Expectations and experiences of CSCW in an engineering environment

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Existing organisational context and user expectations have a huge effect on the success of introducing CSCW technology, and should have a correspondingly strong influence on the choice and design of these tools. This paper first discusses organisational context and end-user expectations encountered in a large distributed engineering organisation planning to implement a CSCW pilot. It is demonstrated that while the organisational structure was apparently ripe for support with CSCW tools and tools existed which matched clearly expressed user requirements, potential users remained sceptical of their value. An account is then given of the pilot itself, where a range of collaborative technologies was implemented, of which the primary tool actually used was email. Reasons for this are discussed. While this organisation is, in the final analysis, unique, we hope that our conclusions will be of interest both to practitioners working in similar contexts and to CSCW researchers.

1. Understanding organisational context

Many authors have stressed the necessity of tailoring CSCW applications to organisational realities, whether this be in the larger sense of the whole organisation, for example, Orlikowski's case study of the introduction of Lotus Notes™ and Grudin's generic observations on matching systems to context [1, 2]; or in the smaller sense of individual workgroups, their practices and cultures, exemplified by numerous reports such as [3-8]. In establishing organisational context for the DUCK[2] project (see next section) we explored organisational structure, infrastructure and culture as well as eliciting organisational and end user requirements for, and expectations of, CSCW technology. We were particularly interested in existing expectations and perceptions, so as to plan appropriate technology, training and support, and ideally to identify benefits for those who currently foresaw little personal gain from the introduction of collaborative tools.

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1.1. The project

DUCK aims to provide a specialist CSCW toolset for the practice and management of engineering design. The project is supported by funding from the DTI and EPSRC and comprises a consortium of academics, IT specialists and a large engineering company which will be referred to as *Metre* in the text which follows. DUCK is a three year project and began in January 1994.

1.2. The organisation

Metre Ltd operates in the domains of marine engineering, software engineering and command and control systems. Its clients are predominantly from the defence industry. It is a joint venture company formed by two large organisations in the engineering domain. Metre's history and ancestry are however rather more complicated than this simple statement would suggest, and has involved a number of other organisations which have changed names, disappeared and reappeared over the years: this has consequences for organisational structure, culture and work practices. Much of the impetus behind the DUCK project arose from a realisation within Metre that CSCW technology might have a useful role to play in improving its current collaborative work practice.

1.3. Requirements methods for CSCW

Best practice in requirements engineering is a vexed issue, and the subject of much current debate. A wide choice of possible techniques and approaches, varying in formality and focus, are preached and/or practised. Even the choice of nomenclature can be contentious, as Jirotka and Goguen [9] note. In the context of the current work, we prefer to *elicit* requirements, rather than to capture, define, specify or generate them. We do not consider that requirements exist fully formed in the minds of stakeholders, ready to be somehow acquired and tabulated, but that they may need to be stimulated by consideration (and eventually prototyping) of potential socio-technical solutions. However, such techniques need to be used with care to avoid generating requirements divorced from current organisational realities. This organisational and solution focused approach stems largely from the work of the ORDIT project (Esprit 2301) [10] and elements of the ORDIT methodology for eliciting organisational requirements have been used in the current work.

Requirements elicitation for CSCW necessarily involves consideration not only of individual end-users, but also of the way they work together. The initial requirements exercise for DUCK focused heavily on these issues in stakeholder interviews. In the DUCK context security considerations at Metre and project resource constraints precluded the use of more situated techniques deriving from ethnography and the methods adopted were therefore traditional ones. These initial methods were:

- scoping interviews with key policy-making stakeholders;
- interviews with a range of other stakeholders;
- validation of interview material;
- organisational and end-user cost-benefit analysis[3];
- questionnaire survey of a larger group of stakeholders.

As the project progressed, the information generated by these methods was supplemented by the results of the first DUCK pilot implementation at Metre as described in the final sections of this paper.

2. Context, requirements and expectations

2.1. Structure and infrastructure

The Organisational structure at Metre

Our first scoping interviews revealed the complexity of Metre as an organisation. There are three divisions: Fighting Systems, Engineering and Aquatics. Within each Division are four technical subdivisions and central support functions; each subdivision is further organised into a number of business areas.

The company's nine sites are widely scattered throughout the length and breadth of the UK: this distribution is in part attributed to the location of the various antecedent companies, while other sites are located close to prime customer sites. There is at present no intention to rationalise this distribution. Divisions, subdivisions, business areas, project teams and specialisms are distributed across sites. Metre presents a diversity of organisational climates, which vary with the type of work undertaken, the expectations of clients, and the traditions of particular disciplines or sites. Co-ordination is achieved through frequent meetings, a practice in part originating from procedures convenient for staff distributed around central London. This means that travel is a heavy overhead: senior staff will be away from their base at least one day a week and frequently as many as four or five days.

Project teams vary in size from around 3 to 30 or more people, and project time scales from 6 months to 2 years or more. The start of a new project often requires people to move house or commute long distances daily or weekly. The team is then redistributed at the end of the project. Staff may also move between projects and sites as part of their career, or timeshare between projects at different sites.

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[3] An ORDIT technique, not reported in this paper.

A number of 'remote experts' with specialist skills (e.g. ergonomists, AI specialists) act as consultants to projects at their home sites and elsewhere. They are rarely dedicated to any one project for any length of time and thus are not generally transferred away from their home location. Current practice is for remote experts to travel as required, but this makes them temporarily inaccessible to other sites and removes them from most files and reference material.

Most staff were thought[4] to be receptive to technological change, although organisational change was recognised to be a more sensitive issue and to require careful handling. It was stressed that the climate for change would vary with the part of the organisation concerned. There was also some suggestion (from Facilities Management) that users were often unaware of the potential of their current tools, and therefore the introduction of CSCW would need to be backed up by substantial training effort.

The existing infrastructure

The scoping interviews revealed a highly heterogeneous range of hardware and software. While machines were often linked by local networks and secure data links between sites, the transfer of on-line information was limited and the use of email (both internal and external) far from common. Security was a key issue - this partly accounted for low use of external email, although Facilities Management observed that many users had access to internal mail but did not use the service. Machines were commonly shared, a feature of organisational life discussed in more detail in section 3.

2.2. User requirements

High level organisational requirements on any CSCW implementation were provided by the key stakeholders at the scoping stage. This first set was:

- reduce amount of travel
- improve co-ordination of distributed working
- tools must be usable without much training
- generate enthusiasm for CSCW by introducing tools as early as possible
- reduce need to co-locate teams
- current levels of security must be maintained
- stimulate a critical mass of users
- the tools must run on at least one of the existing hardware platforms

This set was then supplemented by the results of a round of 22 semi-structured interviews covering a spread of domains across a number of Metre sites. The interviews made contact with the stakeholder groups identified in the scoping

[4]by the Metre representative who held the key role of organisational champion for CSCW technology.

exercise and listed below. (There are of course other potential stakeholders outside Metre, e.g. clients, who do not appear in this list.)

Direct users

- project team members
- project managers
- business managers
- remote experts
- facilities management

Indirect users (i.e. use the technology infrequently or through intermediaries)

- business managers
- senior managers
- finance staff
- quality staff
- contracts staff
- administration staff

Systems staff

- facilities management

Change agents

- the Aquatics Technical Manager
- members of the Technology Boards
- the divisional Executive
- the Facilities Manager

Purchasers

- budget holders in business units
- facilities management

Above all, our interviewees wished to improve routine communication with distant sites through the type of facilities commonly provided by email tools, e.g. simple messaging, read receipts, message arrival alerts, file attachments and so on. They also considered that there would always be occasions when working away from the home site (or indeed at their own homes) for longer or shorter periods of time would be necessary, and in these circumstances they wanted to be able to access their own files and online reference materials. Those who had experience of working on large, distributed, collaborative projects suggested that some means of information sharing, remote reviewing, co-ordination and version control would also be helpful.

Most senior staff were keen to reduce the number of routine face-to-face meetings, but two significant caveats were expressed in this context. A desire was voiced for full spectrum face-to-face interaction where matters were to be negotiated (expressed vividly by one manager as... 'I need to see the whites of their eyes') while remote experts in particular felt that there was a need for occasional physical presence at other sites to maintain their visibility, and thus tacitly promote their services.

As is often the case with requirements work of this kind, despite our best efforts to the contrary, a high proportion of those interviewed were senior managers and consultants, whose main concerns were to streamline their communications and to reduce the burden of travel for people like themselves. Their junior colleagues tended to view the inconveniences of travel and relocation as an immutable feature of company life and usually focused on how to improve their own information resources, typically through access to libraries of reference materials.

Finally, in accordance with the ORDIT solution-focused approach, we canvassed opinions of possible technology matches to requirements. In some cases apparently very close matches could be found[5], but the potential users of these tools (particularly more junior staff) were often quite unenthusiastic about their potential - reasons mainly related to current culture and working procedures. A questionnaire survey was undertaken as a means of exploring further the context and requirements for CSCW tools.

[5]In one instance, a pair of individuals who had been responsible for co-ordinating a very large bid described their needs in terms which could have been drawn almost *verbatim* from a Lotus Notes sales brochure. When this was put to them (they were not aware of Notes), they replied, 'Oh, no, no-one would use that...'.

2.3. The questionnaire survey

Introduction

The questionnaire aimed to validate the initial requirements exercise and to extend coverage to more people; to gain an impression of how different CSCW tools were viewed, and to explore some specific premises suggested by the interview results. These were:

Premises	Rationale
Senior staff will express more positive attitudes to the CSCW technology than junior staff.	This was the case in the interviews. Junior staff were more preoccupied with the problems of carrying out their own individual tasks, which in most cases were relatively self-contained.
Staff who travel more will express more positive attitudes to the CSCW technology.	The technology may reduce the need for some travel.
Responses will differ according to the location of the respondent.	During the interviews references were frequently made to the varying culture of staff at different sites, e.g. degree of computer literacy, sociability and so on. Further, staff at 'distant' sites might be expected to be more enthusiastic about enhanced communications than those at 'central' sites.

The questionnaire was circulated via internal post to the 200 staff located across 6 sites (including two client sites) of the Aquatics division. Response was voluntary and anonymous, and it was made clear that the exercise formed part of the DUCK project rather than a management initiative. The text mixed forced choice questions and open-ended opportunity for comment.

Items covered the following areas:

- personal details e.g. job title;
- current working practice e.g. computer use, amount of travel;
- problems relating to communications, distributed working and travel;
- perceptions of the technology e.g. perceptions of the utility of each service, perceived frequency of use.

The services covered by the questionnaire are listed below.

- internal email
- external email
- remote sharing of applications
- shared electronic whiteboard
- desktop videoconferencing
- shared electronic daybook[6]

Since at least some of the services were likely to be novel, the functionality of each was described in the questionnaire text and a brief usage scenario provided. In the case of desktop video conferencing a screen shot was also included.

One hundred and three questionnaires were completed and returned, providing a 51.5% response rate.

3. Results

How were the different services viewed?

Respondents were asked to score the services on a scale of 1 - 5 for potential usefulness, 5 being the most positive score. Overall, enthusiasm was lukewarm, the mean for the most positively viewed service (internal email) being only 3.41. The mean for the least positively viewed service (desktop video conferencing) was 2.65. Thus, as figure 1. shows, the range in perceived usefulness was apparently not great.

[6]A concept under development by the DUCK project allowing designers to share emerging design information and enabling the recording of design rationale.

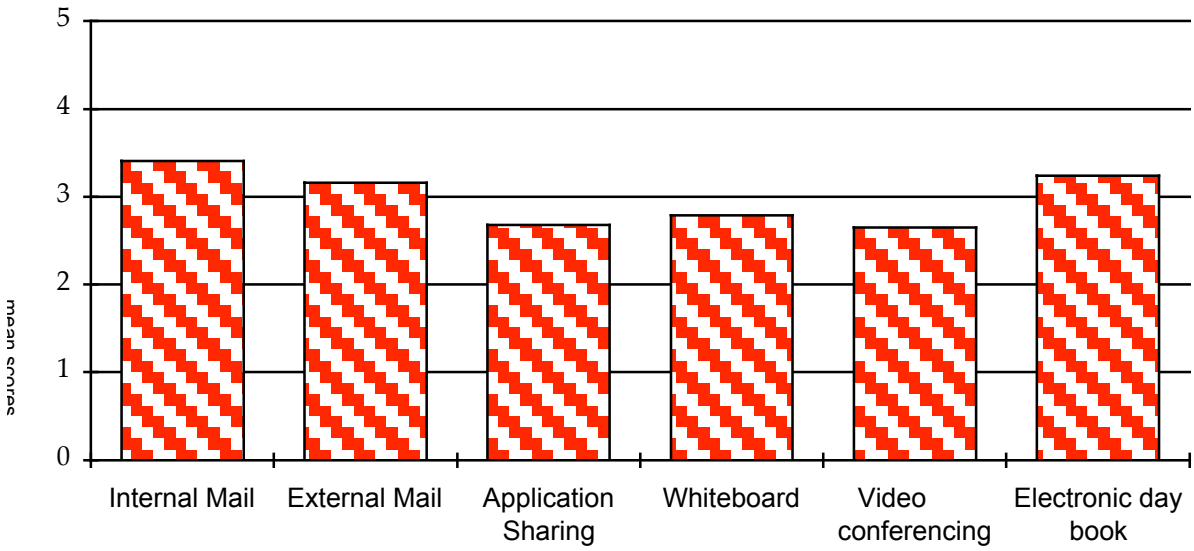

Figure 1. Mean scores for the services, scale of 1 - 5.

Taking mean scores in this way obscures the variation in the distribution of scores for the individual services. Applying an ANOVA [11] to the data clearly indicated significantly reliable differences ($p > 0.01$). A series of independent Student *t*-tests [11] was then conducted to identify where these differences lay. It is clear from the results of these that there was significantly more enthusiasm for:

1. internal mail as compared with application sharing ($p<0.01$), the electronic whiteboard ($p<0.05$) and desktop videoconferencing ($p<0.01$).

and

2. the online design journal as compared with application sharing ($p<0.05$) and desktop videoconferencing ($p<0.05$).

Consideration of this suggested dividing the six services into asynchronous and synchronous services. For this purpose, asynchronous services are those where users' communications are distributed over time, synchronous services those where communications take place more or less simultaneously[7].

[7]This spilt is only one of convenience: a fast exchange of email could be considered synchronous, whereas passing control of the input device in shared applications is strictly speaking asynchronous.

Asynchronous	**Synchronous**
Internal mail	Application sharing
External mail	Electronic whiteboard
Electronic day book	Desktop videoconferencing.

The mean score awarded by each individual to the services in each of the two groups was obtained. A *t*-test showed that the difference between the scores for perceived usefulness of synchronous and asynchronous services was highly reliable ($p<0.01$). The asynchronous services were scored much more positively, as shown graphically below - note the different peaks of the two distributions.

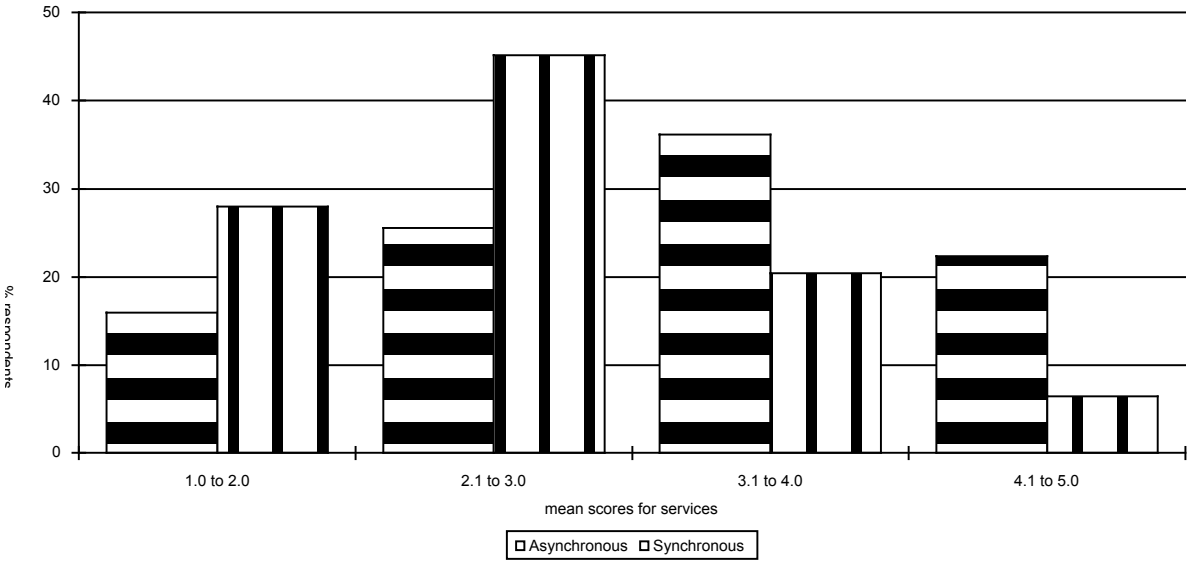

Figure 2. Mean scores for asynchronous and synchronous services compared

Do senior staff express more positive attitudes to the CSCW technology than junior staff?

Respondents were grouped according to their seniority using their declared job title, supplemented by background knowledge of job content at Metre. This resulted in groups of 33 senior staff and 61 junior staff. A *t*-test applied to these mean scores showed that senior staff were significantly more positive than their junior counterparts ($p < 0.05$).

Do staff who travel frequently will express more positive attitudes to the CSCW technology?

Respondents were asked to categorise the frequency of their business travel into one of six groups. These were:

- never
- more than once every 2-3 months
- every 2-3 months
- once a month
- every 2-3 weeks
- more than once a week

The results show that many of our respondents were frequent travellers.

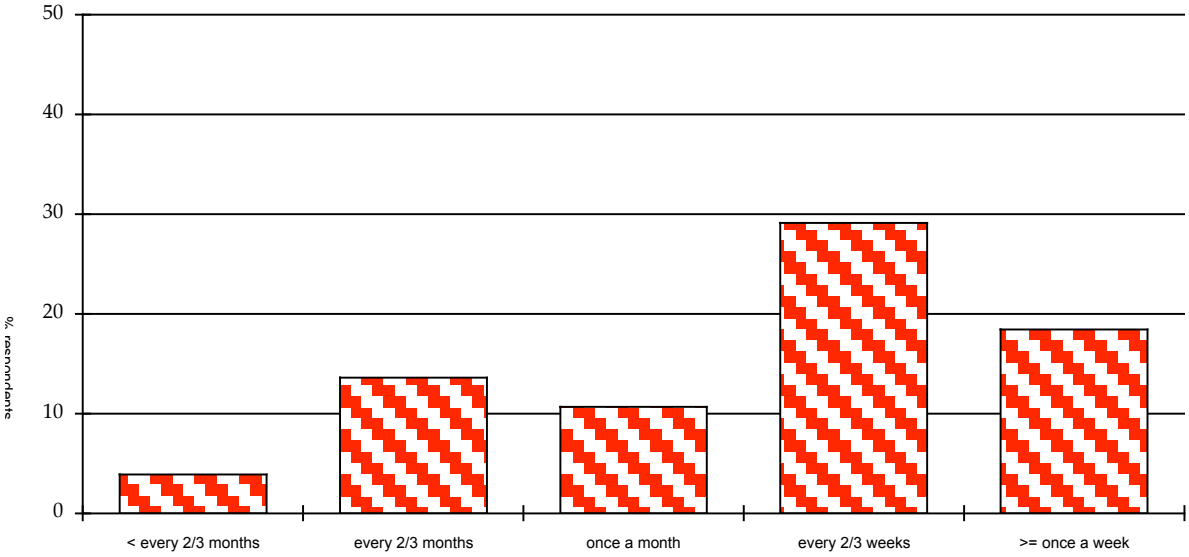

Figure 3. Frequency of travel by percentage of respondents in each group

The responses were divided into two groups:

- non-travellers and infrequent travellers (up to and including 'every 2/3 months';
- frequent travellers ('once a month' or more).

There were 37 non- or infrequent travellers and 57 frequent travellers. A *t*-test applied to the scores allocated to the services by these two groups supports the premise that frequent travellers will be more positive about the CSCW technology ($p < 0.05$).

Do responses differ according to the location of the respondent?

Respondents were grouped according to the 6 home sites. Results from two of the sites with only 1 and 2 responses respectively were discarded. An ANOVA applied to the scores allocated to the services by these four groups indicates that there are no reliable differences between the remaining sites and therefore the premise that the sites differ is not supported.

This completes the reporting of results concerning the *a priori* premises. Consideration of these, in particular the modest level of overall enthusiasm,

prompted examination of one further factor, access to computers[8]. It seemed possible that expectations may have been dampened because of current problems in access to machines.

Do responses differ according to ease of access to computers?

Respondents were asked how many other people used 'their' computer. More than half (53.4%) shared their machine with at least one other person, while 27.2% of the total group shared with two or more others.

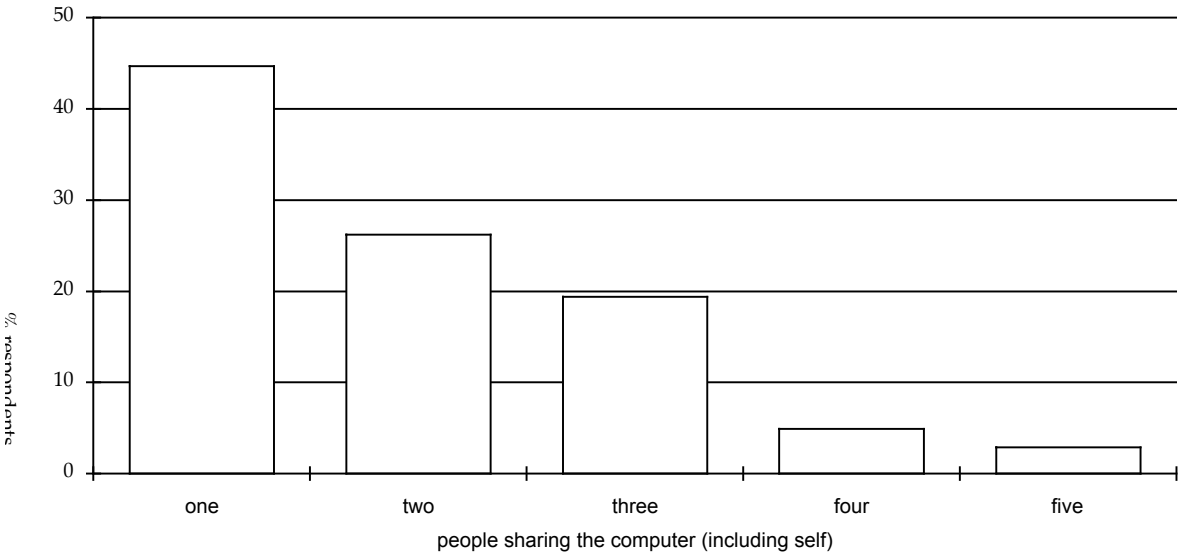

Figure 4. Computer sharing by percentage of respondents in each group

Respondents were grouped according to the number of co-users. Applying an ANOVA to the scores allocated to the services by these five groups indicated no reliable differences between groups - the degree of machine sharing had no effect on perceptions of the services proposed.

Discussion of questionnaire and interview results

The questionnaire results largely confirmed the impressions gained through requirements interviewing. Enthusiasm for CSCW was muted, but more evident in more senior staff and frequent travellers, and there was significantly more interest in asynchronous, as contrasted with synchronous, services. While managers and consultants expressed the most positive views, they wished to retain face-to-face meetings for matters of negotiation, for making new relationships and for maintaining their own visibility. For more junior staff, perceived benefits lay in improved access to information. The opinions expressed did not appear to be related to the home site of the respondents, contrary to expectations derived from reports of

[8]It was also useful to have information on the level of sharing for the planning of any large scale implementation of CSCW.

widely varying company culture[9]. Nor did the ease of access to computers, as expressed by the degree of machine sharing, appear to have an effect on potential users' views.

Why was the overall level of enthusiasm somewhat tepid? The free form comments collected in the questionnaire hint at some reasons...

People may find it difficult to visualise the benefits of new technology when they find their current infrastructure inadequate. This position is worsened if it is felt that only management benefit from the latest technical wizardry.

> Prior to any of the glossies mentioned here being procured, it would be nice to have my Mac SE upgraded. (Technical Consultant)
>
> ...at present it's difficult to get even a free Mac or a free telephone tie line. (Senior Consultant)
>
> ...expensive toys for the upper management to show off to clients... and eventually end up in a cupboard. (Senior Design Engineer)

Much of Metre's business involves information which is security classified. There is a good deal of concern as to how this could be transmitted over public networks and even about classified information being accidentally visible over video.

> What about protection of classified information? (Systems Engineer)
>
> Inappropriate to use in the defence environment because of the lack of control of views from cameras. (Principal Consultant)

People are reluctant to be tied to their desktops.

> A variety of means to communicate - telephone, fax, meetings etc., allows me the opportunity to have a break from the Mac. (Secretary)

There is anxiety about effects on group dynamics.

> Would give undue power to the participant familiar with the technology - not a natural way of interacting. (Senior consultant)

Those who express the most positive views of CSCW technology are managers and consultants, and those who travel frequently[10]. Again, the comments help to detail the background to this finding.

> I have high hopes that CSCW will enable me to manage multi-site projects successfully in the future. We cannot easily overcome our geographic dispersion so this promises a means of reducing travel costs, personal disruption etc. (Project Manager).

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[9]This may have been a result, however, of the small numbers of respondents at some of the six sites covered.

[10]These groups overlap to some degree.

> People seem to be more and more reluctant to work away from home and I believe CSCW will make it easier and prove that it is both acceptable and entirely possible. (General Manager)
>
> This questionnaire suggests an infatuation with 'problem-solving by technological overkill' that ignores the major problems (cost and time) involved in trying to make the things work. (Senior Design Engineer)
>
> Too knackered. Too expensive. No facilities for working once meeting over. Seriously limits possibility of social life. Wife gives me s**t. (Consultant, on travel related problems)

The finding that there is significantly more enthusiasm for asynchronous rather than synchronous services is illustrated by these final comments:

> Need (real) face-to-face to meet new people, once you know them, telephone is OK. (Principal Consultant)
>
> Personal visits have the virtue of forcing people to prepare properly which they otherwise (in my experience) often wouldn't do for an electronic interface. (Senior Design Engineer)

How realistic are the views expressed by the potential user community for DUCK? Several of the issues raised are discussed in published case studies and meta-analyses of CSCW implementations, as discussed below. Overall, the prospective evidence from the user interviews and the questionnaire accords with much of the retrospective evidence from the literature.

Little is reported about users' expectations of CSCW technology, although Bullen and Bennett [12] observe that expectations derived from the original description of groupware continued to influence patterns of use some five years on. It may be that the tepid enthusiasm is simply part of a more general reaction to novelty - in a recent survey of users, suppliers and 'experts' views on groupworking technologies, Lewis [13] notes that the results of market research are often misleadingly negative for new products. As the pool of potential users at Metre predict, in many groupware implementations only the simplest tools are used. Bullen and Bennett's survey [12] of groupware use in 25 enterprises provides strong evidence of this. More recently, Bowers' account [7] of the introduction of CSCW systems to a government organisation graphically illustrates the phenomenon. Bowers observes that "for many users, it has only been the electronic mail facilities which have even come close to being part of their daily working lives." (Note, however that this selective use of system functions is by no means confined to groupware: Eason [14] quotes the example of a system for bank staff where of 36 available functions, 5 functions accounted for 75% of the usage.)

Anxieties about undue advantage to those familiar with the technology are supported in some studies of electronic meeting rooms. Austin, Liker and McLeod [15] studied how groups distributed control of the technology, the determinants of which members took control, and the consequences of acquiring control. Proficiency with the computer interface and the social influence were factors which predicted

who would take control. Another concern about unequal benefits, that benefits would only accrue to part of the target group (in this case, management) is certainly reflected in analyses of the failure (or partial success) of groupware systems, for example [2, 7, 16, 17].

There is also support for the DUCK user community's wariness of video links for getting to know people and conducting negotiations. Among others, Heath and Luff [18] in their report of the use of the rich communication tools provided by the EuroParc media lab note that interaction over the video channel was less effective as evidenced by the use of gesture, and this was among co-workers who knew each other well. In an early study of the use of video, Abel [19] discusses a video wall used to link two geographically distributed research labs. The system is described as just about adequate for creating a joint sense of place and culture. It worked well for sustaining relationships, but less well for establishing them and for negotiations of tricky points. The efficacy of video for supporting everyday working relationships is further emphasised in Tang's work with an established distributed team of software engineers [20]. Here the addition of videoconferencing significantly increased the take up of a basic audio and email system. Indeed our potential users expressed fewer caveats about the use of video for this type of routine communication.

4. The design, implementation of an initial CSCW pilot

We now sought to assess the practicality and usefulness of existing CSCW tools in the Metre context so as to provide a relatively quick and easy method of validating, revising and expanding the requirements acquired through the interviews and the questionnaire. This section is a summary of this activity and its results.

Considered as a whole, the evidence discussed above showed that our potential users viewed CSCW technology primarily as useful for improving the more routine, asynchronous communications, and the literature suggested that their expectations were reasonably realistic ones. The next step was to match technology to a particular project within Metre.

4.1 The pilot project and its requirements

The choice of host project to serve as a testbed for the CSCW pilot was naturally constrained by the small number of projects operating in a distributed fashion over the period scheduled for the exercise. The project selected, referenced hereafter as SUB2, was engaged in the preparation of a large-scale bid for a new submarine. The entire team, at its largest, comprised some 240 people who were distributed among three widely separated sites. The duration of the SUB2 project was scheduled to be 14 months.

Two sub-teams were to be supported by the DUCK technology: mechanical design engineers, some of whom worked at site A (where the main project office was located), some at the second site (site B); and human factors engineers who were

almost all based in site B but spent several days per week at sites A (mainly) and C (occasionally). The co-ordinator of the human factors work[11] was based in site A.

4.2 The pilot technology and its support

At this stage, best practice would have been to refine the general requirements by working closely with those people who would be using the pilot technology. However, the extreme pressure of work on the SUB2 team, and the secure conditions under which that work was carried out made this impossible. Therefore the overall requirements list and the information about user attitudes and expectations were used to guide the selection and introduction of readily available off-the-shelf technology for the pilot. In making our selection, user requirements and tasks belonging to the domain of preparing collaborative design proposals were matched to the features of a wide range of tools; choice was also constrained by cost and the need to operate in a PC environment. The tools eventually selected were:

- Lotus Notes™, which supports asynchronous working by providing a structured, shared information space, email and file transfer. A number of purpose built databases were provided within Notes: document archive, discussion, project diary, library, requirements tracking and document reviews (the last two of which were workflow applications).

- Fujitsu DeskTop Conferencing™ (DTC) which supports synchronous working through remote application sharing, a shared electronic whiteboard or flipchart and file transfer, but not videoconferencing. (DTC was included because we wished to discover if such tools would be used in practice despite there being little initial enthusiasm for synchronous working online.)

The two main sites were linked by an ISDN line which enabled the collaborative use of DTC and Notes. Resource constraints limited the implementation of the technology to two PCs, one at each of sites A and B.

Training and demonstrations were provided at the beginning of the pilot, and on-going support from members of the DUCK team was readily available, in person (at site B) or by phone or email. We also provided simple, task-based, 'minimal' manuals [21] for both the Lotus Notes applications and DTC and a 'procedures' guide, which suggested how the tools might be used to support the distributed tasks undertaken by the group. This was drawn up with the co-ordinator of the human factors team.

[11]This was the Technical Manager who had played such a large part in the requirements elicitation process.

4.3 The pilot in operation

At Site A the project PC acted as a general project resource as well as running the DUCK technology. The machine was located in an open office, next to one of the potential users but not on his own desk. The site was a large one, and the DUCK machine was 4 or 5 minutes walk away from some users. In Site B, the DUCK PC had its home in an office which was usually empty and near to the project team's working area.

Fourteen potential users of the DUCK technology (9 engineers and 5 human factors staff) were identified at the start of the pilot and interviewed. From the interview data, it was clear that the pilot users had varying background experience and technical and domain expertise, but had already formed an established working group. The group were asked to estimate how much of their work on SUB2 fell into each of the categories of independent working, sequential working, reciprocal working and team working, following the classification developed by Van de Ven [22]. Combining the estimates[12], 40% of the team's work fell into the reciprocal category *'Work flows between you and one or more other members of the team in a reciprocal 'back and forth' manner'* and 31% in the team category *'You and one or more other members of the team problem solve and collaborate as a group at the same time to deal with the work'*. On this evidence, then, the pilot users spent much of their time collaborating in ways which were suitable for support by the technology provided by DUCK - email, asynchronous conferencing and information sharing and synchronous electronic conferencing. And much of this work was cross-site.

Having witnessed a comprehensive demonstration of the DUCK technology, users were asked to score the tools for potential usefulness on a scale of 1 to 5, 5 being the most positive. Direct comparisons cannot be made with the questionnaire data, since the DUCK technology did not directly equate to the services canvassed in the questionnaire. But the figures for the nearest comparable services are shown below. Enthusiasm was still muted, but at a level rather higher than that of the general Aquatics Division population[13]. One might speculate that the raised enthusiasm was the result of experiencing the demonstration, but this remains a speculation.

	Mean Score	Questionnaire (equivalent) mean
DUCK tools as a whole	3.50	2.99
DTC tools	3.43	2.74
Lotus Notes tools	3.21	No direct equivalent

[12] This excludes one user who invented a new mode 'director'.
[13] Because response to the questionnaire was anonymous, it is impossible to know how many of the pilot group were represented in the questionnaire data.

Comments made during the interviews fill in the background to these judgements: there was a degree of interest in the new tools, but doubts were expressed by more than one user about the convenience of the DUCK machines, the fit between the technology and the teams' established working practice, and the time available for experimenting. All these were to be salient factors in the actual take up of the technology.

The pilot ran over a period of almost 5 months. The only DUCK service to have been used seriously over this time was Notes email, which had been exploited primarily as a means of transferring files between Site A and Site B. However, informal comments made during the pilot and the information from the follow-up interviews showed that such use of email had been invaluable in the execution of technical work in the preparation of the bid - the team was working to tight deadlines and it was frequently necessary to transfer documents and other files very quickly. The alternatives to email were to drive around 170 miles or to post or courier disks, since no other electronic network existed.

Thirteen of the original 14 interviewees were re-interviewed after the pilot had been running for 4 - 5 months together with a further 5 users who became involved after the pilot start-up. Users were asked to assess the DUCK tools for usefulness as before. This time DUCK was viewed much more positively, as shown below. Since we wished to investigate the effect of experience of the technology and only Notes email had been used, scores were not obtained for the DTC tools and other Notes services.

	pre-pilot mean score	late-pilot mean score
DUCK tools as a whole	3.50	4.50
Notes email	3.31	4.41

Why were the other services not used? The interviews elicited the view that the inconvenient location of the DUCK machines, and the fact that there was only one machine per site were, not surprisingly, a significant deterrent to use. Other reasons voiced were related to the ease of use of the applications and their supporting manuals, the difficulty of collaborating electronically in the context of a larger, paper based project, and to the time pressure under which the team was working. Nevertheless, where a use for a service had been found, the determination to exploit it overcame a whole series of obstacles. Thus while the factors mentioned undoubtedly had a bearing on take-up, they were insufficient to deter use where substantial benefits were to be had. In illustration, for the users at Site A, the typical sequence of steps to send a file by email would be:

1. Write the file to a floppy disk
2. Walk several hundred yards to another building
3. Dispossess the habitual user of the DUCK machine (a senior manager)
4. Reboot the machine (the DUCK technology did not work when the machine was connected to the normal network)
5. Make the ISDN connection
6. Run Windows
7. Run Lotus Notes
8. Change the Notes user ID if not the last user (a single ID per site was implemented in the later stages of the pilot)
9. Login to Notes
10. Compose a Notes message, attaching the file, and send it.
11. Close down Notes
12. Reboot the machine and relinquish it to its *de facto* owner.

5. Discussion and conclusions

General user expectations as elicited from the requirements interviews and the questionnaire were a good predictor of the behaviour of the particular group studied in the pilot implementation. There may, of course, have been an element of self-fulfilment here, but since the pilot population represented only 19 at the very most of the general population, this cannot have been substantial. Email, the definitive asynchronous service was the only tool to be used seriously by the SUB2 team, a finding which at first glance is in line with, for example, Bowers' and Bullen and Bennett's[14] observations [6, 7]. The difference is, however, that in this case email was used almost exclusively for file transfer - so much so that distant users would be alerted by phone, rather than email, that a file had been sent. This is certainly in part a consequence of the 'one terminal per site' constraint imposed on DUCK. Since users did not have a machine at, or in most cases, even near, their desktop, email did not become the familiar and natural communication tool it is for many office workers. However, while 'one-per-site' is an abnormally low level of provision, experience at Metre and in other technical environments suggests that engineering and scientific professionals, in the UK at least, do not expect, or necessarily want, one per desk. It should be stressed that this is a matter of culture and preference, some design engineers being firmly convinced that good design is not done on a computer. In such contexts, computers are tools used as necessary for specific purposes - calculations, finite element analysis and the production of completed drawings, and as such they are usually shared among the members of a team.

The team's limited use of the other DUCK tools is also consistent with the results of implementing conferencing and information sharing systems reported elsewhere, as in [1, 23-26]. Again this result will have been influenced by the low level of machine provision. A more significant factor, however, may have been that while emailing a file is not too dissimilar to posting a floppy disk, discussing complicated design issues using the telephone, shared applications and an electronic whiteboard requires a whole new range of technical, sensori-motor and social skills. Furthermore, the benefit to be gained from acquiring these skills was probably not great, since travel to

[14] Bullen and Bennett's review, published in 1991, was naturally restricted to technologies then in common commercial use. Hence the synchronous technologies of shared applications and electronic whiteboards were not covered, although the systems studied provided a range of asynchronous conferencing, document sharing, administration and collaborative writing tools.

other site for meetings was necessary anyway to discuss matters lying beyond the boundaries of the teams using the DUCK tools. Similarly, the teams were also dependent on information produced and managed outside their own boundaries, so that the gains to be made from Notes as an information tool were less apparent.

These observations have striking parallels with the conclusions of innovation characteristics research, a discipline which seeks to describe the relationship between the characteristics of an innovation and its adoption. Tornatzky and Klein [27], provide a meta-analysis of 75 papers in this area. Three innovation characteristics (compatibility, relative advantage and complexity) had the most consistent relationships to innovation adoption, where the innovation was, in the broadest sense, any new technology or practice. The findings of the DUCK pilot fit this pattern well, and indeed together with other reported results, may suggest that CSCW systems are not a special case, but follow the adoption patterns of any new technology.

The work reported in this paper produced a snapshot of requirements and expectations for CSCW at Metre and then used this information in the implementation of a trial of collaborative technology by a real life design team. Not all initial comment was fully informed - few of our potential users had experience of the applications proposed - but the data proved reasonably predictive of actual patterns of use over the 5 months pilot period. (It is however quite likely that through the processes of adaptive structuration [28], patterns of use and attitudes might have begun to change and diverge from expectations once technology had been in place for longer - in our case this particular phase of collaborative work for the SUB2 team was drawing to a close, thus providing a natural point to end the trial, but precluding the collection of more longitudinal data.)

Finally, although these findings are founded on evidence from one company, with its individual culture, history, infrastructure and work practices, we expect that some at least of our experience will generalise to other large, distributed organisations, particularly those in the engineering domain. We offer the following concluding observations.

- The expectations of the wider community of potential users of collaborative technology in an organisation are a useful guide to the actual behaviour of particular sectors of that community.

- Collaborative tools often have implicit assumptions of one-per-desk or near one-per-desk - designers and implementers need to consider the requirements of environments where machines are team resources rather than personal accessories. This may be particularly important for the support of informal tasks such as *ad hoc* technical discussions.

- However, given a sufficiently substantial benefit, users will overcome equally substantial obstacles.

- Pilot trials of technology are by definition limited. However, if the pilot cannot be self contained, care should be taken to design for the management of information and work which crosses boundaries between the subjects of the pilot and the wider organisation.

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