Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work,
September 10–14, Stockholm, Sweden
H Marmolin, Y. Sundblad, and K. Schmidt (Editors)

Workflow From Within and Without:

Technology and Cooperative Work on the Print Industry Shopfloor

John Bowers
Department of Psychology, University of Manchester, UK.
Computing Department, Lancaster University, UK. (visiting 1994-5)

Graham Button
Rank Xerox Research Centre Cambridge Laboratory, UK.

Wes Sharrock
Department of Sociology, University of Manchester, UK.

This paper reports fieldwork from an organization in the print industry, examining a workflow system introduced to the shopfloor. We detail the indigenous methods by which members order their work, contrast this with the order provided by the system, and describe how members have attempted to accommodate the two. Although it disrupted shopfloor work, the system's use was a contractural requirement on the organization to make its services accountable. This suggests workflow systems can often be seen as *technologies for organizational ordering and accountability*. We conclude that CSCW requirements should acknowledge such exigencies and the organizational status of workflow technologies

Introduction: Workflow Systems and Work Practice

This paper reports a field study of workflow technology in a nationally distributed organization in the print industry. By 'workflow technology' we understand any technology designed to (in some way) give order to or record the unfolding of work activity over time by, for example, providing tools and information to users at appropriate moments or enabling them to overview the work process they are part of or to design work processes for themselves or others or whatever. The

development of workflow technology has been an important part of the research endeavour within CSCW (Medina-Mora et al., 1992; Agostini et al., 1993) arousing much controversy and debate (e.g. Suchman, 1994; Winograd, 1994). However, not all of the discussion of workflow technology has been directly informed by empirical studies of cooperative work or of the use of emerging systems. For example, several systems have been developed on the basis of general theories of communication such as speech acts (e.g. Winograd & Flores, 1986) or abstract process models (e.g. Medina-Mora et al., 1992) rather than empirical studies of talk at work or the details of actually occurring work practice. This exposes such systems to the objection that they are insensitive to the contextual details of work and interaction in ways which inhibit their usability. Indeed, an increasing number of case studies of workflow and groupware technology in CSCW point to this as a critical problem when such systems are implemented in actual organizational contexts (e.g. Bowers, 1994; Orlikowski, 1992).

Our study adds to and extends the emerging literature of empirical studies of workflow technologies in use by examining a workflow system in the print industry. To date studies of technology in use in CSCW have been dominated by office work in adminisitrative and managerial sectors. Indeed, with a few exceptions (e.g. Hughes et al., 1992), 'the office' constitutes the default development context for much of CSCW research. To us, this is an unfortunate narrowing of the horizons of CSCW and one which has influenced the debate over workflow systems. The presence of computers in office work, from familiar word processing and database systems to local area networks and so forth, is ubiquitous. This makes it easy for designers to consider adding to the functionality of office systems with the introduction of workflow applications. Indeed, in some of the most developed visions, workflow will become less another application more an 'embedded enabler' of work invisible to the user much like many of the features of today's workstation operating systems (cf. Abbott & Sarin, 1994). However, it is notable that this vision depends upon the ubiquity of computers as the tool and medium for the work. While this may be becoming the case for much administrative and managerial work, not all work has this character. Indeed, the existence of special purpose tools and materials, not necessarily computational or informational in nature, is precisely part of what makes production and manufacturing work distinct.

For example, on the print industry shopfloor, while computer controlled digital technologies are becoming more prominent, older methods such as lithography and 'hot metal' presses are still deemed essential for various forms of work. Many contemporary print shops are likely to contain a heterogeneous suite of technology to maintain flexibility in how jobs can be done. Thus, currently, in much of the print industry, the vision of ubiquitous computer-based workflow technologies is someway off. This means that workflow technologies in such industries need to be at least in part *external* to the tools and materials of the work. While an office based

workflow system can take the approach of providing information and computer based tools as and when they are appropriate, it is not feasible for a workflow system to set up a litho-machine or move a comb-binder onto the shopfloor as and when they are required for the job! In short, we feel that much of the debate surrounding workflow has been specific to *internal* workflow technologies where the tools and materials are not different in kind from those used in the work itself.

Of course, those who criticise workflow systems are often precisely objecting to the internal positioning of the system within the work. It is this, some would argue, that allows workflow systems to overly constrain the work by imposing some process model or theory of interaction on it. If a workflow system were external to the work and did not directly control the availability of resources for the work, then perhaps more flexible support for cooperative work could be offered through workflow. In some respects, this is the approach taken by De Michelis & Grasso (1992) who present a system which separates out support for the negotiation of the nature of the work from support for communication about it.

By going beyond office work into an industrial production context for our fieldwork, we hope to subject such claims to examination while adding to the corpus of empirical studies of workflow systems and bringing cooperative work on the print industry shopfloor to the attention of the CSCW community.

Fieldwork in the Print Industry

Our fieldwork has been conducted at an organization which we shall call 'Establishment Printers' (EP), a nationally distributed printing company in the UK, employing a total of over 2,000 personnel. EP engages in a variety of forms of print production work from large run printing of books and pamphlets to smaller scale reprographic work. It uses a range of traditional print technology including hot metal presses and off-set lithography but has also introduced a suite of technical changes into its printing work, incorporating high end photocopying and digital reprographics machines which offer digital scanning, storage, reproduction and networking functionality.

Recently, EP has won a number of contracts to take over the printing facilities of UK Government organizations who had put out their print services to competitive tender. This paper concentrates on the nature of cooperative work and the use of workflow technology at three sites (two in the North of England, one in London) which are maintained by EP within an organization which we shall call 'The Department'. The commitment to install and use a Management Information System (MIS) with 'real time shopfloor data-capture' to monitor workflow was a requirement of each tender. Subsequently, the demand to use such a system has formed an element of EP's legally binding contract with The Department, alongside stipulated monthly 'audit' meetings where reports from the system are inspected to ensure that EP is delivering the level of service the contract requires. It is this

system (which we shall call PRINTFLOW PF2) and its impacts upon cooperative work on the shopfloor that we shall describe.

Maintaining a Smooth Flow of Work

A reprographic site at EP faces great variability in the kind of printwork they may be required to do. They may receive little or no notice of work which may itself have varying degrees of importance to the customer. Additionally, the work can run to different deadlines. At The Department, for example, EP offer a same day turnaround counter service for smaller jobs alongside a ten day turnaround for work requiring shopfloor processes. Furthermore, very little of the scheduling of when jobs come in is under the direct influence of EP themselves. Indeed, as EP has undertaken to diversify its services and to adopt a 'customer centred' business philosophy in recent years, the problem of managing the work has become especially acute. How are these problems to be dealt with? How is the work of the reprographic sites to be ordered so that EP can provide the level of service its customers expect? How can the massive contingencies of printwork be managed?

Our claim is that, in essence, reprographic work is managed by the contingent organization of *a smooth flow of work* through all parts of a site's capability. A smooth flow of work involves ensuring, for example, that no one operator is conspicuously occupied while others are idle, that no one job needlessly ties up the shopfloor while other jobs are waiting, and that machines are appropriately used to their best capabilities. In short, a smooth flow of work consists in ensuring the even distribution of work across operators, machines and jobs.

Crucially, EP personnel will organise their work so that there is a smooth flow of work *through the shopfloor* as jobs typically spend most of their time there rather than in the 'front office' or awaiting dispatch. Hence, time delays there are likely to be more critical. Indeed, people in the front office (who open the mail, process new orders, deal with customer queries by 'phone and fax and so forth) are attentive to the nature of shopfloor work, often having worked there themselves, and allocate jobs with the smooth running of the shopfloor as a major consideration. In our observations, we have identified four major ways in which smooth flow is accomplished on the shopfloor: (1) prioritising work, (2) anticipating work, (3) supporting each other's work and knowing the machines, (4) identifying and allocating interruptible work, and it is these that we shall now explicate in turn.

Prioritising Work

On receiving an order for printwork, administrative staff in the front office enter the details of the job (materials required, cost code, numbers, desired delivery dates etc.) into their records. A copy of the order is then used as a 'docket' accompanying the job in a see-through jacket as it undergoes the various printing processes

appropriate for it. Administrative staff allocate the jobs to shopfloor workers, depending on (i) the kind of work it is (e.g. colour work will go to the operator skilled in colour lithography) and (ii) who is currently most able to do the work. Typically, jobs are then placed in an in-tray located near the machinery which the first process will be executed on. Once the first process (say colour lithography) is complete, the operator will consult the docket and pass the job to the operator who is most appropriate (either in terms of their skills or availability) for the next process (say comb binding), again depositing the work in the relevant in-tray. And so forth.

Typically, jobs will be sorted or inserted into in-trays so that date-order is maintained. That is, the work with the soonest delivery time will appear at the top. However, operators do not always process work in date-order. Operators will juggle the contents of their in-trays to ensure that a smooth flow of work will be promoted. Operators will examine job dockets to make assessments about how complicated a job is and how long it will take, whether there are further time consuming processes that the job will encounter later on and so forth - these considerations being balanced against the customer's delivery date. This re-ordering will also be influenced by whether there are outstanding jobs from the previous day's work, whether a regular large scale job is imminent and so forth.

The use of digital reprographics technology makes it especially important that operators carefully schedule their work and do not blindly follow date-order. For example, a job involving several thousands of copies of white A4 paper may only require the operator to make periodic checks on the functioning of the machine and copy quality while replenishing paper. In the mean time, the next few jobs can be scanned into the machine's memory and, if necessary, cropped to size or blemishes can be masked. On the digital machines at EP, scanning and copying can be executed independently. In this way, a skilled operator can set the machine off with a large routine job while at the same time engaging in the more labour intensive processes of scanning, cropping, masking and so forth. Accordingly, operators search their in-trays for such routine jobs and juggle the rest of its contents to enable the machine to be kept in continual and smooth production. Finding a large routine job also helps keep digital machines in continual use over lunch and other breaktimes. One operator will set a long job in train and take a break with another coming back from their break to complete the work. The identification of such jobs within the in-tray and ways of covering each other accordingly is essential for the effective and smooth use of the machine. Thus, very rarely will strict date-order happen to coincide with the ordering that makes for a smooth flow of work.

Anticipating Work

To a limited extent, the flow of work through the shopfloor can be organised by taking regular, known-in-advance work as a 'grid' around which other work can be fitted. While this certainly does not provide a complete solution to the problem of managing the complexity of printwork, the fact that some of EP's work is

anticipatable enables shopfloor workers to ready themselves and their machines for when the job does properly arrive. Indeed, some parts of a regular job like a monthly report done to a standard format may be started even in advance of receiving the month's contents. Not only can the materials be ordered in advance, perhaps the front and back cover and standard introductory material can be printed if they are identical month-by-month. In other words, to ensure a smooth flow of work, EP staff will maximise the benefits of scheduling jobs around known-in-advance work by 'jumping the gun'.

'Print-on-demand' work (where EP stores the customer's originals digitally and prints copies to order) especially lends itself to jumping the gun. As the originals are already 'in hand', no setting up is required, merely the production of a specified number of copies. Indeed, some print-on-demand work may involve a fixed number of copies to be produced weekly or monthly. Under such circumstances, EP may often produce copies in anticipation of the order being confirmed. What is more, customers in The Department may merely 'phone through the order rather than themselves complete an order form. An order form may then be completed retrospectively or the details may be inserted into EP's records from a memo taken by EP's own staff at the time the phonecall was taken. Accordingly, by jumping the gun both administrative and shopfloor staff can invest print-on-demand work with the character of regular, known-in-advance work and use this as a way of promoting the smooth flow of work through their hands.

Supporting Each Other's Work and Knowing the Machines

We have already remarked that administrative staff are attentive to the workloads of shopfloor workers and are able to take this into account when allocating work. This awareness is obtained by periodically walking through the shopfloor and checking all is well, by discussing workloads when new jobs are to be allocated, by chatting at break times and so forth. Equally, shopfloor workers are attentive to each other's workloads and take this into account when negotiating with administrative staff or judging whom to pass work on to for its next production process.

Importantly, various architectural, machine lay-out and other features of the shopfloor support this monitoring of each other's work. The 'ecology' of the shopfloor provides lines of sight between workers which enable their awareness of each other's work and which support ad hoc cooperation. In addition, operators are able to *hear* whether the work is progressing smoothly. Many of the machines have 'designed-in' alerts (beeps and so forth) which draw attention to paper jams or empty paper trays. These sounds are available, of course, not only to the operator of the machine but to anyone else within earshot. Accordingly, operators can help each other out by replenishing paper if the operator who initiated a job is elsewhere at the moment. Furthermore, skilled print workers are attentive to the regular noises a machine makes at different stages during production. For example, a change in pitch can inform an operator that a paper tray is about to become exhausted, or a

noise of a certain sort might suggest an obstruction in one part of the paper path. In short, both an awareness of the state of the flow of work through the shopfloor and ad hoc cooperation are sustained through listening to and knowing the machines. Not only do these activities acquaint workers with whether the flow of work through the shopfloor is smooth or not, they provide them with resources for the swift and ad hoc remedying of irregularities by, for example, helping someone out.

Identifying and Allocating Interruptible Work

We have remarked that very little of the workload of EP's sites can be thought of as known-in-advance work and that most of the flow of work has to be 'ad hoc-ed'. Knowing that interruptions by urgent work and rescheduling are endemic to print production, EP's staff have evolved ways of allocating and re-allocating work to ensure that such events have as minimal an effect on the work's flow as possible.

We have already seen that local, ad hoc cooperative arrangements will be made by operators to help each other out in times of trouble. A job which turns out to be more labour intensive than anticipated by administrative personnel may be split between two operators by local agreement on the shopfloor. Furthermore, the workers who are normally dedicated to the counter service may be utilised if a job passing through the shopfloor requires extra hands. Counter service work is subject to daily and weekly fluctuation. There can be moments when the counter staff are overworked, in which case staff from dispatch or even the administrative office will 'turn a hand' But equally, there can be idle moments. Accordingly, knowing this, administrative staff allocate counter service personnel further print jobs but ones which tend (i) not to be urgent, (ii) not to require special materials or techniques not available on the photocopiers in counter service, and (iii) to be interruptible in the event of new counter service work coming in. In short, simple, non-urgent, interruptible jobs will also be allocated to counter service workers to be 'taken up and put down' as and when there are slack moments on the counter.

Not only can administrative staff more fully utilise counter service staff by allocating them interruptible jobs, shopfloor operators may also pass appropriate work to counter service personnel when the workload on the shopfloor is becoming intense. At one of The Department's sites in the North of England, a large window has been positioned between the counter service area, where Mary works, and the shopfloor. This enables both parties to check on the workload of the other and detect moments when work is unevenly distributed. At times, no more than a raising of eyes to Mary and an agreeing nod will ensure that work is quickly passed on. Indeed, as Mary's non-counter work is designed by administrative staff to be interruptible, she is also able to help the shopfloor workers if required and if her or her machine's capabilities are appropriate. Thus, 'passing work to Mary' (or her equivalents) becomes a further means for ensuring the smooth flow of work.

The Promise of Workflow Technology

The practices we have identified constitute the indigenous means by which staff at EP's sites within The Department organise and give structure to their working day. However, EP winning the contract to provide printing facilities to The Department had the major implication that a new MIS with workflow components should be overlaid on the work to support monitoring by The Department. PRINTFLOW PF2, the system proposed and installed by EP, has two basic components.

An administrative component in which jobs are registered in terms of their type, customer, cost code, delivery deadline and so forth. A job name will be assigned by the member of administrative staff registering the job. Specifying the type of job it is involves the entry of how the job will be executed in terms of the series of processes it will go through (e.g. copying, binding, finishing etc.). This information is stored in a database which can be searched in various ways and from which periodic reports can be extracted.

A shopfloor component consisting of a number of 'shopstations' arranged around the shopfloor and locally networked to the administrative database. The shopstations consist of a series of keypads. Some of these keypads are specifically configured with the names of workers. Others refer to the machines in the vicinity of the shopstation. Others name the processes which can be executed by the machines near the shopstation and are used to notify PF2 whether an operator is starting a process or has just completed it. Others name materials which are commonly used by the machines in the execution of their processes. Yet others are used to control an operator's interaction with the shopstation and are labelled 'enter', 'yes', 'no' etc. A numeric key pad is also available. Running across the top of the shopstation is a single line, 20 character display which echoes input and illuminates with system messages while the shopstation is being used.

It is by interacting with the shopstations that shopfloor data is 'captured' by PF2. For example, when a process starts, an operator makes herself and the job number (read from the docket) known to the system. Similarly, when a process is completed, the operator re-identifies herself and the job, followed by recording the details of materials used and wastage (if any).

PF2 was selected because it promised a number of important benefits for EP. As they have been explained to us: (1) it was specifically designed for use on the shopfloor of the print industry; (2) it was consistent with the requirements of the invitation to tender and specifically would enable EP to provide management reports which could detail the time spent on processes, materials consumed and wastage figures, while supporting the production of invoices as well as, if required in the monthly 'audit', the justification for the charge made in the form of a job report; (3) it can, in principle, support stock control, through keeping an accurate and up-to-the-moment record of materials used which can be inspected at the administrative

component; (4) it can record worker activity and hence could, in principle, replace clocking on/off; (5) it can support process management by giving administrative staff and site managers a view of shopfloor activity which can be sampled from the administrative component; (6) as the PF2 databases had been networked across all three of The Department's sites, cross-site monitoring would be supported so that sites can be aware of what each other are doing; (7) as jobs are registered and their execution is recorded on PF2 as a series of print processes, this reinforces the quality standards which EP subscribes to as this is how they depict printwork too.

The promises of PF2, then, were many and varied. However, of all these, the most important to EP is that PF2 can provide reports of various sorts on how the work has been done, so that EP can demonstrate to The Department, when required, that they are indeed conducting The Department's printwork to contract.

Workflow Technology: Disrupting Smooth Flow

In various ways, the introduction of PF2 itself disrupted the smooth flow of work through the shopfloor of EP's sites, raising a series of problems about how the technology should be used and whether its use could be legitimately 'suspended' on occasion. At the time of writing, nearly a year after the commencement of EP's contract with The Department, a number of the dilemmas surrounding the use of PF2 in relation to the print workers' indigenous practices for organising their work remain unresolved. Let us give some details.

The Imposition of Procedure

We noted that printwork at The Department often requires jumping the gun. Urgent jobs often need to be started before order forms have been received or job numbers issued. Similarly, much regular, print-on-demand work needs to be started in advance so that, amongst other reasons, more contingent work can be flexibly structured around them. However, a job for which no job number yet exists has the same status as a non-existent job as far as PF2 is concerned: no details of its execution can be recorded at the shopstations because there is no job number to enter. Accordingly, just how jobs which have jumped the gun have actually been completed cannot be made visible to PF2 using it conventionally. This raises some dilemmas. For example, independent records could be manually kept for how such a job is done and its details entered some time later. However, in this case, PF2 would give inaccurate information for process management and cross-site monitoring, as well as out-of-date stock control information. Alternatively, one might not use PF2 at all for such work. But then EP would be seeking to charge The Department for work which, according to the record, had not been done, while keeping independent records with no corresponding version in PF2 would risk defaulting on the contract. Finally, counter service work is especially problematic as

PF2 would seem to require the registration of administrative details before the copying service can be completed. While a solution would be to have all counter work set up as one 'rolling' job, this would not allow separate billing for each customer according to individual customer codes. In short, PF2 imposes a procedure on the work (first register it, then do it) which negates important means for ensuring the work's smooth flow and timely delivery.

Work as Processes in Series

Shopfloor workers soon discovered a major constraint on how PF2 could be used to record data on the execution of print processes. PF2 embodies a process model which depicts jobs as a series of processes, each the responsibility of just one operator, each to be terminated before the next commences. Indeed, as PF2 was proposed as a means for capturing accurate data about shopfloor workers as well as about jobs, it had implemented the constraint that a single operator cannot engage in more than one process at a time. This means that the organization of the smooth flow of work by juggling in-trays cannot be made visible to the system. For example, we noted that operators of digital reprographic technology need to order their work so that a long job can be scheduled alongside one or more labour intensive jobs. However, once PF2 has been notified of the start of the long job, the same operator cannot notify the system of any of the scanning jobs. Again there is a dilemma. Either workers accept PF2's constraints and cease juggling their in-trays or they continue to juggle their workload and not log-in the scanning process. Both of these upshots are problematic: the first because it disables an important means for ensuring smooth workflow, the second because it makes invisible to The Department something which had actually been done and which EP would like to separately itemise in billing precisely because of its labour intensive nature.

The Overhead of Use

Shopfloor workers experienced a considerable overhead in using PF2 to log their activities An interaction with PF2 consists of much keypad pressing. Indeed, a job involving different materials with non-standard codes and some wastage may require several minutes to register. This, when an operator may get through tens of jobs a day, is a noticeable overhead. Furthermore, the time spent using PF2 is not itself calibrated with the time spent on the job. Twenty thousand copies takes approximately the same time to record as two copies. Small scale print jobs which happened to use three colours of paper would require about three times as many key presses at the shopstation than a big job using one colour of paper. Using shop stations, then, was proportionally a very big overhead for small jobs. This problem was especially acute for counter work, when the use of PF2 directly disrupts the service customers receive as they have to wait a little longer while job details are inserted (even assuming appropriate customer codes can be found for them!).

The Individualization of Work

PF2 conceives of print processes being the responsibility of single operators. However, this means that the contingent cooperative activities so important to organising a smooth flow of work cannot be represented to the system. If a big job is done on a digital reprographics machine, say, by one operator replenishing the paper, while another unloads the copies from the stacker, while a third scans in the next ten pages, they have to discuss amongst themselves which of the three should appear as having done the work and which two would potentially appear as 'idle'! Equally, if a job is taken over by another operator to maintain continual production over lunch, the second operator would have to 'impersonate' the first to be able to register the job done at all, thereby making the first operator's lunch break invisible! Again, PF2 presents problems as to how it is to be incorporated into printwork without either dismantling the ad hoc practices which promote smooth workflow or falsifying the record in a way which is potentially detectable by The Department.

Re-Working the Order of the Shopfloor

How did the staff at EP cope with these problems? It is first worth reminding ourselves that they do *have to* solve them practically because working with PF2 is necessary due to contractual requirements. EP *cannot* discontinue the technology. Accordingly, they have to *re-establish* the order of their work with it (or in spite of it). This has been accomplished by different sites in different ways. At The Department's London site, some built-in workarounds in PF2 were discovered and put to use. In contrast, after experimenting with PF2's own workarounds, The Department's sites in the North of England took a more drastic step and reorganised their entire working day to accommodate the system. Let us take these in turn.

Some aspects of the 'overhead of use' problem can be addressed through a facility called 'gang job'. This involves using the shopstations to define a 'gang' of jobs. While each maintains its own customer code, materials used can be registered in a single total per material type Thus, if there are a large number of small jobs all using white standard grade A4, all the copies made can be returned as just one overall total. While a little effort is required to define the gang initially, much time is saved finally as separate figures need not be entered for each job. However, this workaround leads to anomalies In order to assign operator times, materials and wastage to each job, the total time and the rest are divided through by the number of jobs and equal numbers counted to each job. This will mean that a two copy job and a two hundred copy job, if they are part of the same gang, will be equally recorded when there is a hundred-fold difference in materials between them. Furthermore, if the gang involves a range of materials, a job which consisted of only white paper may (absurdly) be recorded as having 0.09 sheets of blue included! Clearly, there is

another dilemma here. Easing the burden on the shopfloor may lead to inaccurate management information to present to The Department and potentially incorrect billing. Avoiding this dilemma means that 'gang job' can only be used marginally: e.g. when a number of highly similar jobs do happen to turn up at the same time.

Some aspects of the problems of individualising processes can also be addressed by recording a process as a 'labour charge'. This can be done by an operator even if they are engaged simultaneously on another process which they have initiated by interacting with PF2. To record a 'labour charge', an operator presses a button on the shopstation marked 'labour charge', identifies themselves, types in a job number, confirms the title when PF2 retrieves it, enters a time in hours and decimal parts of an hour, followed by the details of materials and wastage as before. At The Department's London site, this facility is used to workaround the constraint that an operator cannot start up a new process on PF2 while another is active. However, this workaround does have its own problems. Labour charges can only be recorded *after* the process has been completed, so they do not support any moment-by-moment process management or cross-site monitoring and require operators to keep an independent record of when they started a job. Furthermore, whether something is recorded as a labour charge or as a timed process depends (arbitrarily) upon what happens to interrupt what in the unfolding of an operator's work and not necessarily in terms of any other feature of the job.

At the time of our last visits to The Department, the London site was persisting with using PF2's 'labour charge' facility as best they could to record concurrent work, keeping independent, manual records when necessary (e.g. if the gun is jumped) and encouraging the workforce to be as accurate as possible in recording materials and wastage. In this way, a momentary peace has come about between the indigenous practices for maintaining smooth workflow and the demands of using PF2. This 'peace' though has come at the cost of working overtime every week since EP's contract began and of only 'clearing the in-trays' during the working day once in six months. And that was after PF2 had been 'down' for three days!

In contrast, the northern sites have developed a more radical solution. Here jobs are entered at the start of the day into the administrative component of PF2 as intended. However, the system is not used to record how jobs are done while working on them. Rather, manual records are kept on the dockets which accompany jobs and, where necessary, further paper notes are added to the see-through jacket. The shopstations are untouched and work is organized by the methods we have noted. However, at the end of the day or the beginning of the next, one administrative worker takes all the dockets and orders (including those for counter service work) and records the operators, materials et cetera into PF2. Thus, PF2 is not used for real-time data capture, rather it is employed to *retrospectively reconstruct* the work in a form which can nevertheless provide The Department with an account of what occurred and why they have been charged in the way they have, even though this forfeits many of PF2's other promised benefits.

Conclusions: CSCW, Workflow and Design

Our fieldwork suggests to us that extreme difficulties can be encountered when introducing workflow systems into a workplace, even when the system is external to the tools and materials of the work itself. PF2 does not (directly) constrain workers' access to the resources for their work, nor (directly) impose an ordering on the work by insisting that some task be completed before another one. However, it does embody a process model of how printwork is done which makes recording the work problematic in the light of what is actually done. This case suggests, then, that the impacts a workflow system may have on work can be extensive even if there are no 'hard wired' links between the system and the conduct of the work.

Workflow From Within and From Without

We feel that the image of 'workflow' captures well the question of the temporal ordering of work. Indeed, this is how several of EP's staff themselves characterised things when all was well: 'the work flows smoothly' and such like. Work unfolds over time and has to be organised (scheduled, conducted, recorded, managed) attending to this. The question is not whether smooth workflow is to exist or not (at EP it has to) but how this is to be accomplished. In this connection, we offer a distinction between workflow *from within* and workflow *from without*.

Workflow from within accomplishes the smooth flow of work through methods which are internal to the work To do printwork competently requires that, on receipt of a job, an operator is able to orient to matters such as: Is this job properly for me? Should it be done next? How urgent is it? To whom should I pass it when I am done? And so forth. By resolving these questions in working on the job, not only is the job done, so is the organization of the shopfloor in part accomplished. Workflow from within characterises the methods used on the shopfloor which emphasise the local and internal accomplishment of the ordering of work. Workers juggle their in-trays, jump the gun, glance across the shopfloor, listen to the sounds coming from machines, re-distribute the work in the *here and now* so that what to do next can be resolved. In the here and now, in *real time*, workers encounter multiple jobs of a varied nature, requiring artful scheduling and completion.

In contrast, workflow from without seeks to order the work through methods *other* than those which the work itself provides. In PF2, a formal model of the work is provided which depicts printwork as processes in series such that (i) each process has to be terminated before another can begin, (ii) each process has just one operator associated with it at any one time, (iii) each operator can only engage in one process at any one time, and so forth. It would be inaccurate of us to say that these methods from without are just plain wrong. Rather, they offer *another way of organising printwork*, one which is encountered by the workers at EP's sites as

alien to *their* methods of organising printwork. Their methods crucially attend to the problem of the ad hoc, real-time ordering of multiply instantiated jobs. PF2's are concerned with the processual character of individual jobs, engaged with by individual workers, measurable by clock time and so forth.

In the case of EP's sites, workflow from within comes to be in tension with workflow from without as soon as the latter also has to be *reckoned on within the work*. The difficulties with PF2 arise not because some technology merely offers an 'incorrect' workflow model, nor (even) because that model is inserted into the work, but because it is inserted in such a way that makes the accountability of workers and the work that they do problematic in new ways which are themselves hard to deal with. It is because PF2 *has to be* worked with and accommodated that the tensions and dilemmas we have noted arise. These tensions can be negotiated in various ways - distributing them across the shopfloor and throughout the working day (as at the London site, where all shopfloor workers use the system as best they can at the cost of overtime and delays) or allocating them to one worker at a given part of the day (as at the northern sites where the day's work is reconstructed retrospectively). Either way these accommodations arise through the practical necessity of having to use the system. And it is this practical necessity which binds the use of PF2 to printwork at EP just as strongly as any internal 'hard wiring' of a workflow system to the actual conduct of work might do.

Technologies of Accountability and Organizational Ordering

Suchman (1994) argues that many CSCW and workflow systems can be regarded as 'technologies of accountability'.

> By technologies of accountability, I mean systems aimed at the inscription and documentation of actions to which parties are accountable not only in the ethnomethodological sense of that term (Garfinkel and Sacks, 1970), but in the sense represented by the bookkeeper's ledger, the record of accounts paid and those still outstanding. (p.188)

This is a useful way of understanding PF2 with respect to the relations between EP and The Department. PF2 is the required means for producing *accounts* both as records of charges made and as documents which *visibly testify* to EP's efficiency, capability, loyalty to contractual terms and so forth. Management reports from or based on PF2 can be used to provide not just a record but a *justification* for what was charged and what was done, if EP are *called to account* by The Department.

We feel our fieldwork adds some important details to Suchman's concept. In particular, technologies of accountability need to be understood *organizationally* and *inter-organizationally*. Introducing technologies of accountability can be in tension with existing ways of organising work, as well as provoke or fall in line with new ways of constituting the very organization within which the work is done. For The Department, EP are not merely the organization that happens to do their printing. They are the organization who do printing in a visible, inspectable, documentable, accountable way. This is a matter of organizational change not only for The

Department (who have 'lost' their print facility to external contractors through competitive tendering) but for EP (who have not only gained business but business which has to be conducted in a new manner). In all these senses, technologies of accountability can be *technologies for organizational ordering*, as part of how organizations come to be redefined through new trading relationships.

Design Requirements for Cooperative Technology

It is not within the available scope of this paper to offer detailed recommendations for CSCW technology as a result of our fieldwork. In fact, the case of PF2 at EP has caused us to reflect upon the larger issue of the very relationship between fieldwork findings and CSCW systems, and just how the former might influence requirements for the latter.

On the one hand, the methods we have uncovered by means of which print workers organise the flow of work from within can be taken to point to domains for application support. We would not be the first to commend that CSCW systems offer support for awareness and mutual monitoring or at least do not contradict members' own methods (cf. Heath & Luff, 1992). Equally, as a workflow system, PF2 could be criticised for not allowing flexible mappings from processes to operators, for not specifically supporting 'run-time' re-allocations, for not recognising ad hoc collaborative arrangements, and for adding to the work that people have to do (cf. Abbott & Sarin, 1994). These are all familiar emphases within CSCW which our study also underlines.

However, we take it as a more challenging and urgent matter that CSCW research consider the implications for system requirements of understanding workflow technologies as *technologies for (inter-organizational) accountability*. This opens up a whole new set of issues for CSCW requirements. First of all, we feel that CSCW research must be more attentive to the formal (in the sense of 'for administrative and managerial purposes') problems that organizations face and often impact upon not only their technology policies but also the details of usage. Accordingly, we are worried about the equation of CSCW with *informal, non-structural interaction* that some researchers make. It is not that we advocate traditional 'structural' notions of the organization. Far from it. Rather, we wish to draw attention to the multiple considerations which impinge upon the acceptability of technology in actual contexts - considerations which often require very difficult trade-offs. If, for example, there are good organizational reasons for accounting for the work in new and more detailed ways, how are these to be balanced up against the requirements of smooth workflow on the shopfloor or in the office? Indeed, in the current case, one might even argue (after all!) that a workflow system like PF2 *is* a reasonable solution, *provided* an organization anticipates the extra work and reckons on it as a cost in bidding for new business, *provided* those offering work for tender do not incorporate demands which might rebound on them, *provided* tenderers do not make similarly unrealistic promises, *provided* an appreciation of

how workflow is organised from within and can be disrupted from without is maintained by all parties and so forth.

If CSCW research is to learn one thing from settings like the one we have studied, it is that a naive view of cooperative work and its support has no place on the shopfloor. Organizationally acceptable technology is achieved not through the pursuit of ideals but by ensuring that the list of *provisos* is tolerably short.

Acknowledgments

We are grateful to all personnel at 'Establishment Printers' for their willingness to have us hang around and ask obvious questions. James Pycock and Tom Rodden have given useful suggestions for improving this paper. John Bowers and Wes Sharrock acknowledge help and support from Rank Xerox Research Centre Cambridge Laboratory and from ESPRIT Project 6225 (COMIC).

References

Abbott, K. & Sarin, S. (1994). Experiences with workflow management: Issues for the next generation In *Proceedings of CSCW '94, Chapel Hill, USA.* New York: ACM.

Agostini, A., De Michelis, G , Grasso, M. & Patriarca, S. (1993). Reengineering a business process with an innovative workflow management system: A case study. In *COOCS '93, Proceedings of ACM-SIGOIS Conference on Organizational Computing Systems.* New York: ACM.

Bowers, J. (1994). The work to make a network work: Studying CSCW in action. In *Proceedings of CSCW '94, Chapel Hill, USA.* New York: ACM.

De Michelis, G. & Grasso, M. (1992). Situating conversations within the language/action perspective: The Milan Conversation Model. In *Proceedings of CSCW '94, Chapel Hill, USA.* New York: ACM.

Garfinkel, H. & Sacks, H. (1970). On formal structures of practical action. In J. McKinney & E Tiryakin (eds.) *Theoretical Sociology*. New York: Appleton-Century-Crofts. pp.337-366.

Heath, C & Luff, P. (1992). Collaboration and control: Crisis management and multimedia technology in London Underground Line Control Rooms. *Computer Supported Cooperative Work*, 1 (1/2), 69-94.

Hughes, J , Randall, D. and Shapiro, D. (1992). Faltering from ethnography to design. In *Proceedings of CSCW '92, Toronto, Canada.* New York: ACM

Medina-Mora, R , Winograd, T., Flores, R. and Flores, F. (1992). The action workflow approach to workflow management. In *Proceedings of CSCW '92, Toronto, Canada.* New York: ACM.

Orlikowski, W (1992). Learning from Notes: Organizational issues in groupware implementation. In *Proceedings of CSCW '92, Toronto, Canada.* New York: ACM.

Suchman, L. (1994). Do categories have politics? The language/action perspective reconsidered *Computer Supported Cooperative Work*, 2 (3), 177-190.

Winograd, T (1994). Categories, disciplines and social coordination. *Computer Supported Cooperative Work*, 2 (3), 191-197.

Winograd, T. & Flores, F (1986) *Understanding computers and cognition: A new foundation for design* Norwood. Ablex