. Some people may even see the introduction of telework as a first step in some companies’ payroll reduction objectives (ie a suspicion of a certain “hidden agenda”).

Regarding the Organisational Climate, the questionnaire was not intended to make a full assessment on a variable as complex as this one. It only attempted to get perceptions from the participants about how the possible changes introduced by the new way of working could end up affecting their working environment, particularly in terms of stress, motivation and performance recognition.

In this sense, it is worth recording that no meaningful negative impact on the organisational climate has been reported, despite some unexpected fears from some participants on possible “hidden agendas”. Another way to interpret the same result could be to consider that the motivation generated in the team was high enough to compensate for the negative effects of those possible fears.

In the following two tables we can see some of the conclusions reached for the organisational impact analysis.

**Stress Level and Motivation Evaluation Table**

**Answers measured in %**

**How do you think teleworking has affected your stress level?**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>9</th>
<th>82</th>
<th>0</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same</td>
<td></td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Considerably</td>
<td></td>
<td>9</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**How do you think teleworking has affected your level of motivation?**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>8</th>
<th>64</th>
<th>14</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased</td>
<td></td>
<td>8</td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Slightly</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased</td>
<td>14</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Considerably</td>
<td></td>
<td>14</td>
<td></td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

**Are you having more free time for yourself as a result of teleworking?**

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>50</th>
<th>42</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Even less</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Much more</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Communication and Leadership Evaluation Table

ANSWERS MEASURED IN %

Do you think that the teleworking platform improves relations among experts?

- 0 No
- 36 I do not know
- 18 May be
- 46 Yes
- 0 Very much so

To what extent do you believe that telework impacts authority and leadership?

- 10 No impact
- 20 I do not know
- 0 Positively
- 30 Yes
- 40 Negatively

It seems very relevant that 50% of managers say that they do not feel comfortable in their management role when supervising teleworkers. This seems to be a clear explanation for some of their pessimistic/negative answers to some of the variables previously commented on, particularly regarding their perceived needs for resource relocation as well as their higher (than the average) estimate of communication costs.

Finally, regarding the usability of tools provided by the teleworking platform, the following table shows the users’ perception:

<table>
<thead>
<tr>
<th>Functional Value Evaluation</th>
<th>Answers measured in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Value of</td>
<td>Not needed</td>
</tr>
<tr>
<td>Video Communication</td>
<td>0</td>
</tr>
<tr>
<td>Audio Communication</td>
<td>0</td>
</tr>
<tr>
<td>Shared Whiteboard</td>
<td>0</td>
</tr>
<tr>
<td>Tele-pointer</td>
<td>0</td>
</tr>
<tr>
<td>Shared display</td>
<td>0</td>
</tr>
<tr>
<td>Slide presentation manager</td>
<td>0</td>
</tr>
<tr>
<td>Fax component</td>
<td>0</td>
</tr>
<tr>
<td>Shared editor</td>
<td>0</td>
</tr>
<tr>
<td>Data encryption</td>
<td>0</td>
</tr>
<tr>
<td>Document authentication</td>
<td>5</td>
</tr>
<tr>
<td>Electronic mail authentication</td>
<td>5</td>
</tr>
<tr>
<td>Electronic mail encryption</td>
<td>5</td>
</tr>
</tbody>
</table>

**Recommendations**

The recommendations outlined in this section are intended to reflect, from a management viewpoint, the learning experience of the TECODIS management team in its effort to introduce telework as a common sense tool for distributed software development in a multisite and multicultural corporation.

**On planning**

The introduction of telework, even on a trial basis, represents a considerable challenge for
any large organisation. Every aspect needs careful and detailed planning well in advance to avoid negative perceptions, misunderstandings or even open opposition from key actors. Chief among the issues that need careful planning are the communication strategy, the technological platform to use, the training programme to apply and the learning-oriented evaluation to implement.

Regarding the issue of substitution for travel to meetings, it should be taken into account (and has been commented on by users) that a teleworking platform cannot totally replace the need for travelling. It is a matter of common sense that personal contact is in some cases indispensable. The recommendation resulting from this point is to plan carefully, in the early phases of the project, which travelling can be avoided and which cannot.

One example in this case could be project management meetings, used for project follow-up, that on average are scheduled on a monthly basis. Some sort of personal contact between the overall project manager and the corresponding subproject managers (one for each site) is a must. However the need for project tracking meetings every month is difficult to justify and rather expensive. In the TECODIS project (taken as a model) the partners agreed, once the project was totally stable, to use ISABEL for every second Project Management Board meeting. The results were quite acceptable, but the actual schedule of meetings should be considered and planned for in each project.

**On the communication strategy**

The importance of communication for the success of the experience cannot be over emphasised. Communications is key in all the steps of the project from project preparation to evaluation.

The communication strategy needs to take into account all of the cultural filters people will always introduce, even if they are apparently not aware of it. To rely exclusively on the belief that the corporate culture would be enough to compensate for these site dependent cultural differences could be a serious mistake.

Communication should avoid anticipating possible organisational changes. On the contrary, it should try to overcome existing apprehensions or fears at all organisational levels. For different reasons, these fears are present at practically all levels, although it may be more evident at middle-level management.

It is therefore advisable to involve the middle-level management in the early planning phases of the project. They should also develop an ad-hoc methodology for controlling and supervising their own people when working for other projects through teleworking platforms. They could even use the teleworking platform themselves for such management.

**On the technological platform**

The decision to select an R&D product such as ISABEL as the supporting platform for TECODIS, although proven to be a good one to meet the demanding functionality required by the target users, came as an inescapable decision due to the lack of a commercial alternative.
This has, in turn, resulted in the need to further develop the existing platform, while still planning and even trying to implement the first trials.

The time consumed for platform development, avoidable by using products already in the market (if they were available), introduced negative reactions among the key actors.

The main suggestions received from the participants can be summarised as it follows:

- Larger shared display
- Improve sound quality
- Availability of more than one camera
- Better bit rate
- Problems of booking rooms and equipment
- More detailed step-by-step documentation (user oriented)

**On training**

The fact that, in the case of TECODIS, there was not a formal training package available to support the trials may prove to have been a bad decision. There was apparently an excess of confidence in the perception that telework was a concept already well known in the organisation as well as in the high level of technical competence of the actors involved. Although these two assumptions were in general correct, the lack of a formal training program to guide the actual trials was a fact that many key actors regretted.

**On key strategic allies**

It is important to identify and to capture key strategic allies (or supporters) as early as possible in the process of implementing the project. The experience gained during the TECODIS trials seems to suggest that it would be equally easy to get these allies from two apparently extreme levels. The upper management is particularly concerned with the possible impact of telework on the project lead-time for competitiveness reasons. At the other extreme, the people who are more able to grasp the enabling power of the new technologies are concentrated at the technical level.

**On the evaluation methodology**

A learning-oriented evaluation methodology is the key to securing timely feedback on critical aspects, especially the communications related ones. It is very important to communicate clearly to be able to develop a shared vision, a common understanding on critical issues and an overall feeling of being stakeholders among all participants.

This can only be achieved if people perceive that their contributions are considered important, their needs are listened to and they do not feel threatened by evaluators that behave as auditors.

To a large extent this has been the experience of TECODIS and is thus a key success factor to recommend to other organisations trying to implement very challenging projects like TECODIS in a very complex environment.
Outstanding issues

The solution adopted to support network communication between remotes, based on public ISDN and the PPP, MP and IP protocols, even if not the solution initially planned by the project, proved to have sufficient flexibility and reliability. The public ISDN network is available almost everywhere in Europe and is widely accepted by everyone. That is in contrast with ATM, which is not yet available to the common user and, in particular, was not available at TECODIS industrial partner’s premises. On the other hand, the ISDN solution posed some interoperability problems between equipment from different vendors, related with the MP protocol and security (CHAP protocol). Although a commercial broadband solution with European coverage would be a great advantage for the development of multimedia applications for enterprise co-operation, the development of multimedia platforms under narrowband conditions must continue, especially as new facilities in mobility networks (UMTS, GPRS) will provide emerging conditions for this kind of co-operation.

The adoption of an IP based solution and the type of selected terminals (Sun WS) proved to be a good compromise. With this solution, the project gained a terminal that proved to be easy to use and well integrated in the daily working environment of teleworkers. The drawback is the costs involved in setting up the teleworking platform. First, terminals require specific pieces of hardware, namely a Parallax Videoboard for video encoding, and the gateway between the private and the public networks was made using IP routers. Also, a significant amount of effort had to be put in to the terminal design to reduce the bandwidth needed for communications and to adapt traffic with a variable bit rate profile to the constant bit rate available in the public ISDN network. However, to get a greater penetration of these kind of multimedia facilities, the applications must include portability to cheaper platforms like the PC world.

Quality Support Services were integrated with success in the TECODIS teleworking platform. This assumed a particular importance when the Ericsson corporate network had to interconnect to the public ISDN network. In addition to the security level achieved by the ISDN and IP network, teleworking sessions were open only to authenticated people. It is interesting to note that these security conditions were a requirement from Ericsson to allow transmission of internal information over the ISDN network. The conclusion from this experience is that the development of security aspects over IP protocols is not only limited to electronic commerce.

Regarding interoperability between different platforms for telework practices, the project performed a number of studies. This addressed several areas, from available videoboards providing the same coding standards on different platforms, to the identification of standards applicable to the domains in which the project was moving. The common acceptance of H.323 was identified as the solution to achieve interoperability between different types of terminals working on top of different network technologies.

The selection of the Isabel application as the main component of the TECODIS Teleworking Terminal proved to be crucial for the success of TECODIS. During the project, some important
changes in project strategy had to be implemented (e.g., change from broadband to narrowband, QSS component integration, integration of new components) and its open architecture and the control the project had on its development facilitated the execution of those changes. Otherwise, if a commercial platform had been chosen, that would have been an extremely difficult, or even impossible, task to be performed without changing the base terminal, going through a new training phase and losing some features to obtain others.

One other aspect, regarding the legal coverage and conditions the law provides in European countries for teleworkers, is that it would be highly valuable to have or promote a comparative analysis, or even to initiate some European recommendations acting as a guideline.