Landscapes of Practice:
Bricolage as a Method for Situated Design

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Abstract

This paper proposes a 'bricolage' approach to designing systems for cooperative work. This involves users, participatory designers and ethnographers in a continuing cycle of design and revised work practice, often in settings where resources are limited and short-term results are required. It exploits the flood to market of hardware, software and services. The approach is illustrated with results from a project with a practice of landscape architects. Their work is analysed in terms of communities of practice and actor networks. These perspectives help to identify the 'socialities' of people and of technologies and of the relationships between them. They help to distinguish different forms of cooperation with differing support needs, opportunities and vulnerabilities. They inform the design of technical support, the assessment of outcomes, and the design of further solutions, in a cycle of 'situated experimentation'.

Keywords

Actor-Networks, Bricolage, Communities of Practice, CSCW, Ethnography, Participatory Design.

1. Æsthetic production in a changing environment

CSCW is the main field in which serious attempts have been made to mix systems design with analyses of the social organisation of work. As designers and sociologists gain experience of working together, it gets easier to move from a 'hand-off' relation

between the two activities towards a more continuous engagement. This paper reports results from a project that tried to do this. A second main aim of the project was to develop the relationship between ethnographic and participatory approaches to design. Has participatory design anything to gain from the 'intrusion' of the ethnographer? Does the analysis of the social organisation of work benefit from 'action research'? Do these benefits justify abandoning ethnography's traditional ambition to minimise the effects of its observation, in favour of immediate and continuing implementation of designs which it has informed? Is organisational change made easier, more benign or more comprehensible to those engaged in it through combining these approaches?

The project tried to adress these questions through action research with a practice of landscape architects. This profession was chosen because of the diversity of the materials that they work with and of the skills – spanning the æsthetic and the technical – which they bring to bear. The fieldwork was carried out at various times between 1995 and 1998. The practice of landscape architects was one of eight branches of 'ABC-Co', based in Northton in north west England. ABC-Co employed around 100 people, of whom around a half were involved in the landscape architecture side of the firm, while the other half worked in environmental science undertaking such things as ecological surveys and environmental impact studies. The two sides often worked together – for example, undertaking an ecological survey and making corresponding conservation plans as part of a proposed development.

For a project to pass successfully through its various stages it must 'carry conviction' with an evolving set of collaborators. The principal vehicles through which it can do so are the graphics, texts, measures etc. collated together in diverse documents. In the terms of the actor-network approach to which we will refer later, these have to serve as 'conscription devices', which will help to recruit adherents for the particular 'programme' which they embody. At the heart of the work, therefore, is the need to mobilise and assemble materials which are accountably appropriate for diverse purposes and audiences (cf. Henderson, 1995). In common with other design professions (cf. Molotch, 1996, on artefact design), but perhaps more than most, landscape architecture has to fight for its 'place at the table' for construction projects. Landscape architecture is a relatively young profession. In Britain the Institute of Landscape Architects was founded in 1929 from a background concerned mainly with garden design, both as a historical study (e.g., Shepherd and Jellicoe, 1925) and as a contemporary practice (e.g., Mawson, 1900). A number of factors helped it to gain standing and broaden its field of application to landscape design and planning. These include the introduction of planning controls, wartime bomb-damage renewal, post-war local authority housing schemes and industrial renovation, the New Town movements of the 1950s and 1960s, the activities of major public undertakings such as forestry and power generation, and more recently legal requirements for environmental audits. Along the way they have claimed, and sometimes achieved, an overall co-ordinating and reconciling role for all the planning, designing and constructing activities on a site or for an area (e.g., Hackett, 1971).

Growing concerns for the ecological and cultural sustainability of new developments in urban and rural landscapes have resulted in laws that require environmental assessments, and analyses of effects on landscape character and of the visual impact of new developments, to be carried out. The legislative incentives for co-operation combine with an awareness that 'sustainability will be the consequence of good and holistic design' (Zunz, quoted in Fisher 1997). Together, these forces have increased the range of projects that landscape designers become involved in. Moreover, the nature of the landscape profession has changed as a result:

> The emergence of landscape architects as the [Department of Transport]'s preferred lead profession for environmental assessment of new schemes not only provided an important alternative source of work for private practices in the face of the declining property market, it also brought a new prestige and status. … Many landscape architects now see themselves as broad-based environmental professionals, rather than designers of new landscapes. (Etchells 1995, p. 11)

Despite these advances, many potential clients, e.g., executives of firms engaging in industrial development, are likely to have only the vaguest idea of what contribution a landscape architect could make. One consequence is a major focus on marketing and the maintenance of contact and client databases. Unusually for a profession in Britain, it is normal practice for senior partners to, for example, scan newspapers for items on impending developments and 'cold call' in search of business. When money is tight, professional landscape design is most vulnerable to seeming a dispensable frill – in actor-network terms, it will appear as anything but an 'obligatory passage point' for a project. Hence the process of 'recruitment' must often start a stage back even from the selection of a particular firm for the job. Where the philosophy of a design is strikingly original, such as the first use of excavated soil for large-scale 'earth sculpture', then not only the client but the profession in general must be 'recruited' to the concept (see discussion of the work of Sir Geoffrey Jellicoe in Harvey 1987, pp. 21-22). More usually, a concept which makes 'landscape sense' must be 'sold' to a client, especially where there is a tension with maximum profitability – for example, planting forestry in relation to the contours and character of the land rather than simply filling the rectangular blocks of land purchased.

Emerging from this background, landscape architecture now divides into two main types of activities. Landscape *design* involves making specific changes to a specific site, creating visualisations of the changes and corresponding drawings and plans for it. These are often used in applications and negotiations for planning consent, e.g., to a local authority or at a public inquiry. It may also involve putting the work out to tender (i.e., competitive bid) to appropriate contractors, and overseeing the construction work. Landscape *planning* involves a more strategic assessment of larger areas of landscape, and concerns such issues as the qualities and characters of the landscape, and appropriate uses. This is likely to be an important component, for example, in drawing up a local authority's strategic land use plan.

All work unpacks into a wide range of overlapping practices. A distinctive aspect of landscape architecture – one which it shares with architecture, artefact design and

other examples of æsthetic production – is the way in which it crosses boundaries of qualitatively very different kinds of work. First, it is æsthetic, creative, open-ended and visual. Second, it is craft-based, involving a range of drafting, constructing, assembling and other manual skills. Third, it is also professional, technical and quantitative, involving such scientific knowledge as the soil, climatic and geographical requirements of different species of plants. Landscape architecture is æsthetic production also in the sense that its outputs must do 'æsthetic work'. For some purposes a graphic must be precise and photo-realistic – for example, a photomontage for planning consent showing the change to a landscape resulting from the introduction of a building. For other purposes, a graphic must be 'painterly', sketch-like and not too fussy – for example, the master-plan showing the concept for a development. The same set of plans will traditionally be monochrome with a patterned key for contractors (reflecting the importance of being able to copy them); but a coloured set, more visually striking and more easily interpreted by the layman, may be required for the client.

Æsthetic production of this kind figures centrally in debates about contemporary economic and industrial forms. While production has never been 'purely functional', it can be argued that in the advanced economies there is an increasing interpenetration of the cultural, the æsthetic and the economic. In these developing 'economies of signs and space' (Lash & Urry 1994) the production of goods and services has a heightened cultural component and depends more and more on design intensity for its success. In terms of its industrial organisation, æsthetic production of this kind increasingly takes a flexible and specialised form (Shapiro et al. 1992). ABC-Co survives as a very small unit networked into a global environment, with work, for example, in Spain, Mexico, Ethiopia and China. In these respects it is also 'post-fordist' production. It therefore occupies a niche with great potential in theory, but which is extremely vulnerable to the penny-pinching practices of the still predominantly 'lumpen' UK business sector.

ABC-Co is now owned by a large multinational firm, and this did afford it some opportunities and a degree of protection. While it was therefore technically not a 'small or medium enterprise' (SME),[1] that remains by far the most appropriate light in which to regard it. In better economic times work was plentiful and the partnership spun off several branches in other parts of the country. At the time of the fieldwork there was intense competition for a reduced volume of work and strong downward pressure on prices. It was necessary to accept ever more demanding constraints, for example on deadlines. The areas in which several of the branch offices were located were generating more work than the Northton 'core', which was forced to reduce its staff. They therefore themselves generated the survival strategy of supporting work obtained by other branches. Competitive pressures have also led them to develop specialised 'skill bases', located in different branches. Together, these mean the need to communicate and co-ordinate within a distributed organisation has increased.

2. Co-operative networks

A key aim of this project is to research means of developing CSCW 'in practice'. We are trying to use this case study to contribute to understanding and developing the *process* of designing appropriate technical support. In particular, we are trying to make progress on seven inter-connected fronts. Much of the point, and much of the difficulty, lies in trying to move forward on these simultaneously. They are:

1 *analysis* of the social organisation of the work. That in turn has two components. First, *ethnographic accounts* of detailed work practice which are oriented towards conceiving appropriate technical support. But second, to bring in broader conceptualisations of work processes which are shortcuts to lines of understanding and attack, both for designers and for users. The ones we use here are *communities of practice* and *actor-networks*.

2 *participation* of practitioners as co-designers and co-developers of their technical support, drawing on experience and approaches from participatory design (CACM 1993; Kuhn et al. 1992; Trigg et al. 1994).

3 *totality*. All of the aspects of technical support, of the context in which it is embedded, and of the working practices which surround it, need to be thought of as links in a chain. It is no good for a technical system to be a success 'except for' some minor aspect or exogenous element, unless they can be and are addressed.

4 *affordability*. The costs of technical support should have at least a realistic prospect of being 'in scale' with their setting. For small enterprises, that means using readily-available mass-market components and software rather than custom-designed systems.

5 *immediacy*. Benefits of technical support should start to be available on a very short time horizon, not months or years later when both the needs and the possibilities will probably have changed beyond recognition.

6 coping with *uncertainty*. The take-up, modification, and rejection of technology in a work setting, and the accommodation of work practices that will take place around a developing technology, are radically unknowable and unpredictable. At first sight, this makes 'design' impossible. If it is to happen, this paradox must somehow be overcome.

7 *continuity*. Because of (3) totality and (6) uncertainty, appropriate technical support unfolds over time, and cannot be treated simply as a matter of discrete stages such as requirements, then production, then delivery.

There would be little point in these as pious statements of what is desirable if there was no realistic prospect of attaining them. Together, they form a large and long-term agenda which certainly cannot be disposed of within a single project. Nevertheless, we suggest that the time is ripe for significant progress on them, and one of the aims of our project was to explore that claim. We discuss them again after describing some examples of the developments in the case study. In essence, we sought to support co-operative networks through situated experimentation. That is directed towards

'satisficing' solutions to the challenge of bringing together escalating demands, current work practices, preferred futures, standard software, affordable hardware and existing networks.

In the following sub-sections we will describe three 'cameos' of the work that we encountered, chosen to home in on some divergent aspects of the work. The first cameo, 'distributed revision', focuses on relations between the landscape architects and other professional consultants also engaged on a contract. The second cameo, 'distributed production', focuses on attempts to share a job of work between landscape architects in different offices of the firm. The third cameo, 'collective production', focuses on co-located shared work. Next, in Section 3 on "Practices, actors and networks", we consider some theoretical approaches which, we argue, help in understanding these aspects of the work and in designing systems to support them. In Section 4, "Co-evolving work and technology", we illustrate the results of applying these approaches to the issues described in the cameos. Lastly, in Section 5 on "Bricolage", we outline the approach to systems design which we think emerges from our project.

2.1 Distributed revision

This cameo concerns the work of putting together a photomontage for proposed developments at a famous wetland conservation centre and bird sanctuary. These developments include landscape changes, a new visitor centre, car parking, and the creation of reed-bed grey-water recycling ponds. The purpose of the photomontage is to show the visual consequences of these changes. It is a prospective bid for National Lottery funds which must be put together on a very tight budget and deadline. Paul has received photographs of the site as it is now, a plan showing an outline of the proposed changes, and some architects' drawings which are incomplete.

The usual procedure for such a photomontage is to start with the photographs of the site – typically 2 or 3 photographs are joined side by side to simulate a 'vista' and approximate a 'natural' human field of vision. Next, one or more transparent sheets are overlain containing the changes to the landscape, new buildings and other structures. Often the representations of the buildings are produced using wire-line diagrams, generated by AutoCAD from input measurements. The purpose of the wire-line is that it will give an outline which is precisely located, precisely oriented, and precisely to scale, for buildings or other structures with particular measurements, as seen from a specified point of view. This is then hand-painted with appropriate colours, features and shading. Then a further transparent sheet is overlain, showing foreground planting and features (sometimes several sheets, showing, for example, growth after one year, after 5 years, etc.) This is therefore a 'scientific' representation in that it shows the exact spatial relation to the environment, accurately detailed, not some optimistic 'artist's impression' (though much depends, of course, on which viewpoint is chosen). There are professional standards and expectations about objectivity and neutrality. In theory, landscape architects acting as consultants either for proposers or for objectors would come up with a very similar representation.

In principle, the production of this photomontage should be a procedure with a clear division of labour and a clear temporal sequence. It is the job of the architects to supply to the landscape architects a package of all the materials and information which they need. In practice, that was far from the case. The information provided was sketchy and incomplete. Paul knew, for example, the kind of building materials proposed, but had not been given a precise colour specification. Over the two days in which the work was to be completed, a series of faxes came in from the architects notifying changes – to the roof shapes, to part of the main building, and, on the last day, an entirely new building and changes to the layout of the car park. With the manual procedure, each of these more or less means starting the photomontage over from scratch. While somewhat extreme, this example is indicative of a trend. With the general speed-up and the squeeze on resources, clients and consultants expect to be able to impose these last minute changes, and there is an ill-formed expectation that the landscape architects will have the means to cope.

2.2 Distributed production

Cameo 2 concerns a project, undertaken together with a firm of traffic engineers, to redesign a 50-mile stretch of a trunk road in Wales. The road carries a heavy volume of traffic and there have been frequent accidents including several fatal ones. A plan of their incidence identifies particular black-spots. But it is also a scenic road through a National Park with environmentally sensitive countryside, meandering wooded valleys, and many other valued landscape features. The overall options being considered include downgrading the status of the road and encouraging traffic to take another, longer but easier route. The strategy for the redesign therefore places emphasis on traffic calming rather than road realignment. This is to be achieved through such things as signage, textured road surface strips, and 'gateway features' – drawing hedge and fence features in towards the edge of the road at certain points to reduce its perceived width and encourage drivers to slow down. The project is shared between the Welshtown and Northton offices.

One of the tasks is to produce a set of colour plans of the route, demonstrating the strategy for the project. The plans identify 20 sections each with their own particular environmental characters and constraints. They will show the features and planting proposed, together with an explanatory text. These are generated from a range of source materials: the traffic engineers' plans, accident incidence plans, maps showing ancient woodlands, ancient monuments and other landscape features, photographs, sketches, video footage taken driving the entire route, and of course direct experience of the route and its surroundings from site visits.

Drawing up the plans involves a series of exchanges between Northton and Welshtown. In December, Keith sends to Paul and Robert in Welshtown a set of 'baseline' drawings and a detailed information package about what to do. They send back a set of 'negatives' – monochrome drawings on tracing paper – which mostly seem to be fine. However, much of the information which will be required on the final drawings was not contained in the negatives, and when the final drawings arrive

in January, with the deadline looming, several drawings turn out to be missing while most of the others are 'incorrect' in one way or another.

A great deal of very diverse and intricate source material is drawn together in the plans, and we discuss this further below. As such, they generate large scope for debate and disagreement about their adequacy, since what is most salient or effective for some parties and uses can seem irrelevant for others. These concern matters of accuracy and fitness for their purpose. But they also concern issues to do with the æsthetic effects of the way the plans are drawn up, and of adherence to a certain 'house style', which are matters largely of culture and local convention rather than of standards. In this case, the problems concern the missing drawings, and missing or inaccurately indicated features such as woodlands. They also concern such matters as the colour scheme and the choice of symbols to indicate particular features – aspects of the work which were considered arbitrary at one end (with a stronger environment science focus) but crucial at the other (with a stronger landscape architecture focus). Because of this, Northton has to redo several drawings and recolour all the others, with Paul and Robert travelling from Welshtown to Northton to assist. The offices, it seems, were attempting distributed production of quite a complex job under conditions which were inadequate to support it. It proved not to be possible to oversee things on a day to day basis and pick up mistakes before it was too late.

2.3 Collective production

Cameo 3 is primarily an example of shared work. It concerns a short section of a different trunk road in Wales which is being realigned. The old road now needs to be broken up, profiled and planted. The part of the job described here is to issue documents so that competing contractors can tender (i.e., bid) for the work of planting, and protecting and maintaining the planted areas for a period of three years. The documents to be produced are a planting plan (map), a detailed specification of the work, a bill of quantities, and various covering letters. It is a rush, because the planting must be completed within the season, which will end in about four weeks. The tender documents must go in the post today. Four landscape architects and two secretaries are collaborating to meet the deadline (while also attending to other jobs). Gwen has done initial work on a draft plan but cannot be in the office today and has left the plan in a condition for the others to take it up.

A division of labour is agreed: Annie will do the plans, Lynne the specifications ('spec') and Keith the covering letters and client liaison. Before they do this there is an informal conference of about 20 minutes in which the three of them talk the job through. Many issues are brainstormed. Keith has seen the site, the others have not. Keith is also the 'manager' of the project. His involvement in the discussion therefore has a triple aspect: as local expert, as an equal professional contributor, and as someone for whom the decisions are 'run past' him, if only as a courtesy.

It is striking that each of them makes multiple distinctive contributions, with the discussion taking unpredictable directions and revealing many further 'wrinkles' to

the job (for example, that one strip of the site has, incorrectly, been topsoiled, creating a problem for the wildflower mix intended for it). These are resolved with remarkable efficiency. The 'knowledge' and experience with which to do so are thoroughly distributed, forming a common construct. It seems inescapable that if any one of them were doing the job alone, several issues would be missed or less elegantly addressed.[2]

They separate for their tasks. Keith is in a different room, Annie and Lynne work at two drawing tables in the same room. For the rest of the day they continue to make mutual adjustments to what they are doing – they themselves describe this as a 'mosaic' – with changes to the plan affecting the specification and vice versa. They consult each other over these adjustments, paying attention to the other's level of concentration and 'interruptability'. The plan and spec are not just representations of work and decisions which have occurred elsewhere, but are a site of the work, the performance of which reveals and produces further aspects of the job (Shapiro et al. 1994).

3. Practices, actors and networks

Whenever work is observed in detail, one is caught up in admiration for the accomplishment with which it is achieved, and the infinite subtlety with which activities are accommodated to their settings and connected together. Their very flexibility and continuity tempts one to think of this as a 'seamless web' of practices. But in some ways that does not do justice to what is involved, since effecting the seams in the garment is among the most impressive of work's accomplishments. Activities flow into each other, but the terrain of work is not uniform, it has a topography.

In using the term 'practice' to characterise work activity one is placing emphasis on its practical and grounded accomplishment. On one hand, this refers to the continuity of knowledge, intention, cognition and physical action on and with tools and materials. When, for example, Annie uses a razor to scratch out a boundary line from a negative and replace it with another, this practice of 'correction' plays continuously over forming a view of the need for a change, experience and craft skill in handling the razor to achieve the desired effect, understanding the practical significance which the plan in its different states has for its relevant readers, etc. On the other hand, 'practice' connotes the situated character of action (Suchman 1987) and the way that activities are resourcefully adapted in response to their changing context and the particular combination of circumstances. Action is constructed anew each time and is never altogether identical to anything that has gone before.

Practice as a term also connotes the sociality of work and the mutual adaptation that takes place between participants. A *community* of practice is one in which the participants share a body of relevant knowledge and experience, have a set of competencies in the field of activity, and know what kind of things to expect from the work setting and from each other (Jordan 1996; Lave & Wenger 1991). This allows

them to take a great deal for granted in sharing and connecting their work. It means they can communicate with great economy, getting straight to the heart of a current matter without needing to specify a host of pertinent but 'obvious' elements. It also allows them to recognise at once if something in their exchange has 'gone astray', and to effect appropriate repairs. In the example of the road realignment in the third cameo, when Keith mentions that a strip of the site has been top-soiled, it is immediately obvious to the others why this is a problem – despite the fact that this is actually a complex technical matter of the suitability of particular habitats for particular plant species. The conversation can therefore move straight to some 'gossip' about how it went wrong, and a very economical discussion of different ways in which it might be fixed which would be largely incomprehensible to a layman. Similarly, a participant can usually tell at a glance whether a colleague can be interrupted without much inconvenience or whether they are doing something requiring great concentration, and they can mesh their work accordingly. From the placing of files and drawings, overheard snatches of conversations and telephone calls, and the 'demeanour' of colleagues, a participant can gauge at once the 'state of play' of the office and its work, what is rolling on pretty much to schedule, and what is in a panic. They are therefore able continuously and in the background to monitor their own progress and that of others, and to adjust reflexively. This is part of a 'hidden hinterland' of work, which is nonetheless fundamental to its successful accomplishment.[3]

If the term 'community of practice' conjures up an ideal-typical image, it would be of something like an open-plan office, in which the play and flow of work between people, tools and materials can most readily be both achieved and observed. Not surprisingly, many ethnographic studies of work practice take this kind of control room, small office or small workshop setting (Anderson et al. 1989; Heath & Luff 1992; Rouncefield et al. 1994; Shapiro et al. 1994; Bowers et al. 1995). But not all work has this character, and that raises important questions about where the boundaries of a community of practice are to be located and what happens to work which crosses them.[4] Indeed, one of the key things that a community of practice usually has to achieve is to prepare materials which it can pass on beyond its borders, and which can serve their purpose and 'live in the world' even when denuded of the context and supports which gave rise to them. Equally, materials which flow into the community of practice must be in a condition to take on a life in their new context in an appropriate way.

This applies very directly to landscape architecture, since in the vast majority of cases its output is in the form of documents, which might comprise a report with a mixture of text and graphics, or a set of plans, or a contract tender specification, or a sketch of the overall concept for a project. The work is organised around the achievement of these material outputs. And these often constitute particular points of passage between the parties to a process, both internal and external. This was apparent in all of the cameos, with the photomontage, the road redesign plans, and the tender documents forming the culmination and 'reification' of the work for which they stand. This suggests some useful parallels with the application of actor-network theory

(ANT) to the study of science (Latour 1990; Latour & Woolgar 1979; Law 1992). There too, there is a concern with the way in which the resources of a process – people, machines, materials – are mobilised; and with the way that the outcomes are sometimes simplified as 'punctualizations' which realise in a particular form the summation of a network's activity (Law 1992, p. 384). This can often be as texts, or what Latour (1990, p. 26) terms 'immutable mobiles' – artefacts which hold stable the intractable and heterogeneous materials from which they were composed, and which can be conveyed, collated, compared. These are very powerful assemblages, both in the density of meaningful content which they can contain, and in the material effects they can have when let loose upon the world.

One way of making use of these two perspectives of communities of practice and actor networks is as a shorthand for two distinctive ways of orienting to work processes, to the kinds of problems to which they give rise, and to the kinds of support that may be relevant for them. As a first pass, it is tempting to regard the intimate engagement of an ongoing work process as a community of practice, and an actor-network approach as helpful in understanding the hand-offs and translations which are also a natural feature of the work. The distinction would have to be used with caution, since hand-offs also occur within a community of practice, and punctualizations are themselves situated practices. But crudely, a punctualization can be a point of closure for a situated practice. Needless to say, such closures often do not go smoothly, the closure they effect is often a local and temporary one, and negotiation, clarification, and the work of maintenance and repair are often required (Star & Griesemer 1989).

It would, however, be too simple just to pose communities of practice and ANT as contrasting or competing approaches. An orientation to communities of practice is strongly identified with an ethnomethodological perspective, and as a leading exponent of ANT Bruno Latour has frequently made connections between his work and the ethnomethodological tradition. He clearly regards them as closely linked in the project of overcoming agency-structure and micro-macro dualisms, rather than as alternatives. 'For us', as he puts it, 'actor-network theory was simply another way of being faithful to the insights of ethnomethodology …', in its respect for actors' self-knowledge (Latour 1999, p. 18).

Other proponents of ANT have described it as, 'a semiotic machine for waging war on essential differences' (Law & Hassard 1999, p.7). Most famously, one of the essential differences which they challenge is that between persons and objects, including technologies, regarding their capacity to act in the social world. One of the most important and interesting things claimed about immutable mobiles, for example, is their very ability to interact in complex, surprising and unspecifiable ways with people and with other objects. Exponents of ANT therefore apply the new term 'actant' equally to persons and to objects. Latour (1996) argues that it is precisely objects as actants which make it possible to do the work of localising and globalising, over a continuous scale and spectrum of activities, through which the dualisms of agency-structure and micro-macro can be overcome: 'Neither individual action or structure are thinkable without the work of rendering local – through channelling, partition,

focussing, reduction – and without the work of rendering global – through instrumentation, compilation, punctualization, amplification.' (Latour 1996, p. 234) For Latour, this localising and globalising work permits human societies to make the transition from a 'complex' (i.e., densely interactive) social life, to a 'complicated' (i.e., framed and partitioned) one, mediated by objects, enabling us to, 'timeshift, dislocate, make lopsided and delegate the present interaction so as to make it rest provisionally on something else, while waiting to take it up again.' (1996, p.235)

These are powerful insights, and in the next section we give some attention to aspects of the technology which can usefully be described in these terms. But from a CSCW perspective, or within what one could more broadly call 'social informatics', they also raise particular problems and alarms. Latour and others are reacting against a critical analytic tradition which is hostile to the 'sociality' of objects mainly because it perceives the damage this can do in the form of 'commodity fetishism', through which the powers and properties of human social action, and especially human labour, are magically (or ideologically) displaced in alienated form into the apparent powers and properties of things (Latour 1996, p. 234). But computer science has its own distinctive legacy of fetishism around the powers of machines, most obviously in artificial intelligence but with a strong presence in many other sub-disciplines too. Here, the notion of the machine as actant is not (or not only) a new perspective pregnant with exciting possibilities, but something that has been frequently and glibly asserted, usually with very troubling consequences. And Lucy Suchman's (1987) critique of such claims was something of a foundational moment for the fields of CSCW and social informatics.

The rediscovery of objects as actants is therefore not something that can be celebrated without qualification in these fields and there are a couple of essentialisms that may still deserve defence. The first of these is that humans act intersubjectively, in that social order is not a pre-existing arrangement which they enact, but something which they actively produce in radically creative ways in the very process of acting together. Entities, concepts, terms and actions have an indexical character in use, they are radically contextual and cannot be fully independently specified. Humans, one could say, are in their essence organisms for handling indexicality and constantly inventing and producing social order anew through their interactions. Machines, including computing machines, cannot (now, and in the foreseeable future) do this. Machine systems can be so complex that their properties are emergent and unspecifiable; but that is not the same as purposively, intersubjectively and continuously re-making themselves, as a collective endeavour. This, the most distinctive aspect of sociality, cannot be shared with other actants.

The second essentialism to be defended is a political one concerning the respect and obligations which are due to persons as opposed to objects. This also arises with distinctive force in information systems because these have often been imposed, as for example in business process re-engineering, in ways that do seem to accord far more respect to the systems than to the people. Here again, then, we can say that the idea that objects and technologies are entities deserving regard and consideration as social

actors in their own right is not entirely new, and has not been an entirely happy one. So when designing and constructing social-technical systems it is important still to recall that respect is due to the dignities and freedoms of people which are not due to objects (except, perhaps, in an environmental sense, which is rather a different matter). Perhaps the importance of these two essential differences can be most clearly seen exactly when one moves from an analytic context (as in ANT) to a design and intervention context (as in CSCW).

Much accommodation exists and much more is developing between ethnomethodologically-inspired perspectives emphasising communities of practice, and ANT perspectives emphasising the social role of objects. While that focus remains so strong – Latour (1999, p. 19) quotes Mike Lynch to the effect that "'actor-network theory' should really be called 'actant-rhizome ontology'" – the two perspectives will point intriguingly and usefully in different directions. Two of the most salient aspects of the 'design' of work processes are that they must facilitate communities of practice, they must facilitate handoffs and linkages mediated by objects, and they must offer ways of dealing with the 'troubles' that arise in the course of both. To stretch our initial metaphor of the 'seamed garment', then, we can say that the 'panels' of our garment can change shape, texture and hue, and the seams can change location, form and technique; but a seamed garment remains a fruitful image of what emerges.

This work of conceptual clarification is mainly intended as an aid to design, that is, to conceiving appropriate connections between work practice and its technical support. But we have tried to explore their utility not only for ourselves but also as shorthands for the practitioners with whom we are working. That is, we have tried to explore whether the concept of a community of practice helps practitioners, in a productive way, to 'render the familiar strange' and make newly visible the intricacy of their own work. When this happens it is a powerful instrument for appreciating what a technical support system needs to achieve, and what it must not disrupt. Similarly, the concept of an actor network can help to make visible the ways in which hand-offs occur, that these represent instrumental choices about divisions of labour both within and beyond the organisation, and that technical support can be used to open up new choices and make different decisions possible.

4. Co-evolving work and technology

This study is carried out 'under the sign' of supporting co-operative work with appropriate technology, and so that is its focus, though of course it could have been undertaken for many other purposes. But the emphasis on 'totality', introduced earlier, means that envisioning technical support is just the starting point in considering work processes, which spill over into many other aspects. These include the strong possibility that for many processes the best technical support may be to leave well alone. A reader reasonably familiar with office technology in general, and with CSCW in particular, may well think that the work settings we have described in

the cameos are crying out for 'obvious' means of technical support. We explore this in what follows, but will argue that when it comes to devising and implementing appropriate support, nothing is obvious except in retrospect. Since some of the fieldwork dates back to 1995, inevitably some of the examples look dated, but the key issues and processes remain the same.

4.1 Revised distribution

In cameo 1, 'Distributed revision', we described some aspects of the work of putting together a photomontage. The problems in that example arose from repeated late changes to the buildings and the layout made by the firm of architects, breaching the temporal sequence which should in theory have applied. In the terms we have just been considering, we could say that outside contractors are in effect transforming themselves from punctualised inputs or outputs, into would-be parties to the practice. But they are not parties to the *community* of practice, because they lack precisely the intimate engagement with the landscape architects' work which would allow them to relate smoothly and manageably.[5] As this is a condition which is here to stay and there is little prospect of avoiding it through changes in work organisation, it is relevant to consider whether technical support could help.

There are two main concerns. The first is to try to find methods for producing photomontages (and, for other purposes, sketches and drawings) which are more tolerant of successive changes. The second concern is to find better methods for communicating revisions between the landscape architects and their co-consultants. For the first, an obvious option for Northton was to use Adobe Photoshop, since all related practices who have computer support use that as a standard, and they already had a version purchased bundled with a scanner but not yet used. The idea was to scan in the set of pictures from the site, splice them in photoshop, adjusting for the inevitable variations in brightness levels, import wire-lines from AutoCAD in a layer on top of the picture, and finally paint the new structures in Photoshop on top of the wire-line. The result could then be taken on floppies to the local print shop in town for colour printing. As well as coping better with last minute changes, this would allow re-use of earlier work or re-use of elements within a photomontage, e.g., when painting in 50 almost identical trees; and the ability to use colours from the original picture to paint the new construction.

The second concern leads to consideration of the possibilities for electronic communications. The main options were, first, modem-to-modem connections, which would be the simplest and, in terms of initial costs, cheapest way of enabling file transfers. The drawbacks include the need to synchronise the transmission, and that the receiving machine needs to be in a state to receive the file. While such arrangements might come to work reasonably well between branch offices, they could not be expected to work with outside partners. The second option was Internet access via modem, which with then current technology would enable a 28.8 Kbps connection to an Internet provider. The cost is very low – modem, fee to provider (then c. $150 annually), and local phone bill. It enables a kind of 'asynchronous ftp' mode of file

transfer, with sender and receiver making the transfers when they are ready to do so. It has the advantages of access to general Internet services, and the reasonable expectation that steadily increasing numbers of potential outside partners will acquire Internet connections. The third option was Internet access via ISDN, which is the most flexible solution and the one providing the most bandwidth (64 Kbps and upwards). At the time, however, it was much more expensive – something like 10 times the capital cost and 20 times the operating cost for only a 2.2 fold improvement in speed. The second option was therefore adopted.

In terms of how such connections would actually be used, in the context of cameo 1 we can envisage the transfer of photoshop files between Northton and the architects. But considering the layers of a Photoshop assembly, one can more specifically regard the background layers of the photomontage to be a stable and punctualized component. The foreground layers – planting features and new growth – are also punctualized in that they are relatively stable and fully under local control: any small adjustments that may be necessary can easily be made. The middle layers, however, containing details of the new buildings and new landscape formations, are in this context subject to rapid and capricious change. If emailed to and fro, e.g., in JPEG format or as a compressed photoshop file, they could take on the character of what we might term a 'mutable mobile' rather than an immutable one – an 'artificially' and temporarily punctualised intermediary for the process of distributed revision, which is purpose-designed to have all the virtues of both fixity and fluidity.

4.2 'Mechanised drawing'

How did these proposed solutions work out in practice? In fact the first attempt to introduce Photoshop for photomontages failed because the demands of picture quality in terms of resolution and number of colours could not be reconciled with the technical limitations of the equipment in place – trying to work with pictures up to 60 Mbytes on a 33 MHz 486 with 16 Mbytes of RAM and 200 Mbytes of hard disk space was just not feasible. Taking pictures to the print shop on disc also did not work as the results proved to be of very bad quality, and it was evident that their colour calibration could not be relied on. This appeared to leave three options: reduce the picture quality (and thus memory requirements), invest in more powerful hardware, or abandon the idea altogether. Northton opted for a new machine and an A3 colour ink-jet printer. After installation, the new 'graphics workstation' was successfully tried out on a project to depict the visual impact of a series of wind turbines, but only after what was, in context, quite a significant additional investment, involving the unanticipated addition of in-house A3 colour printing.

It clearly emerged, then, that the graphics software provided an opportunity to react more flexibly to these new pressures. However, the introduction of Photoshop unleashed an unanticipated cascade of further changes to the whole social-technical network. Evidently, it facilitated external communication. But it also introduced significant changes to the local organisation of the work. Under the old manual procedures the production of a photomontage was carried out by a landscape architect.

Bill, who has degree-level qualifications in geography and in IT, but whose graphical skills are limited, was responsible specifically for generating the scale wireline diagrams from AutoCAD. Now with Photoshop, and because the landscape architects had little experience as computer users, Bill took over much more of the process. His lack of drawing skills was compensated for not only through the graphical support the system provides (e.g., re-use of previous work, pasting in standard items such as trees from an image library, or scanning in a model), but also through strengthened communication with the partners involved. Early drafts of photomontages including wire-lines, colour samples and rendered surfaces were discussed with landscape architects in Northton or if, as was increasingly the case, the pictures were taken by another branch, they were sent there and discussed with them.

At first sight, this appears to be a definite, and rather worrying, de-skilling process in which a diminished imitation of some of the capacities of the landscape architects have been taken over by a combination of technician and machine. In part, this was because the landscape architects were then unfamiliar with computer systems in general. But there is also a particular limitation with the use of Photoshop and AutoCAD in that it is very difficult, using a mouse or 4-button puck, to recreate the drawing actions which are fundamental to the landscape architects' way of working. These drawing skills are particularly important for anything that has a 'sketch-like' character. More specifically for the photomontages, they are used, for example, to draw hedges, trees and other planting features, and for anything curved, such as the blades of a wind-turbine, or the droop of a power cable between pylons.

Having come to a shared understanding of this problem, we experimented with a pressure-sensitive pen and tablet as an alternative input device, to see whether it was capable of sufficiently reproducing in the specific context of this work the tactile familiarity and ease of manipulation of pen and paper. The result has been a qualified success in that most landscape architects regard the tablet as falling some way short of 'real drawing', but as a very acceptable substitute where there is a clear incentive and benefit, such as communicating work in progress and avoiding the duplication of work. Most important of all, the work done with the pen and tablet was judged to result in an acceptable output product from a professional point of view. With that in place, the work practices which evolved between landscape architects and technician have come much closer to a reciprocal sharing of both technical and drawing skills, rather than a displacement in either direction.

It is possible, and perhaps helpful for grasping the character of the changes that took place, to consider the photomontage production as a web of socialities, connecting object to object, person to person, and person to object. Photoshop output and external printing refused to enter into a relationship, so that new objects had to be introduced whose social engagement could be more effectively policed. The computer entered an intimate relationship with the technician but turned its back on the landscape architects. Landscape architects and technician were thereby bullied into a new relationship, with the latter 'drawing by proxy', and the former reduced to criticising the results. But extending the machine's perceptual capacities – with the

pen and tablet – meant, perhaps paradoxically, that it could once more be put in its place.

This small example illustrates the dynamic and unpredictable character of a situated approach to design. Far from being a matter of analysing a setting, prescribing solutions and then departing (or perhaps, at best, evaluating), it is much more like embarking on an open-ended journey of innovation and experimentation, a kind of situated trajectory or migration, with unknown commercial, professional and even personal consequences. In this, it may be as much assimilable to the category of 'risk' (Beck 1992) as to rational planning – as too, if unwittingly, may be all other design approaches. A particular piece of technology may be adopted to address a current problem. However successful it is for that, it must be expected itself to generate new problems, either for that same practice or for different ones. These can in turn be addressed, either by yet more technology, or by changes to working practices, or both. At every point in the journey an assessment must therefore be attempted of whether, overall, the gains from the new practical-technical assembly outweigh the losses. Yet after a certain number of steps, land has been left so far behind that there may be little realistic prospect of return. We might therefore (with a nod also to the company's increasingly hostile competitive environment) term this the 'life-raft' model of systems development – a continuously unfolding bricolage of technologies to hand, requiring much patching and baling, with an unknown destination. Of course, that is unlikely to be a wholly new condition, but probably describes quite well the whole history and development of an organisation. If change associated with IT is different, that is because it sometimes involves a large and concentrated step change in skills and work practices, and major commitments of expenditure, with benefits that involve a large act of faith.

4.3 Distributing presence

In cameo 2, 'Distributed production', we described some of the difficulties that arose when the Northton and Welshtown offices tried to share the work of preparing plans for the redesign of a 50-mile stretch of trunk road in Wales. Despite setting up apparently suitable arrangements, in the end they found that this required a greater degree of 'mutual presence' than they had anticipated, and they had no adequate means to establish it.

If we consider this in the light of the technology we have already introduced, some specific aspects of the communications required could be punctualised – sending a colour and symbol key for approval, for example. But the complexities of this job, which would be typical of many others if distributed production among different offices were to be seriously attempted, mean that something much closer to a distributed community of practice must be supported. That requires us first to speculate on the technical possibilities and then to explore their adequacy in practice for these particular tasks, together with the difficulties to which they give rise in their turn. Given the limits of bandwidth we must anticipate rather limited options, and we

would expect from a wide range of existing findings (e.g., Robinson 1991) that sharing materials (such as drawings in progress) together with a two-way voice channel are likely to be much more useful than a video channel showing faces.

This suggests technologies which support shared screens or distributed conferencing (Greenberg at al. 1995). A variety of challenges face this kind of technology in this specific setting. First, there is the need to connect some offices where PCs are in use at each end, but also one particularly important connection where there are PCs at one end and Macs at the other. Second, it must be able to incorporate or integrate with existing applications in use (e.g. Photoshop, AutoCAD). Third, it must perform adequately over a 28.8 Kbps connection (though with higher effective rates sometimes possible with compression). Fourth, it must be reasonably robust – if it only resulted in a productive session, say, one time in three, it could never be trusted for time-sensitive work. We are currently experimenting with various commercially available and share-ware products with which to set up an experiment between the Welshtown and the Northton offices.

As was the case with the example of 'mechanised drawing', distributed production also involves far-reaching changes of work organisation. The survival strategy of sharing work among the branches had gradually evolved without particular reference to its technical support. But Northton's trials with Internet access changed the climate for how that should be regarded. Northton and Welshtown had already held a 'post-mortem' on the difficulties which had arisen over the A123 work. In February, representatives from the Southton, Weston, Easton, Welshtown and Northton offices all met in Northton to discuss the strategy for landscape architecture in the organisation. Building on the experience of the realistic possibility of buying and using communications technology, sending visual material, or seeing visual material on shared screens, the course of the meeting saw them shifting their description of themselves. They began to identify their various skill bases and to describe themselves as a distributed organisation. They were forced to face the difficulties of communicating and working with each other from different offices because of the severe competitive pressures and consequent downsizing in the organisation. They saw the technology, however, as offering them the opportunity to reshape themselves in order to survive the changes, with consequences which are still unfolding.

4.4 Virtual absence

In cameo 3, 'Collective production', we described the shared work involved in drawing up tender documents for the realignment of a short section of trunk road. That revealed an elegant and effective community of practice and working division of labour (Anderson et al. 1989) which, since it all took place in the same set of offices, raised no problems to do with the absence of any of the participants. Yet in other respects, much of the work is crying out for apparently 'obvious' means of technical support. We can cite a number of examples. First, the plan is assembled on A1 tracing paper ("negative") using pen, patterned adhesive tape, and text (e.g., labels) printed onto adhesive transparent sheets and razored to shape. For any amendment,

and there are always several, these items must be 'scratched out' with a razor and replaced. Second, for many jobs the underlying plan – the new and old road alignments, for example – would be available in digitised form from the contractor's or client's engineers. Third, for ease of use on site, summaries of the planting schedule and of the spec are pasted onto the plan. The former is in a standard spreadsheet format but is currently produced by hand with a calculator. Both are then word-processed and printed onto transparent sheets, requiring negotiation over access to secretarial support, before, again, being razored to shape and pasted onto the plan. Fourth, production of the spec and bill of quantities is done by searching out a recent close equivalent to use as an initial template, working out extensive variations to it, writing these onto the copy (involving a lot of physical cut-and-paste), and competing for secretaries' time to produce a new fair copy. Various tables are worked out (with a calculator) for the bill of quantities, which are identical to the corresponding items on the plan.

The possibilities for enhanced technical support which at once spring to mind include, as a first stage, more effective use of technologies, such as word processing and spreadsheets, which they already have on site. A second stage involves bringing into use graphics packages such as AutoCAD and Photoshop for actually producing the plan, as an extension of the process of increasing familiarity with graphics tools which we have already seen in the previous cameos. A third stage involves technical support for meshing all the different kinds of materials (text from WordPerfect, tables from Excel, drawings from AutoCAD, pictures from Photoshop, etc.) which need to be assembled on the plan. We have explored this with Macromedia Freehand, which supports the meshing and assembling of these different components, and can also support the drawing process as such (e.g., by importing the drawing in AutoCAD format and using Freehand to support colouring and the making of keys).

These are rather large changes in work practices for the people involved (landscape architects, technician, secretaries) to take on all at once and, even at best, some time would be required for them to stabilise. They have worked successfully in that as time has passed they have increasingly been used in preference to the old manual procedures. They have yielded some of the kinds of advantages one might hope for in terms of the ease of making changes, the reuse of materials, and avoiding repetitive routines.

Those are valuable results, but the main point in the context of this discussion is a rather different one. The introduction of the technology for the uses just described is oriented more towards the *individual* aspects of the work – a landscape architect, and his or her own self-contained activities in producing a plan. Indeed, if anything it increases the 'individuation' of the work through, for example, reducing dependence on secretarial support for these particular activities. But in depicting cameo 3 early in the paper, the aspect of it which we emphasised was as a fully 'naturalised' (socialised) community of practice working elegantly and effectively through the co-presence of its main parties. If it is proposed, for reasons which are not immediately to do with the *collaborative* aspects of the work, to support components of it with new

technology, then a key question is whether that technology risks disrupting the co-operation. Would access to the use of shared material be significantly hampered? We have become used to speaking of 'virtual presence'. What we need to worry about here is whether moving work onto the screen will create what we could call 'virtual absence' in a previously collaborative environment. The screen as actant effectively 'shoulders the other participants out of the scene'. 'Virtual absence' arises when actors are physically co-present but the technologies through which they are acting diminish or destroy the effects and benefits of that co-presence.

As we saw, for the most part, the collaboration took the form of discussions in a context understood as common. There were two occasions in particular when two or more people were clustered around the work. The first was during the initial brainstorming, in which continual reference was made to the large-scale draft coloured plan – involving such activities as moving it about, pointing and gesturing, redrawing and annotating. It seems obvious that replacing that with, say, working from a monitor or set of monitors would generate 'virtual absence'. Yet, at least for as long as this activity remains co-located, there is no necessity to make such a change. There is nothing to prevent brainstorming continuing to take place around a hand-drawn or printed draft plan. The second occasion occurred when Annie and Lynne were both attempting to measure quantities from the plan – Lynne was measuring the lengths of fencing, Annie was measuring a particular area of grass. But in this case there was no interdependence in their work and they were simply getting in each other's way, so that, for example, separate representations on different monitors would actually be preferable. Another example where separate representations would be helpful is in the newly-adopted Quality Assurance (QA) procedure. Parts of documents could be checked while last minute detailed changes are made to other parts, as happened, for example, when Annie gave Lynne her plan to check, but had to get it back a few minutes later, to use it in order to ensure consistency with changes she was making to another, related plan. In these particular respects, then, this can be seen as a 'counter-case' in which the community of practice can be retained by preserving the proximity of work, and so needs no electronic reproduction in the form of shared materials.

There is, however, also a more diffuse sense in which working on a plan and other materials at a drawing table is a resource for collaborative work. First, it is an important component in providing for the 'readability' of the state of the office and its work. It enables participants to see 'at a glance' who is working on what and how far particular jobs and tasks have progressed. This is vital for the smooth mutual adjustment by means of which the flow of work through the office is achieved. Second, being able to casually overlook what others are doing (indeed, scarcely being able to avoid doing this) continually provides cues for others, reminding them of things they themselves need to do or of information they need to pass on. At one point, for example, Lynne observes Annie drawing in an area to be planted with a particular species and size of plant in an exposed part of the site, and is reminded to include strong enough stakes for them in the specification (in fact, they negotiate this exchange as a joke over whether the plants will actually survive there).

If the work that is being done disappears onto a computer screen, then this creative public availability is very much reduced, if not lost entirely. We intend to experiment to see if we can ameliorate this, and our first line of attack will be with a video projector, projecting onto a wall at true size. However, we will seek to project, not the current screen 'window' on the plan, but the entire plan (A1 or A0) at full size. This could significantly address not only the 'public availability' problem, but could also help the user to better relate his or her own work on the screen to the larger context of the plan as a whole, perhaps by displaying a rectangle on the projected image showing the location of the screen window. It would also open up new sets of possibilities for remote collaboration, by projecting the plan being worked on at another site.

If we consider this wall projection as an actant, it extends what is in some ways a slightly colder embrace to the co-present members of the community of practice than does a physical plan on a drawing table. But it could also extend a warm inclusiveness to potential members elsewhere. And it is part of a larger 'environmental economy' of sociality: if it mitigates virtual absence, it makes it easier to live with a computer-based system which, potentially, also makes the plans easier to revise. This postpones a premature punctualisation, the tendency for the previous physical materials to congeal too quickly and over-materialise the actions and social relations that composed them. That, together with their much greater transportability (at least for those with technologies at the other end which will enter into appropriate conversations with the technology at this end) means that others can be drawn more easily and more casually into the revision process. And, as we saw earlier, that in turn gives sense and material form to an obviously-available category, a new social-technical composite with new properties, the 'mutable mobile'.

5. Bricolage

Earlier in the paper we said that a key aim of this project is to research means of developing CSCW 'in practice', and that we are trying to use this case study to contribute to understanding and developing the *process* of designing appropriate technical support. We also said that at the moment that translates as the need to make simultaneous progress on seven inter-connected fronts:

- ethnographic and conceptual *analyses* of the social organisation of work
- the *participation* of practitioners as co-designers
- the *totality* and *affordability* of technical support
- the *immediacy* and *continuity* of design
- coping with the deeply built-in *uncertainty* of the relationship between technical systems and work practices.

The examples we have been discussing illustrate how we have tried to tackle these issues. We consider that they can usefully be brought together under the heading of a 'bricolage' approach to design.

As we have seen, a principal aspect of the theoretical approach we have adopted for understanding work in context is in terms of the communities of practice through which work is achieved. One consequence of taking this approach seriously is to perceive that the social organisation of work does not pre-exist in any precise or detailed way, but is constituted 'in the doing' by practitioners (Suchman 1987). This means that the take-up, modification and rejection of technology in a work setting, and the accommodation of work practices that will take place around a developing technology, are radically unknowable and unpredictable. Several examples of that have been demonstrated in this paper.

Those in information systems design who have been influenced by this perspective understand very well that this unpredictability poses serious problems for some of the existing approaches to design. It undermines the illusions of some engineering software culture, such as that software has, in any straightforwardly operationalisable sense, requirements which can be specified, or that the information components can be logically modelled and that this will be sufficient for a successful working system. It also undermines parallel illusions of some cognitive engineering culture, such as that work is done purely by individuals, using knowledge which they store in their heads, engaged in tasks that can be analysed and work processes that can be modelled.

The 'negative' consequences of this for the design of technical support systems are relatively clear, and it has often been possible to sound useful warnings about the ways in which new systems could disrupt work practices. However, it has been less obvious exactly how to use these perspectives in a positive sense to inform systems design. For that reason we have been developing the idea and practice of what we might call a 'bricolage' approach to design. We think this is consistent with other explorations, for example by Ciborra (1996) regarding improvisation with information technology in organisations, by Sumner & Stolze (1995) regarding the 'toolbelt era' of computing, and by Hales (1996) on architectures for making best use of standard software. It has some parallels, but also some significant differences, with explorations of end-user computing.

Bricolage can be described as 'designing immediately', using ready-at-hand materials, combinations of already existing pieces of technology – hardware, software and facilities (e.g., Internet providers) – as well as additional, mostly 'off-the shelf' ones. It therefore also involves design as assembly. Bansler & Kraft (1995), in a critique of Participatory Design, point out that the trend is for organisations to make use of shrink-wrap software so that custom designs, whether participatory or not, will be increasingly irrelevant. However true this may be in general, it certainly applies to the SME sector. But shrink-wrap solutions can rarely be successfully dropped into a setting without a great deal of further work, and our project has illustrated this. The approach we have adopted is appropriate for this setting. We are seeking the maximum effect from limited resources, through situated experimentation with integrating and customising standard software, hardware and network technologies within the practice in question. A challenge facing CSCW in this area today is not so much to develop new software based on a thorough understanding of work practices,

but to use this understanding to assist organisations in navigating through the vast array of existing shrink-wrap solutions, to assess the needs for customisation and linkage, and to help get new technologies into effective use. It is most important, however, that this is not just an assembly of *technical* components, but also of appropriate workpractices, skills and training, communications, affordability, legal and contractual arrangements, etc. In other words the design is of a *totality* of technical support in context - it is a matter of co-evolving work and technology.

In such an environment, no developments are obvious or straightforward except with hindsight. As 'designing immediately' implies embarking on the radically unknowable, it becomes necessary to literally test each solution, step-by-step. Also, problems need to be defined in relation to what one knows about the possibilities in reach. As we also argued earlier, a particular piece of technology may be adopted to address a current problem, but however successful it is for that, it must be expected itself to generate new problems, either for that same practice or for others. These can in turn be addressed, either by yet more technology, or by changes to working practices, or both. At every point in the journey an assessment must therefore be attempted of whether, overall, the gains from the new practical-technical assembly outweigh the losses.

One particularly positive aspect of a bricolage approach is its capacity, under the right circumstances, to 'rescue' failing technologies. This is because the 'misfit' between technology and work practices may be due not so much to failures in the design of the technology, as to failures to think and work through the relationship between available hardware, software and facilities, and the real setting and context of the work. That may be amenable to relatively simple adjustments which enable technologies to be taken into use. The ambition is to compensate for the limitations of technology and money through careful attunement to the circumstances of the work. This way of proceeding deviates substantially from most existing CSCW approaches in that it takes account of the very real pressures and constraints surrounding the need for technological support in a small enterprise fighting for survival. It is oriented towards immediate improvements and solutions while also keeping longer-term development firmly in view.

In addition to the seven aspects discussed above, two relatively new and accelerating aspects of the environment help to make bricolage an attainable reality. These are:

- The *flood to market* of relatively cheap hardware, software, peripherals and services, constituting a global 'hinterland' of entrepreneurial experimentation. Several times during the project we put effort into designing a particular custom-made solution, or investigating research prototypes, only to find cheap off-the-shelf equivalents announced within weeks or days of finishing. We think this will be an increasingly common experience.
- The development of *modularity and standards*, such as ActiveX or COM, so that assemblages of packages can be attuned to each other and to work practices.

Though these sometimes, disturbingly, are allied to market dominance rather than to truly open standards, they can also be a very powerful resource.

These are not a substitute for bricolage, however, in that few can do useful work without a considered integration with their setting.

Bricolage can at the same time be considered as a description of the existing context (which will itself be an evolved and evolving assemblage of 'things that work'); as a method for design; and as a kind of 'solution' – the (unforeseeable) outcome of a particular round of development. It requires investigation of the process of assemblage as well as designing for it. Bricolage is therefore an approach to be commenced before and independently of the development of new technology. But it is also an overarching framework within which newly developed technologies are set in place and helped to 'work'. It is itself made up of an amalgam of participatory design, action research, and ethnography.

6. Conclusion

In this paper we have been investigating the process of devising appropriate computer support for the co-operative work of landscape architecture. In the work practices we have described, and the social-technical combinations which we have followed through, the project can be characterised as continuously working with and between long term possibilities and current conditions. Visions of the future suggest where we might go, current conditions tell us that we cannot attain this yet, and the concrete work explores how far along the road we can get. The conditions of ever changing requirements and the relocation of markets triggered the visions of computer supported graphical work and networking in ABC-Co. These visions, given current financial constraints, informed and guided the actual changes, which in turn led to new visions of the organisation and the possibilities it contains. The experimentation and user involvement allow us on the one hand to envision and enable preferred futures given current conditions and practices (Ehn 1988; Greenbaum & Kyng 1991), and, on the other hand, they provide means to investigate some of the more dynamic aspects of current practice (Mogensen 1994). The result was to attempt a co-evolution of work and technology, interlacing the new technology with changes in both local and distributed practices.

Our aim has been to support CSCW 'in practice'. We have taken a modest, real-world work setting and, for the most part, we are applying modest, widely-available technology to it. The working environment that we have chosen for our study is typical, in the resources it has available and in the competitive environment which it faces, of a vast constituency of work settings. If CSCW is to be relevant in such settings, it must use the technical possibilities which are readily to hand or whose affordability can be reasonably foreseen. We believe we have shown that such ambitions are realistic, even with very modest means, provided that attunement to the real circumstances of the work is the main focus.

Æsthetic production is bound, very properly, to retain its creative and perhaps essentially mysterious aspects. But it equally involves a distinctive set of practices of reading and writing in the material culture (Miller 1987) which can be identified in interaction, explored, and hopefully supported. For CSCW to succeed, not just as a set of technologies but as a paradigm and an approach, then it must increasingly show itself to be capable of addressing the real problems and challenges which practitioners face in open-ended work of this kind.

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Notes

1 SMEs have been the focus of much policy debate in the UK and in Europe. They are claimed to be one of the most dynamic and innovative economic sectors and therefore in need of nurturing.

2 Even so, further 'wrinkles' are hit upon right up to the deadline, and no doubt there could be others that have been missed. There is no such thing as a completely finished job.

3 Of course this is a 'hinterland' of work only insofar as models of work treat such matters as less important than others; and whether it is hidden or visible depends on the methods of study used. One of the advantages claimed for an ethnographic approach is precisely that it can bring such matters to light.

4 These issues are only broached in a very preliminary way in this paper. For example, a community of practice need not be treated as a literal entity with boundaries but can also be considered as an approach or orientation to the analysis of work practice. But in either sense there are significant questions about how to connect it to different entities or approaches.

5 At least, as regards this particular aspect of their relationship. There are other settings – joint site meetings and inspections, for instance – in which both *are* engaged in a shared community of practice.