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A long tradition of discourse and practice claims that technology designers need to take note of the characteristics and aspirations of potential users in design. Practitioners in the field of user-centred design (UCD) have developed methods to facilitate this process. These methods represent interesting vehicles for the pursuit of normative politics of technology. In this article, we use a case study of the introduction and use of UCD methods in Australia to explore the politics of getting the methods to work in practice. Drawing on the work of Bruno Latour and Marc Berg, we argue that UCD methods are tools for engendering new forms of sociotechnical relations. However, their normative potential does not arise out of their ability to manipulate abstract categories such as 'user', 'technology' and 'workplace'. Instead, it arises out of the complex and unpredictable sociotechnical mixes that are generated when people attempt to put them into practice

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Abstract

A long tradition of discourse and practice claims that technology designers need to take note of the characteristics and aspirations of potential users in design. Practitioners in the field of user-centred design (UCD) have developed methods to facilitate this process. These methods represent interesting vehicles for the pursuit of normative politics of technology. In this article, we use a case study of the introduction and use of UCD methods in Australia to explore the politics of getting the methods to work in practice. Drawing on the work of Bruno Latour and Marc Berg, we argue that UCD methods are tools for engendering new forms of sociotechnical relations. However, their normative potential does not arise out of their ability to manipulate abstract categories such as 'user', 'technology' and 'workplace'. Instead, it arises out of the complex and unpredictable sociotechnical mixes that are generated when people attempt to put them into practice.

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Introduction and Background

In Australia in the early 1990s, senior executives in a large mining and manufacturing company became interested in the use of advanced computer technologies to control manufacturing. In 1994, they established an R&D team in the company to develop a prototype holonic system – a set of interconnecting computers that gather data from, and control, successive pieces of equipment along a continuous manufacturing process. The computers are supposed to act both autonomously and co-operatively. That is, each has access to enough data to make sound decisions about a sub-section of a process. However, they are also able to communicate with each other in ways that establish optimal equipment settings for the process as a whole (Valckenaers et al., 1997). For example, if a valve in one piece of equipment is worn down, the equipment settings along other sections of the process can be adjusted to compensate. In the laboratory, the developers used simulated data and a scaled-down model of a manufacturing process to construct an holonic system that they called an advanced manufacturing system, or AMS. The system worked well in the laboratory, and in 1995, senior executives decided to trial the technology in one of the company's 'real life' operating plants.

As part of the planning for the trial, company executives and the R&D team conducted a review of possible risks associated with it. Alongside many technological uncertainties, they identified a significant class of risks that they termed 'human factors'. These included -- that the technology would not be simple enough for the operators to handle, that its use may lead to deskilling, that the end-users would not be adequately prepared, and that they might even sabotage the trial. After the identification of these risks, the leader of the R&D team remembered a telephone call she had received the previous year. Richard Badham, a professor of management and co-author of this article, had tried to persuade her that it was important to take users into account when designing new technologies. He said that he and his colleagues possessed the knowledge and skills to help her do this, and that they would like to become involved in any projects the team was working on. She said that she was interested in his ideas.

However, at the time, the team was busy with many difficult technical problems. She did not see how his expertise could fit in. But now the users were becoming a matter of concern. Perhaps he could help after all.

Our university research group was subsequently contracted to help ensure the cooperation of workers in the experimental trial of the AMS. This article analyses and reflects on the significance of what happened when we tried to expand the scope of our involvement beyond issues of user cooperation, into the realm of user-centred design (UCD) – a set of principles and practices that aim to privilege the needs and aspirations of users in technology design and implementation. The introduction of UCD is an example of a particularly interesting type of technological politics, one in which a group of external agents enter a situation and attempt to shape it according to normative goals and methods that draw on well-established critiques of 'inhumane' technologies. As such, it is relevant to debates about the normative value of STS research and analysis (Ashmore and Richards 1996). Writers with an activist slant, such as Langdon Winner and Brian Martin, advocate much greater involvement by researchers in the politics through which people try to make technologies 'better' (Martin 1993; Winner 1993; Winner 1995). UCD theorists and practitioners have been trying to do precisely this for decades, and Martin and Winner both promote the field as one conduit through which STS researchers can 'make a difference'. They both acknowledge, however, that such action is not simple, and that we, as STS researchers, do not yet possess a sufficiently sophisticated understanding of what it actually means to *do* normative politics of technology. One reason for this is the dearth case studies that examine and reflect on what happens when we intervene in situations and attempt to shape them according to our own political ends (Martin 1996).

In this article, we aim to address this deficiency in a way that acknowledges and explores uncertainty, conflicting interests and political negotiation on one hand, but that also creates a space for normative

procedures and aspirations on the other. To do this, we focus is on the use of formal UCD methods in context. We examine this issue from two angles – the grand and historical, and the fine-grained and microsocial. UCD methods, in common with many other normative political programs, attempt to impose order on situations and steer them in particular directions by ascribing identities to the actors (actants) involved so that they can take up allocated positions within the schemes in question. UCD methods revolve around the identification of users and their 'needs' on one hand and 'technology' on the other. These categories are then manipulated in order to produce a more 'humane' technology. In practice, however, the situation is much more complex. The categories are not pure, and methods must be layered onto, or woven into pre-existing sociotechnical imbroglios of humans (users, but also developers, managers and others) and nonhumans (technologies) that can facilitate and/or frustrate the intentions of those who try to introduce them. To capture the depth and significance of these imbroglios, we draw on Bruno Latour's pragmatogony, a bold and speculative grand narrative that places our interactions with technology in a long-term historical perspective (Latour 1999, 174-215). It provides an interesting twist on UCD, and promotes an understanding of it that accepts and incorporates layers of complexity. To explore the more microsocial aspects, we combine the pragmatogony with recent work on the use of formal packages of knowledge (models, methods, classification schemes) to order our world and actions. A closer analysis of the tool-like characteristics of UCD methods facilitates our understanding of how they can (or cannot) be made to work in the contexts in which people try to use them – how they mediate the complicated cognitive, normative and political processes through which we shape things, and things shape us.

The article proceeds as follows. Firstly, we use Latour's pragmatogony to discuss the nature of the UCD enterprise as a whole. We then outline the scope of our involvement in the AMS project, our sources of data and modes of analysis. Thirdly, we describe the two UCD methods used in our intervention. We recount what happened when we tried to apply these methods to the final stages of

design of the AMS and the trial. Discussing UCD methods as formal tools, and returning to the pragmatogony, we argue that the political potential these tools does not arise from 'the purity of their logic' (Berg 1997, 407). Instead, it is only generated through the complicated and often unpredictable sociotechnical relations that are created when people try to get them to work in context..

UCD and Sociotechnical Relations

The field of UCD is broad, scattered and diverse, and we cannot hope to do justice to all the different approaches here. It ranges across, and links, many different bodies of knowledge - physiology, psychology, anthropology, political philosophy, organisational design and software engineering. The various approaches are held together by a normative claim that technological systems should be, explicitly and deliberately, designed and implemented with the capabilities, needs and aspirations of humans in mind.[2] The enterprise is driven by particular conceptualisations of the 'technical' and the 'human', and the links between these ontological categories (Berg 1998). Many UCD advocates dichotomise these categories in their critiques and proposals for solutions. They attribute the perceived 'inhumanity' of many industrial systems to the evolutionary unfolding of a technocentric world view, a zeitgeist of Taylorism, or a product of the historical march of capitalism. The solution then appears relatively straightforward. We need ideas and programs to reinject 'humanity' into technological systems. While the dichotomy provides a powerful rhetorical driver for UCD, it also simplifies the issues at stake. It is a product of a modern worldview that seeks to separate and purify the categories of the 'human' and the 'technical', ignoring and downplaying the degree to which humans and objects have always mutually shaped each other (Latour 1993).

Latour's 'amodern' scheme, in which the human and the technical are already inextricably fused, provides an alternative framework that casts a different light on UCD. According to Latour, we cannot

and should not think about humans, or about nonhumans, in isolation from one another. The earliest stirrings of human characteristics among our primate ancestors were accompanied by the use of tools. We have, for so long, lived among and *through* our myriad objects, that we cannot really understand who *we* are without taking *them* into account. Likewise, our tools are so deeply infused with our knowledge, aspirations and intentions that they don't make much sense without us. Moreover, they do more than just reflect and embody social relations. Because we have delegated functions to them, they possess (a type of) agency (Latour 1993; 1999).

The amodern perspective begs another question, however. If technologies are so deeply imbued with humanity, why do we see repeated exhortations to 'humanise' them? Latour's pragmatogony is useful for addressing this question. The scheme is presented for the purpose of 'opening some space for the imagination' (1999, 200). It is an alternative to the modern worldview that tries to separate and purify the categories of the human and the technical. Instead of separating humans and machines, the pragmatogony tells of successive layers of ever more complex entanglements among them. During the many thousands of years that separate us from our ape-like ancestors, there have been, according to Latour, at least 11 'crossovers' in properties between humans and nonhumans. At each crossover, new developments among humans (or among nonhumans) have brought about changes in the other. Tool use among prehistoric humans allowed the development of more complex social behaviour. This, in turn, facilitated agriculture and the domestication of animals. These 'technical' advancements permitted larger and more complex 'social' groups (towns and cities) to form, and so on. In the most recent level, which Latour dubs 'political ecology', humans are thinking about the political rights and responsibilities of the nonhumans that share our planet. As a result of ecological concerns, natural and constructed objects – whales, water, factories, cars – are being drawn into systems of legal obligations that were once largely confined to humans (Latour 1999, 174-215). Although Latour does not mention UCD in this context, it is another aspect of the same endeavour - to take some of our new ideas about

what is important and valuable to us as humans (industrial democracy and meaningful work), so that they can be invested back into our nonhumans. It is another level of entanglement created to deal with problems generated by previous entanglements. We can see the quest to produce user-centred technologies as an antidote to the lingering problems set in motion by the 8th crossover - the industrialisation that began in the 18th century and continues even now to create systems that privilege the interests of owners, engineers and managers over those of users.

Conceptualising the UCD enterprise as an extra layer of entanglement that people are attempting to institute over and through many layers of previous sociotechnical relations gives a more complex picture. Because of the layering of our relationships with technology, it is not possible to isolate pure forms of the social (human) and the technical that can be recombined using rational procedures or political programs. Rather, the procedures and programs that we use have to work with already-existing imbroglios that embody a range of sociotechnical relations. We return to this theme below, after we present the case study.

Our Roles in the AMS Project

As noted above, our involvement in the AMS project began after the R&D team and company executives identified the possibility of adverse 'human factors' interfering with their planned trial of the new technology in a 'real life' operating plant. During the first half of 1997, Badham and representatives from the company negotiated a contract to set the parameters of our intervention. The deliberations were complex and lengthy, as our aim was to expand the scope of the project beyond the narrow issue of user acceptance. The final contract was a compromise. Our principal stated task was 'to reduce the risks of user opposition or lack of involvement' in the trial. To this end, we had to ensure that the equipment was 'usable' and that operators 'accepted the need' for the trial. At the same time,

we were mandated to apply and evaluate 'leading edge human factors and organisational methodologies'. This legitimated the introduction of UCD methods which were, for the company and the R&D team, quite radical.

We were involved with the AMS project from mid-1996, when preliminary discussions with the developers began, until November 1998, when we carried out some follow-up interviews. The trial itself was conducted between April and September 1998. One or more members of the research team spent more than 20 days with the developers and/or factory personnel during this time. All took notes and recorded reflections of events. We also had access to R&D and factory documents, e-mails and the factory newsletter. Opportunities for reflection and analysis in this project were enhanced by employing one person (Garrety) to act solely as a non-participant observer and analyst. The project involved a variety of activities - organizing and conducting meetings and workshops, and collecting data through observations and interviews, and from company documents. Our involvement could be characterised as a form of reflexive action research, in which investigators actively intervene in a situation in order to (try to) change it, and also gather data and analyse the events associated with the intervention, and its outcomes (Eden & Huxham 1996)**.** Less reflextive forms of this approach have been widely used in the development of methods for UCD (Avison et al. 1999). Action research has not often been used in STS (Martin 1996).

We do not claim that the account and interpretation provided here are definitive. Indeed, there are many ways that the story of the AMS intervention could be told.[3] The account below draws on literature about UCD, and on an amalgam of records of events that occurred during the period of our engagement.

User-Centred Design – Envisionment and KOMPASS

In the age of political ecology (Latour's 11th and most recent crossover), we humans are busy trying to transform, once again, our relationships with the natural and constructed objects in our midst. The proliferation of UCD methods is an aspect of this enterprise. Two such methods – Envisionment and KOMPASS - were employed in the AMS case. Before considering how they were introduced and used, we present them in their more formal and abstracted manifestations. This will enable us to draw out the normative claims and assumptions embedded within them.

Envisionment grew out of the influential Scandinavian tradition of industrial democracy, which was inspired by analyses of worker alienation under capitalism (eg. Braverman 1974). During the 1970s, researchers and trade unionists in a number of Scandinavian countries agitated successfully for the introduction of laws ensuring trade union participation in decisions affecting the organization of work (Ehn 1992, Sorensen 1998). In a number of high-profile projects, researchers and workers developed methods that could be used to facilitate UCD. There are many such methods, and Envisionment is one of them. The process involves users and developers conducting 'future workshops' - specifically contrived situations in which the users are invited to fantasise about their ideal workplaces. Metaphors and games are used to stimulate the users' imagination, in exercises described as 'design by doing' and 'design by playing'. For example, workers are asked to imagine technologies as toys, telecommunications media or partners. They may also build cardboard mock-ups and prototypes. The overall aim is to generate ideas that are not constrained by perceptions of what is and is not 'practical', and to create a design process that is meaningful and enjoyable. The next stage, with the assistance of developers, is to refine those ideas, select the most feasible and desirable, and to turn them into tangible objects (Bjerknes et al. 1987; Ehn 1988; Greenbaum and Kyng 1991).

Compared to Envisionment, which has been developing since the early 1970s, KOMPASS is a recent innovation. The term is short for the German version of 'Complementary Analysis and Design of Production Tasks in Sociotechnical Systems'. Its developers and proponents have attempted to distil, out of long tradition of German 'scientific' work psychology, a set of criteria that define the characteristics of satisfying human interactions with technology. The criteria, couched in expert language, are:

1. Dynamic coupling. Technology should provide opportunities for humans to vary the pace, location and content of their work. They should also be able to vary the amount of cognitive effort required.
2. Process transparency. Humans should be able to form effective mental models of the technological processes involved in their jobs.
3. Decision authority. Workers should have an appropriate measure of control over the technology.
4. Flexibility. Coupling, allocation of tasks and decision authority should all be flexible.

KOMPASS advocates claim that the implementation of these criteria will improve working conditions. Considerable time and effort has been expended, in particular by Institutes in Berlin and Zurich, to the development of handbooks and methods to operationalise the criteria into procedures that can be carried out in workplaces that use technology (Grote et al. 1995; Wäfler et al. 1997a; Wäfler et al. 1997b; Wäfler and Older 1997).

Envisionment and KOMPASS are clearly normative in that they set out procedures for how workplace technologies *should* (in the view of their proponents) be designed in order to be democratic, humane

and efficient. In other words, they aspire to modernist ideals of emancipation, clarity, rationality and control (Bowers 1992). However, in order for them to work in practice, they have to be layered onto, and woven into, pre-existing sociotechnical imbroglios that often interfere with their normative aspirations. To illustrate how this occurs, and the effects it has on evaluations of 'success' or 'failure', we turn to our account of our attempt to put Envisionment and KOMPASS into use in the final stages of the design of AMS, and in the planning for the trial.

Case Study: An Attempt to Introduce and Use UCD

According to the normative principles underlying UCD, potential operators of a technology should be involved from the earliest stages of development. This did not occur in the AMS case. Badham's attempt to interest the developers in UCD during the early stages of the AMS project were unsuccessful. The operators only came into consideration later, when senior executives became interested in conducting a trial. The men at the test factory were also left out of the contract negotiations that set the parameters of our involvement. We were concerned that they should benefit from the project, even though it was difficult to see how this could be achieved. The AMS would only be installed in the factory for the period of the trial. During this time, it would be attached to pre-existing equipment, providing an extra layer of monitoring and control.

With its sophisticated detection and control systems, the AMS had the potential to either displace human skills, or complement them (Zuboff 1988). The test site housed a continuous manufacturing process, in which products are transformed through heating, rolling, twisting and cooling. Although the heating takes many hours, the other processes are completed in about 90 seconds. Getting the settings right on the equipment doing this work is a delicate skill. The AMS, if it worked, would be able to assist, thus enhancing productivity and competitiveness, and helping to secure jobs. On the other hand,

company executives might decide that the AMS was capable of running the factory on its own, without input from humans. One of our tasks (as we saw it) was to try to persuade managers and technologists of the necessity of tacit human skills, and of the UCD methods that could be used to enhance and complement them. However, because the AMS would not remain at the site, any improvements that could be made to it through the use of UCD in this case would not immediately benefit the people in the factory, but future potential users, should the company decide to go ahead with further implementation.

Right from the beginning, therefore, the political circumstances of the intervention were challenging and ambiguous. Advocates of political action often neglect ambiguity. For example, in his argument in favour of greater political involvement by STS researchers, Martin (1993, 256) states that action research

> could apply just as well to social science research that serves dominant interests as to research that serves relatively powerless groups. The choice of whom to serve - not theoretical sophistication - is a key issue.

In making this statement, Martin assumes that it is relatively easy to ascertain whose interests one is serving. In the AMS case, this was not clear. Were we there to help the technologists develop a system that would ultimately rob people of their jobs, or would we succeed in convincing them that they should develop technologies that privilege and complement human skills? The outcomes were not predictable in advance, but a product of the collective action that unfolded during and after the project itself. Even then (as we shall see later) the immediate effects of the intervention were uncertain. The fate of facts and techniques is in the hands of others. They can fade away, or become obligatory

passage points, depending on the degree to which others can be persuaded to take them up and use them (Latour 1987).

A related ambiguity concerns the category of users. UCD methods often assume that 'users' are relatively homogeneous and easy to identify. In this case, there were several sets of users. In an important sense, the developers were the users of our expertise, as they contracted us to take care of their human factors risks. In a more traditional sense, the factory operators were users, as they would have to operate the AMS during the trial. Then again, the operators of future AMSs (or other technologies the developers might build) were also users, as our attempt to introduce UCD would, ideally, affect their work practices in future design situations. The context was clearly one in which the application of the methods would not be straightforward. We were not simply dealing with 'technology' on one hand, and 'users' on the other.

The Early Envisionment Exercise.

The major planned activity during the intervention was a pair of workshops held in October 1997, timed to coincide with visits to Australia by leading Envisionment and KOMPASS practitioners.[4] Before they began, however, there was an opportunity for a mini-intervention. This episode was important because it introduced the sociotechnical imbroglios of the test site factory into the mix, thus further complicating the context in which the intervention as a whole took place.

In August 1997, while the contract was still being negotiated, the developers informed us that there was a two week period in which we might be able to obtain some operator input into the design of the AMS computer interface. To do this, two members of our team planned an Envisionment exercise in which the operators would be invited to explore 'ideal' interfaces. They planned to feed these ideas back to

the developers as general user requirements. However, on meeting the operators, it soon became evident that none of them had even heard of the AMS. They had been told to attend the meeting by the test plant's senior technical officer, who knew about the trial, but had not passed the information on. This was not an ideal situation in which to conduct an Envisionment exercise. The available time was spent imparting basic information about the trial, and discussing more generally how a combination of user inputs and advanced technology could be used to improve the men's working conditions.

As members of our team were travelling to the test factory for a second meeting, the senior technical officer telephoned Badham (who had stayed behind) to express his concerns about our activities. In his opinion, loose talk about ideal technologies and factory improvements could lead to unrealistic and dashed expectations among the workers. For him, the AMS trial was 'Bill's project' (Bill was the technology developer most closely associated with the test factory). The technical officer said that, in his opinion, it was a fairly narrow technical trial, designed to test whether or not the experimental computers would work in a real life factory. The screen design was not particularly important.

Nevertheless, he supported the use of Envisionment, in principle, to explore alternative sociotechnical arrangements, an idea he called 'pie-in-the-sky stuff'. Over the telephone, he and Badham agreed to split the intervention into two components - a narrow technical trial of the AMS and a broader, more visionary set of activities. It would have to be made clear to the workers that while the narrow trial would go ahead, the technological arrangements generated by the 'pie-in-the-sky' activities would, at this stage, be purely imaginary. The technical officer agreed that, as long as meetings were held with operators to explain the technical issues surrounding the trial, it would also be possible for workers from the factory to attend UCD workshops in which they could explore what he called 'different set-ups'.

The splitting of the intervention into two components served to highlight how far we were from the ideal situation in which to pursue UCD, and the extent to which pre-existing imbroglios can influence the action. The technical officer's unease about the intervention also illustrated the degree to which university researchers and factory managers can occupy different social worlds, with different perceptions and goals (Garrety & Badham 2000). The episode emphasized our lack of power in the situation. The second meeting with the operators did not go ahead, and the opportunity to use Envisionment to gather user interface requirements was lost. Nevertheless, the splitting of the project did help to clarify what was, and was not, going to be feasible. More importantly, it allowed the project to go ahead.

The Main KOMPASS and Envisionment Workshops.

The major UCD activity was a pair of workshops, each lasting one and a half days, held in October 1997, six months before the AMS computers were due to be installed in the factory. Discussions were held beforehand among the overseas experts to plan the contents of the workshops. These were lengthy and complex, as they tried to reconcile their methods and approaches to the circumstances. Due to the availability of expertise, we decided to concentrate mostly on KOMPASS during both workshops, with some Envisionment exercises during the second to stimulate the imagination. The developers were given opportunities during the workshops to explain the AMS and the (narrow technical) trial through which they would test its capabilities.

The factory operators who attended the workshops were a self-selected group of men who were curious about the AMS and advanced technologies in general. They constituted about 10% of the total workforce. During the first workshop, the KOMPASS experts introduced and explained their criteria, and the men tried to apply them to various tasks and technologies with which they were familiar. Minor

disagreements about such things as the degree to which they were coupled to machines were used as opportunities for further discussion of the criteria and their meanings. They found the concept of transparency particularly appealing, as there had been technological disasters in their plant caused by machinery that was difficult to understand. Applying the criteria to the extant technology was largely an imaginative undertaking, as it was unlikely that any of it would be reconfigured, at least in the short term, in ways that take the criteria into account. However, there was some scope for normative action in the exercise, as the technology developers were also present. Introducing and illustrating UCD may have some effect on the way they perceive and involve users in the future.

During the second workshop, the men applied the KOMPASS criteria to the AMS. This was a challenging task, as none of them had encountered the computers in question. In preparation for this exercise, Bill the developer spent some time outlining the technology's capabilities, in both its 'narrow, technical' prototype form and in its possible future manifestations. The men were quite impressed, questioning Bill on what the AMS could do to fix persistent technical problems in the plant. He gave optimistic responses that helped to blur the distinction between the mundane technical trial, and the future possibilities generated by advanced holonic technology. He told the men: 'If the data are there, the AMS could pick it up and do something. If it's predictable, the AMS can do something'. After this positive presentation, workshop participants rated the AMS quite favourably according to the KOMPASS criteria, particularly with respect to flexibility and transparency. It received a lower rating for decision authority, as some perceived the possibility of it usurping their expertise. These ratings were somewhat surprising and disappointing to the KOMPASS experts, who had tried to create a less favourable interpretation of the AMS as a technology that was faulty because it was based on a traditional enemy of UCD – the spectre of the unmanned factory operated by computers.

In its formal version, applications of KOMPASS are supposed to produce work packages to guide the activities of developers. In this case, no work package was attempted. The extant AMS was already too close to completion, and its role in the factory too peripheral (at least during the trial) to warrant total integration into the work practices of the employees. Instead, in response to a request by the plant manager, the workshops ended with the creation of a Project Implementation Group (PIG) among the test site personnel. The UCD practitioners, the R&D team and the men at the test site themselves hoped that the group would be able to do two things. First, it would provide a link between the developers and the rest of the workforce in the period leading up to and during the trial. Second, there may conceivably be opportunities in the future when factory personnel could pursue UCD in relation to other proposed technologies. Should this occur, the men in the PIG may be able to facilitate the process.

The use of the workshop format raises further questions that reflect the political ambiguity of interventions such as these. Workshops have long been used to facilitate participatory decision-making. However, they can also be seen as 'a kind of negotiation game'[5] designed to engineer consensus and subdue conflict (Sorensen 1998).This occurred in the AMS case. Considerable negotiation and compromise took place throughout. There was, for example, an effort to prevent incipient conflict over the operators' favourable assessment of the AMS. One of the KOMPASS experts attempted to 'correct' this assessment by pointing out the possible deleterious effects of the technology. This provoked some disquiet, as some of the men perceived this as an attack on their judgement. In the interests of keeping the operators 'on-side', Badham intervened to deflect the argument. The mixture of methods used was also a result of bargaining and negotiation, this time among the UCD experts themselves. Strict and rigorous applications of KOMPASS, even according to its advocates, can be tedious. It imposes, somewhat firmly, an 'expert' language on participants. Envisionment aims to foster creativity and imagination, in deliberate opposition to methods that attempt to mediate design through expert language and firm directions. It allowed operators to evaluate technologies and define the future in

their own terms. We hoped that the blending of the two methods would facilitate a freer and more enjoyable process that would capture the operators' implicit goals and aspirations, while also inviting them to reflect systematically on whether technologies abide by humanistic criteria. Nevertheless, tensions and conflicts persisted among the more 'expert'/'work package' oriented KOMPASS method, the more 'open'/'political' Envisionment method, and the pragmatic politics involved in managing the project context . The decision to (try to) create an informed and motivated implementation group to empower users in the plant, rather than a specific work package, sacrificed much of the rigour of KOMPASS.

Such issues of ends and means, negotiations and compromise, are familiar to those who contemplate and engage in political action. Not only were there tensions between the normative principles and requirements of KOMPASS and Envisionment, but there were also conflicts between the radical democratic aspirations of both methods and the more circumscribed political context in which they were applied. Following an 'ethic of ultimate ends', in which 'the flame of pure intentions is not quelched' may be satisfying in some respects but, in this case at least, was subordinated to a more pragmatic 'ethic of responsibility', blending different methods to work in context (Weber 1918). Whether we consider this to be 'success' or 'failure' is part of the political process itself.

After the workshops – success or failure?

Shortly after the main workshops, several members of the PIG, together with a few other operators, obtained funding to fly to the company's research laboratories to view the AMS prior to its installation in the factory. None of us was present on these occasions, and our information about them is derived from what others have told us. The visits, apparently, had a significant effect on the conduct and outcome of the trial, as the developers were able to make use of the operators' tacit knowledge. One of

the men who made the trip told us that ‘to be honest, the thing wasn’t really anything like [the plant]. It was completely devoid of the way we do things. Similar principle, but...’. Bill told us that ‘eight or nine’ details were changed as a result of these visits, making the trial more effective. One significant change was that the developers abandoned their earlier plans to use the AMS to control the plant ‘directly’. Instead, the operators were able to accept or reject the equipment settings presented to them by the AMS. Humanistic considerations (the KOMPASS criterion of decision authority) probably did not contribute to this change, however. When questioned, Bill said simply that direct control ‘would not have worked’.

The trial, when it came, progressed smoothly. The users did not reject the technology, and a major ‘human factors‘ risk was averted. The technologists said that, because of the operators’ cooperation, they were able to ‘prove the concept’ of the AMS by demonstrating that when aspects of the manufacturing process were varied, the AMS was able to suggest equipment settings that compensated for the variation. On the whole, the developers judged the usefulness of the intervention according to how it contributed to the success of the experiment, not according to whether the AMS became more ‘humane’, or whether the operators’ jobs were made more satisfying. Their appraisal was summed up in the comment that KOMPASS was useful because it was ‘a way of finding out what is not included in drawings of the process’.

For the men in the factory, the outcomes were more ambiguous. They seemed to find the ideas associated with UCD interesting, although there were few opportunities to put them into practice. The senior technology officer, who did have some control over technological decisions, said that he found the KOMPASS criteria useful for 'looking deeper' into technology, so that ‘relevant’ choices could be made:

> We don’t want to force things onto [the operators]. Give them equipment that is irrelevant from their point of view although it may be marvelous technically and may be a very good-looking piece of equipment, but as far as they may be concerned it may not be useful at all....You really want to put something in there that is relevant – that gives people some benefit.

Another of the men who attended the workshops said, ‘It’s the first time we’ve actually been asked for input. And I will admit that it’s good to get away from the bloody day-in, day-out grind to actually do something different’. When questioned, however, he was unclear about how he could use UCD in his daily work. Another worker, an ex-operator turned manager, said that he appreciated the 'fundamental core' of the methods, which he expressed as 'keeping people and technology working together'. Overall, though, he found it ‘hard so say’ what his fellow workers had learned from the exercise. For real results, he said, we had to spend a lot more time at the factory, keeping things 'on the boil'.

The ability of both ourselves and the PIG to keep things ‘on the boil’ was frustrated by a company restructure after the technology trial that removed the supportive plant manager, and closed many research projects, including the AMS. Planned UCD activities associated with the further development of the AMS did not take place. At the same time, the remaining managers at the plant contracted us to do further UCD work there. Although the AMS project was closed down, individual developers continued to show an interest in UCD after the intervention and the trial were finished. Importantly for us as academics interested in normative politics, the AMS project enhanced our credibility within the company, facilitating our involvement in further participatory design initiatives (Wotherspoon 1999).

UCD Methods as Formal Tools

When we were contracted to apply UCD methods to the final stages of the AMS, we did not encounter neat categories of 'the social' and 'the technical' in the company that could be fitted together to make the AMS more 'usable' or 'humane'. Instead, we were faced with complex imbroglios of already-existing sociotechnical relations within the research laboratory and the test site that needed to be negotiated in order to make the methods work in the context of the project as it developed. Despite the complexity, however, the joint actions undertaken during the exercise were not random or chaotic. They were, if somewhat loosely and pragmatically, structured around the normative principles and procedures set out within the methods.

Many writers have noted that UCD projects often fall short of the humanistic promises that are made on their behalf (Badham and Naschold 1994; Barki and Hartwick 1994; Ehn 1992; Ives and Olson 1984: Mankin, Cohen and Bikson 1997). Such was the case with the AMS – industrial democracy was not installed, and neither the factory nor the AMS was reconfigured to take the principles of psychologically satisfying work into account. Explorations of the disappointing results have usually located them either within the UCD methods themselves, or in the unfavourable structural and political contexts in which advocates try to get them to work. Prescriptions for improvement include making the methods more rigorous and precise, and developing better political skills in order to lobby more effectively for the adoption of UCD practices and expertise (Badham 2000a; Badham and Ehn 2000; Barki and Hartwick 1994; Buchanan and Badham 1999; Clegg 1993; Ehn 1992; Ives and Olson 1984; Perrow 1983; Weedman 1998). In order to achieve the latter, however, we need to understand the peculiar demands that UCD methods make on the contexts in which people try to get them to work. Examining KOMPASS and Envisionment as 'formal tools' (Berg1997) allows us to focus more closely on the contextual micropolitics of their workability.

Following Marc Berg (1997), we define the characteristics of formal tools as follows:

> Formal tools operate on circumscribed input elements using sets of prefixed rules or formulas....Embedded in these rules are circumscribed, abstract 'models' of the workplace in which the tools are to function.

Envisionment and KOMPASS are formal tools for performing a particular type of work – injecting humanistic values (democracy, psychological satisfaction) into the design of technologies. They take certain inputs into consideration and perform manipulations with them according to various rules and abstract models of the workplaces in which they are supposed to function. We will consider the inputs and rules first, as the concept of 'the workplace' throws up some important issues that deserve separate consideration.

The inputs and rules that structure Envisionment are quite loose. Inputs are the malleable sociotechnical arrangements of the workplace that is the object of the intervention, and the workers' expressed needs, preferences and desires. The rules, such as they are, consist of a jumble of resources ('design by doing', 'design by playing' and so on) used to stimulate ideas. The end result is a set of ideas that can, theoretically, be turned into technical artifacts. The inputs and rules that organise a KOMPASS intervention are, by contrast, quite precise and structured. In its formal manifestations, it involves two workshops separated by a period of expert work system analysis. During the first workshop, the facilitator introduces developers and user representatives to work psychology and the criteria (dynamic coupling, process transparency, decision authority and flexibility). The major input is the total work system – either an existing system or one that is about to be changed through the introduction of new technology. Participants identify the 'primary task' of the system, and its various 'functions', whether they be carried out by humans or machines. Between workshops, KOMPASS experts interview people in the workplace and observe their activities, thereby contributing to further

analysis of the system. During the second workshop, under the guidance of the experts, participants systematically apply the criteria to the sociotechnical elements that comprise the workplace. They suggest changes to make the elements conform more closely to the criteria. The ultimate aim is a 'work package' for technology designers, based on the criteria, that details an appropriate allocation of tasks between machines and humans.

While defining the inputs and rules for UCD methods is fairly straightforward, matters become complicated when we consider the workplaces in which they are supposed to function. These complications pose considerable challenges for those promoting UCD, as they take the use of the methods away from the abstract and formal, and into the realm of the material and political. On the simplest level, the UCD workplace is the intervention itself - usually a series of meetings and workshops in which practitioners, users and technologists jointly pursue UCD activities. The ‘abstract models’ of tool use embedded in this workplace are amalgams of the normative discourses and formal statements of method outlined above - the full array of assumptions about the value of work psychology and industrial democracy. Most of these can stay in the background as legitimation without directly affecting the efficacy of the methods themselves. There are, however, some crucial assumptions that do influence the degree to which the tools can be made to fulfil their normative potential. These relate to those other ‘workplaces’ that are subsumed or implicated within the ‘models of the workplace’ that guide the intervention. The first of these is the factory or other sociotechnical system that is the *object* of the exercise. According to the formal procedures guiding an intervention, this workplace can be turned - conceptually, and subsequently more concretely - into input suitable for manipulation by the tool(s) in question. The second ‘other workplace’ is the technology laboratory, and subsequently the factory implementation site, that is supposed to take the output of the intervention and turn it into tangible, sociotechnical configurations that embody that values embedded in UCD. The lining up of not one, but (at least) three workplaces into an influential arrangement poses a considerable

challenge to UCD practitioners. To be successful, they need to go beyond the methods, employing political skills to engineer a favourable alignment of several intersecting workplaces (Badham and Ehn 2000).

Conclusion – The Promises and Limits of Modernity

In our account of our attempt to do normative politics of technology we have tried to 'have our cake and eat it too'. That is, we have tried to tell the story in a way that leaves the intent and integrity of the UCD methods we used intact, while also exploring the ambiguities and problematic political circumstances surrounding our attempt to put them into practice. Conceptualising the methods as formal tools enables us to do this. Because they are, in their abstract manifestations, fairly well circumscribed and self-contained, we can bracket them off (conceptually at least) from the contexts in which they appear. We can investigate the assumptions and expectations embedded within them. As formal tools they are products of modernity. Their abstraction and formality allows them (to some extent at least) to be 'disembedded' from their sites of origin (Scandinavia, Zurich, Berlin) and re-embedded elsewhere (Giddens 1990). They are 'expert systems' of applied knowledge, derived from and allied to professional practice. The ability to transport and apply bodies of knowledge (models, methods, procedures) in this way has been very productive. However, there are limits to our capacity to effect control by these means. As Giddens (1990, 39) notes, 'Modernity is constituted in and through reflexively applied knowledge, but the equation of knowledge with certitude has turned out to be misconceived'.

No matter how well-thought out and well-argued they are, UCD methods cannot capture all possible contingencies and render them controllable. In its idealised version, Envisionment is particularly demanding on context. Scandinavian UCD methods often reflect and encompass political programs,

allied to the goals of industrial democracy, whose advocates argue that workers (not managers or owners of capital) should determine how work is organised. Most ideally, industrial democracy consists of 'freedom from the constraints imposed by the market economy and the power of capital' (Ehn 1992, 97). Such freedom would make it much easier to line up the several workplaces necessary to pursue fully fledged UCD. Even in Scandinavia, however, where legislation requires involvement by unions in technological decision-making, the details of workers' participation are more complex than idealised versions of industrial democracy suggest. Struggles over the forms and consequences of new technologies still occur (Ehn 1992, Sorensen 1998).

While Envisionment (in its idealised form) challenges the capitalist status quo, KOMPASS is more modest in its aspirations. It seeks to make work more satisfying, not by challenging capitalist power structures, but through the application of principles derived from work psychology. Because of its particular language and well-developed criteria, it provides a more structured, constrained and detailed set of topics for consideration in UCD workshops than does Envisionment, with its invitation to delve into the realms of fantasy. In the AMS case, both the developers and the men at the test site found KOMPASS more useful than Envisionment, even though the latter was more enjoyable. For the operators, KOMPASS supplied concepts that they could apply to the technology with which they were familiar. For the developers, it provided a structure and language through which they could systematically think through real and potential interactions between humans and machines. Envisionment relies heavily on context for its normative potential to be realised. KOMPASS does as well, but because its formalisms relate more closely to particular aspects of sociotechnical systems, they are more easily transported from one place to another.

Despite its more modest aspirations, we were not able to conduct a full implementation of KOMPASS in this case. The context provided problems for both approaches, because the categories of 'social',

'technical', 'user' and 'expert' contained within it were not pure. They could not be fitted neatly into the methods we attempted to use. The humans and machines relevant to the project were already tied into complex pre-existing sociotechnical arrangements that could not be swept aside or transformed by rational arguments and/or good intentions. To the extent that the methods 'worked', they did so by generating novel arrangements in which interests could be aligned – a worker's desire to be heard and have his tacit knowledge recognised lined up with the developer's goal of a successful trial, for example. Opportunities such as this arise out of complexity, not simplification.

UCD methods must, in order to work at all, formalise and simplify the categories they deal with. However, their normative potential does not lie in the virtue of their intentions, or 'the purity of their logic' (Berg 1997, 407). Instead, it lies in the unique conditions created by the interaction of method *and* context as people try to get them to work within particular situations. Projects such as that outlined in this paper, designed to introduce normative politics into technology design, are actually better understood as reshaping the character of existing sociotechnical imbroglios. The process of reshaping is one of getting generic methods or techniques (with their cognitive, moral and political presuppositions) to work in context. The purpose of this paper's provision of, and reflection on, ethnographic data on a UCD intervention is to help improve our understanding of (and 'practical wisdom' about) the complexity of such normative practices.

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Endnotes

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[2] There are now ISO standards for usability and human-centred design. ISO/DIS 13407-1997 'Human-centred design processes for interactive systems', states that 'Human-centred design is an approach to interactive systems development that focuses specifically on making systems usable. It is a multi-disciplinary activity which incorporates human factors and ergonomics knowledge and techniques'. In this context, usability is defined as the 'extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'. See also Daly-Jones et al. (1997). For sociological and historical reviews of the field, see Badham 2000b, Berg (1998), Czaja (1997), Friedman and Cornford (1989) and Wilson 1979).

[3] For alternative accounts of the same project see Garrety and Badham (1999), Garrety and Badham (2000) and Badham, Garrety and Kirsch (2001).

[4] Toni Wäfler and Christina Kirsch from the Swiss Institute of Work Psychology (the home of KOMPASS), Pelle Ehn from the University of Mälmo (from the Scandinavian tradition), and James C. Taylor from the University of Southern California (from the North American sociotechnical tradition).

[5] We thank Knut Sorensen for this phrase, and for drawing our attention to the political ramifications of the workshop technique.