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Crossing the line: a field study of inhabited television

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Abstract. This paper reports on an ethnographic field study of 'Out Of This World' (OOTW, Benford *et al.* 1999) an experiment in 'inhabited television' combining broadcast technologies with a collaborative virtual environment in a live show. The study focuses on the work of producing OOTW and how personnel managed the manifold contingencies of working with complex technology. The use of a specially developed virtual camera control application is discussed together with the methods the director used for live editing views from cameras into a 'broadcast from virtual reality'. The challenges faced by the multiple professions involved (TV personnel, research scientists, actors) are documented and the viability of inhabited TV as a 'new medium' is assessed. Future technological refinements are briefly discussed along with some general implications for CSCW and 'media studies' of the work reported.

1. Introduction

Virtual reality (VR) technology is of interest in the research field of Computer Supported Cooperative Work (CSCW) from a number of perspectives. Several authors have proposed shared VR systems (or CVEs for Collaborative Virtual Environments) as a technology to support social interaction between users each embodied by means of a so-called 'avatar' within, say, a virtual meeting room (e.g. Greenhalgh and Benford 1995). Others have studied visualization applications where some database is viewed collaboratively with avatars immersed within depictions of data (e.g. Chalmers 1994). Yet others have begun to study the early use of CVEs from a social scientific viewpoint or use social study to inform application development (Bowers *et al.* 1996, Pycock and Bowers 1996).

'Inhabited television' (I-TV, see Benford *et al.* 1999, Walker 1997) is fast becoming another notable application area for VR technology within CSCW. In I-TV, a CVE is in some way integrated with broadcast technologies to accompany a TV show and, in the more interesting cases, to provide some of a show's content. In what perhaps are the paradigmatic proposals for I-TV, the show itself is set live within a CVE—with views of the real-time activity of participants being broadcast and viewers at home interacting, perhaps via set-top boxes, with ongoing events. As Benford *et al.* (1999) put it: 'Inhabited TV combines CVEs and broadcast TV to create a new medium for entertainment and social communication. The defining feature of this medium is that an on-line audience can socially participate in a TV show that is staged within a shared virtual world. The producer defines a framework, but it is the audience interaction and participation that brings it to life'. Proposals for interactive TV and claims to be exploring a 'new medium' are themselves nothing new (see, e.g., Manovich's, 1998, examinations of cinema, TV, VR and the history of claims to make participants 'present' within new technology). It is the combination of VR and broadcast TV that gives I-TV its technical specificity and the concern to support social interaction, which gives I-TV its CSCW interest.

The current paper reports on field research conducted during and around the performances of 'Out Of This World' (OOTW), an experiment in I-TV. OOTW was one of the events accompanying the International Symposium on Electronic Arts (ISEA98, Manchester and Liverpool, UK, September 1998). The technical aspects of OOTW are described Benford *et al.* (1999). The main focus of the current paper is on documenting the production work involved in getting the show to happen, the problems that were encountered and how they were solved. What should appear from this

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account is 'OOTW in the raw'–the raw work involved in making a complex and ambitious experiment in I-TV happen. The paper's fundamental issues are: Was it possible to establish practical activities within which the technology could be made to work and a show realized? If so, how, and how might the conduct of these activities (or those derived from them) be reshaped in the future either by new designs for technology or new methods of working?

It is hoped that this is of use in at least three ways. First, it is intended that the current paper might influence the future agendas of VR research within CSCW, as the problems and dilemmas encountered should be more in focus as a result of this work than they might otherwise be. What requires future attention might be prioritized as a result and, indeed, this paper will close with a sketch of new technologies being developed following from its results. Second, as this paper takes the cooperative work of I-TV production as its topic, it adds to the corpus of social scientific studies of real-world settings in the literature of CSCW. While I-TV researchers are concerned with supporting social activity, the current paper is concerned with their practical action in making I-TV happen—*their* social activity. Third, it is hoped that discussions of 'new media', 'the future of television' and other such heady topics might be informed by a concern for these practical activities. Much of the literature on contemporary media is highly theoreticized, with speculations about new technology being more likely to be informed by psychoanalysis or poststructuralism than by study of actual work in, say, the TV or cinema industry. A recent collection such as Elsaesser and Hoffman's (1998), with some partial exceptions, only tangentially mentions what people–directors, actors, producers, cinematographers–do when making pictures amidst a main diet of cultural and film theory. The current paper, then, can also be read as a response to Manovich's (1998) call for empirical studies of the making of new media technology (here a form of interactive television) to be done now while we still have the opportunity.

2. Setting, event and technology

Out Of This World (OOTW) was performed at The Green Room, Manchester on the 5th and 6th September 1998. Personnel, though, were on-site two days before and derigging was only completed on the 7th September. During this total time, the equipment was transported and rigged up, a stagger through took place along with three run-throughs and four shows. OOTW can be thought of as a gameshow set in a virtual environment (a stranded, soon to implode space station) and, as such, was intended as an experiment in 'inhabited TV' of a playful sort. However, as the event was performed at a venue with a performance space before an inclined area for a seated audience some compromises were necessary, as we shall see, between a staged performance and a TV simulation. Detail of OOTW and, in particular, of the technology involved can be found elsewhere (Benford *et al*. 1999). What follows here is enough detail hopefully to make this paper readable as a stand-alone document.

OOTW consisted of four games that were cooperative in varied ways played by two teams ('aliens' and 'robots'), each consisting of a team-leader and four volunteers from the audience. All 10 players were embodied as 'avatars' in the CVE. In addition, a 'host' was seen as a video texture projected onto a 'screen' within the CVE. OOTW was presented as a TV broadcast on a large screen in front of the audience complete with title sequences and theme music. As a concession to theatricality, the (physical) team-leaders were positioned either side of screen bedecked in 'head mounted displays' (HMDs), some tracking equipment and pointing devices. Each team-leader had a helper by them to troubleshoot problems.

The audience themselves had one opportunity to interact with the course of events in the show through engaging with 'Wobblespace' by waving coloured pieces of A4 paper. Their movements were picked up by a video camera and analysed by the Wobblespace software for the prevalence of colours and the degree of movement of them. The same software had a role in the audience 'warm-up' where a version of the early arcade computer game 'Pong' was played with audience members using different colours to move the 'paddles' up and down.

At the Green Room there is an area known as 'the mezzanine' separate from the auditorium. It was here that the vast majority of the behind-the-scenes activity during OOTW took place. Sited on the mezzanine was a considerable retinue of personnel.

Four virtual camera operators captured real-time views of activity within the OOTW CVE. A TV director made cuts from the video output of one virtual camera to another to compose the view that was transmitted to the big screen before the audience. She was aided in this by an assistant who had various responsibilities for the operation of videotape inserts into the show amongst other matters. Between them the director and assistant worked with 'conventional' TV direction monitors and mixing desks–the kind and number consistent with a small 'outside broadcast'.

The eight volunteer team-members were physically located on the mezzanine together with four helpers.

One person oversaw the operation of the VR system being used (MASSIVE-2, see Greenhalgh and Benford 1995) and another oversaw the event management application developed to work with it (see Benford *et al*. 1999, for details). Two people managed the audience interaction technology (Wobblespace). One of the show's two producers roved around the mezzanine area together with two researchers observing the event (one the current author, who also helped out with the music and ambient sound for the CVE).

In the lighting and sound control rooms, which (unlike the mezzanine) had direct line of sight to the stage, could be found a production assistant/lighting engineer, the other of the show's producers (who also played the role of the gameshow host), a sound engineer and a musician (who played synthesized sound to give a sense of activity and spatial ambience to the games and virtual environments in OOTW).

3. Research methods and overview of findings

My work during this period concentrated on documenting the real-time working activity of those involved in making the show. The style of field research conducted is broadly consistent with the 'programme' of 'ethnomethodological ethnography' practiced by myself and others in a variety of settings, many involving interaction with new information technology (for a 'classic' example in CSCW, see Hughes *et al*. 1992). The accent in this style of research is to portray as vividly as possible the real-time details of work and social interaction as, I would maintain, that it is in and through those details that coordination between persons takes place. The style of research is also descriptive, rather than theoreticized, and analytical concepts, when they are posed, are always intended to be grounded in observations made, rather than the product of theoretical deduction. An important emphasis is to capture what might be called the 'constitutively specific'–those specific features of what has been studied which make it what it is. Thus, in the current case, I am concerned with highlighting just what are the recognisable features of what went on in Manchester which made the events an instance of 'inhabited-TV' and not just an instance of some more general matter like 'an experimentation with new technology'. It is the specifics of I-TV and how they were oriented to in the work of those involved which is an important topic here. With this in mind, I now present findings under several headings: production contingencies, direction, camera work and sound, together with sections which concentrate on performer, inhabitant and audience participation in OOTW.

4. Production contingencies

4.1. *Budget constraints*

OOTW was not a production with an unlimited budget. Far from it. Although financial support from the ISEA festival made the event possible, this also set limits in a number of crucial respects. In particular, OOTW required the paid employment of a number of television professionals, most notably an experienced television director (RB). The budget set limits on how many such people and how many days could be spent in advance planning OOTW either at the venue or seeing the technology off-site. As one of the producers (JW) explained to me: 'The TV ideal would be for the whole crew to visit the site two times but that was not possible on the little people are being paid'. For JW and RB, it would be desirable to integrate television expertise in early stages in the development of an I-TV project but this has clear and dramatic resource implications for involving experienced freelance personnel on a daily rate.

While RB, for example, is very interested in I-TV and concerned to influence experiments in it, there is a limit to how much time she is able to 'donate'. In addition to her involvement over the days in Manchester, RB was able to take part in an earlier planning meeting and visit Nottingham to see the I-TV applications under development. However, she was not able to thoroughly explore the virtual environments that comprise OOTW to, for example, explore good camera angles and locations. As such she felt she was entering into OOTW less prepared than she would be in a real-world location shoot, where some time would be spent on site taking photographs, shooting video and thoroughly getting to know the location from the inside. Indeed, in I-TV there is a sense in which there are *two* sites to get to know: the virtual environment (here the space station) and the real environment in which the human work will take place (here the theatre itself, in other cases a studio setting).

In short, one of the most critical implications of budget constraints concerned how much advance involvement from experienced professionals could be paid for. As such person-days were limited in number, much of the 'look and feel' of the production was established with a lesser influence of television design sensibilities. Equally, the TV crew had to get themselves 'up to speed' more rapidly than might otherwise be desirable and, as we shall see, RB found herself learning how to direct OOTW during the course of the performances themselves.

4.2. *Advance readiness*

The readiness of the production in advance of occupying the Manchester site was uneven. JW informed me during the first full day of on-site preparation that he felt the system (MASSIVE-2 and its attendant applications) to be 'generally well prepared but hardly tested'. He felt that the system had been developed in a timely way and had not been subject to mission critical slippages. However, the integration of *all* the components and running them at performance-pace was being done for the first time on-site.

Other features of the production were similarly mixed in their readiness. There was no firm advance script or any prepared running order which could serve as a means for coordinating the work (or at least not something which was recognizable and useful to TV personnel). The absence of a script, and the involvement of volunteers, necessitated an accent on improvization but at least one of the performers (team-leaders) informed me that she was more 'at home with scripted character development';. These absences particularly concerned JW (and others familiar with television practices) who ensured that a running order was available in some form before the 'stagger through'. Some semi-scripted components were also introduced to OOTW, particularly for the role of the host and some prepared lines for the performers. However, this writing work was largely done during the time on-site.

I have already noted that RB, the director, had not had the opportunity to thoroughly acquaint herself with the CVEs of OOTW. For their part, the four camera operators also had little advance practice composing shots within the environments. The exploration that they had done was confined to free navigation. They had not had the opportunity to try out, let alone thoroughly get to know, the camera control application that had been built for OOTW. This compounded RB's lack of working knowledge of the environments as it was through the shots given her by the cameras that she was to come to know OOTW's CVEs.

4.3. *Setting up equipment*

As might be anticipated with such a 'technology-dense' event, setting up the equipment and making it all work proved problematic on a number of occasions. Early on, some machines refused to boot. Another refused to recognize its video card. The director's TX monitor, which shows the image transmitted to the large on-stage screen, failed on the first full day on-site and a substitute had to be found. The projector used to front-project the TX to the large screen did not work satisfactorily initially. A repeated pattern of interference could be seen every seven seconds, which could be only eliminated by projecting a black and white image. Various ad hoc experiments were conducted to attempt to troubleshoot these problems as the producers, the Green Room's in-house engineer, the director and others gathered around. Cabling was examined for obvious physical faults. Single S-video cabling was compared with double SVHS. The image on the TX monitor was manipulated and compared with the projected image—a troublesome procedure as the TX monitor was on the mezzanine, the screen in the auditorium, and people had to run between the two to check the differences (and then the TX monitor itself failed!). The projector was moved to try and shorten cable lengths. New cabling was substituted. Finally, one of the mixer desks was removed and the interference disappeared. Accordingly, a substitute mixer had to be locally sourced at very short notice.

Naturally, such instances of creative, collective troubleshooting are as familiar as the fact of unforeseen contingencies. The important point to emphasize about I-TV, though, is that such contingencies are, in a sense, raised to the second power by the coexistence of so much electrical and electronic equipment and of such varying kinds. Computer equipment and TV equipment co-exist, and in abundance. The possibilities for complex interactions between equipment is visibly apparent from the amount and length of cabling involved, something which a number of the TV crew expressed surprise and worry at.

4.4. *Using the real world space*

Though an experiment in I-TV, OOTW was set in a theatre space and, as I have noted, attempted to simulate broadcast in a number of ways. However, TV simulation and theatre show lay uneasily alongside one another and several difficulties had to be resolved. For example, it was felt quite late in the production work leading up to the show that real performers should be incorporated into OOTW to satisfy the demands of theatre. The question then arose as to where physically to locate performers. After the possibility of locating them within the audience was rejected on the grounds of potentially confusing discrepancies between world-sound and PA-mix (an issue I'll return to when discussing sound), it was decided to locate the performers on stage and 'immersively' (sporting HMDs). For JW, it was highly questionable whether this 'concession' to theatricality was 'crucial to the core of inhabited TV' and perhaps for these reasons exactly how the performers were to occupy stage-space and what use they were

to make of it had been underdeveloped in the lead-in to the show (an issue I'll return to when discussing the performers).

Resolving the tensions between theatre and TV simulation, then, had consequences for the use of real-world space. On a similar theme, the question of where to physically locate the TV crew and the team members raises itself. Again, if the audience had line of sight to them, the plausibility of the event as an I-TV simulation might be jeopardized. Fortunately the Green Room was equipped with the mezzanine area located to the rear of the lighting and sound control rooms at a raised level above the entrance and bar. Double doors could sound proof the auditorium from the mezzanine and, again fortunately, the noise from the bar, to which the public has access independently of attending shows, was never loud enough to distract the TV crew or find its way into the mix via a team member's headset. Again in the name of TV simulation, it was seriously proposed to place physical screens or curtains to occlude team members (or at least teams) from one another and from the TV crew, as dispersed home viewers would not be able to see each other or the crew under broadcast conditions. This was still an open question Friday evening, the day before the first performance. Ultimately, the proposal was abandoned as the venue itself did not have screens available and, on the day, more pressing matters required attention.

The use of an on-stage screen also raised questions about how the theatre space was to be used. A screen would have to be sited so that (i) the front row is not confronted with an uncomfortably large image or (ii) the back row with an uncomfortably small one, (iii) an adequately large image is possible from where the projector is located, (iv) there is adequate space for on stage performers without compromising the audience's line of sight to the screen or causing stage lighting problems, (v) adequate lengths of cabling could be found to connect mixer and projector (not a trivial matter as this was a larger 'throw'—from mezzanine to auditorium—than commonplace), and that (vi) some sense of the adequacy of TV simulation could be maintained. The Green Room possessed a permanent fixed screen sited to the very rear of its stage space. On arrival JW, although he had visited the venue before, noted that the distance from the front row of seats to this screen was 'larger than I remembered'. The distance would be appropriate for establishing a comfortable performance space directly in front of the screen as might be required for shows with a critical emphasis on the theatricality of on-stage activity. This deeper staging was not appropriate for OOTW and would almost certainly compromise several of the features listed above. For example, it would be impossible to site the performers each to one side of the screen without withdrawing them excessively to the rear of the performance space. Siting the performers nearer the audience would almost certainly occlude the screen for many audience members as well as compromising the intention of a TV simulation. Finally, it was also determined that the in-house screen was inadequately reflective for a large, sharp image given the distance from the projector. Accordingly, JW decided to locally hire another screen and erect it nearer the audience. Fortunately, an appropriate screen could be hired in at such short notice and a position was found, after no little experimentation, which adequately addressed (i) to (vi) above.

I have documented here a number of examples of how discrepancies between the demands of theatre and the wish to simulate a TV experience relate to specific issues about the use of real-world space and where and how things may be deployed in it. Without artful arrangements in real-world space, the event could not have been plausible as a simulation of a virtual world event, still less as a TV simulation, and let alone as a theatre experience. Other deployments under more ideal circumstances may have contributed to a better simulation or a better theatre show. The important point for an ethnography of the production work is to note the profound contingency that was experienced between the producers' and researchers' wish for an informative experiment (which might yet be adequate theatre) and how the physical space was used—a contingency which required much work attending to it, little of which was anticipated.

4.5. *Timing*

Performance times were fixed and had been agreed with the venue and organisers of the ISEA festival long in advance. As JW put it when briefing the crew on Friday morning: 'We are going to perform six thirty and eight thirty on Saturday and Sunday no matter what, short of a meteor impact'. While this degree of aggressive temporal constraint had been experienced by some of the academic researchers before in earlier I-TV events, to those from that background new to live shows, this took a little getting used to. A relatively relaxed early Friday evening trip to a pizza restaurant was brought to a close by JW entering and complaining that the agreed time to be back had passed 15 minutes ago: 'You are late, this is serious, you must learn television time.' Thereafter, when addressing the crew, JW was very precise about timings and their significance. For example, early on Saturday morning: 'We will run through at 12, 2 and 3.30. This means everyone

in position, on cans and ready to run'. RB, for her part, was commonly asking about timings, whether 'we are on schedule', finding out about slippages and ensuring everyone she encountered knew any revisions.

For RB, this sense of timing comes from the production contingencies of TV. Broadcast schedules are non-negotiable and can give program start times to the minute. A delay is a very serious matter. When a delay is accountable, 'heads can roll', independent production companies can be sued over lost advertising revenue, and adjustments to published schedules require permission at 'the highest levels'. In commercial television, advertising breaks are often automatically scheduled with the consequence that an over-running program might simply be cut. To cope with this, RB as a director of live shows will have a personal assistant 'whose sole job is to count down the minutes and seconds to the next break against the running order and tell me to speed up, slow down or keep on course'. The scripting of recorded shows often involves timing scenes or even camera shots to the second so as to ensure efficient editing into the desired broadcast length (a rarer constraint in cinema). Just as learning 'TV time' needed greater precision for those from a research background, adjusting to 'theatre time' was a (slightly more welcome) feature of the work of the TV crew. RB didn't have to prompt the performers about timings during the shows. She could concentrate more on getting the right kinds of shots from the camera operators and cutting between them. A few seconds lost might have aesthetic but not legal or future employment consequences.

As it turned out, the start of the first show on Saturday was delayed as the theatre box office could note cope with the mass of people arriving at the last moment having just hurried from other ISEA events. This delay was fortuitous in some regards as we shall see. Even so, the crew went into the first show with some known problems (e.g. with the audio from one of the on stage performers, with some of the music unrehearsed) and 'on a wing and a prayer'.

4.6. *Being aware and explicit about contingency*

The experimental nature of OOTW enabled the crew to prepare itself and to calibrate the expectations of others in ways not possible with conventional broadcast or theatre performance. OOTW was advertised as an experiment and JW addressed the audience for a few minutes before the title sequence rolled at the start of each show. He emphasized its experimental status and his anticipation that something would go wrong. He made the tentative yet innovatory nature of OOTW clear to the audience and noted that they were participating in what could be the emergence of a new medium. He invited the audience to stay in their seats after the show and discuss it with the crew, being as critical they wished–'we have thick skins'. It was also made clear before each show that the audience could leave by a rear exit onto the mezzanine and see the equipment and behind-the-scenes personnel that made the show possible. All of these are methods for conveying the contingent and experimental nature of OOTW to the audience.

Similarly, an earlier briefing from JW, in addition to explaining what to do in the event of fire, how they were going to be paid, that they should keep the theatre tidy, advised the crew that things were expected to go wrong but that 'like in a Grand Prix, we hope a crash will make things entertaining'. Not only did the crew encounter, in Garfinkel's (1967) phrase, 'the awesome contingency' of practical affairs, they were prepared for this and their audience was encouraged to be sympathetic. The contingent and experimental nature of OOTW, then, was public for all to see and manageable in part as a result of this. A 'local working culture' for OOTW was established for those 4–5 days in Manchester which emphasized 'getting used to each other and how to communicate' and 'helping out and doubling up' (JW). As RB noted to me, this made for notable differences between OOTW and 'normal TV' where, especially for a routine format like a gameshow which OOTW was emulating, people would be likely to 'just know' what to do.

5. Direction

RB, the director, had an 'expanded' role over what might be customary for directing a TV gameshow. For example, she had a major task in 'coaching' the inexperienced camera operators, training them 'on the job'. She artfully pushed them in run-throughs demanding a faster pace to their work than she would ask for in the shows themselves. As she explained to me: 'I ran the pace deliberately quickly especially as they were inexperienced people but anyway that's common practice so that you ease off when you're actually going for it. That way, I and the camera operators know how much there is to spare'. After several of the run-throughs and the shows, RB showed the camera operators back a video and discussed it with them. Before the stagger through, an extended briefing concentrated on giving specific instructions to indicate what was required at prominent moments.

In OOTW, RB was combining the roles of direction (e.g. shot selection) and vision mixing (e.g. actually

actioning the cut from one camera to another by switching sources at the mixer desk). This combination of tasks, commonly done by two different people, had some consequences for RB's work. For example, she was not able to experiment with anything other than the simplest of cuts—no dissolves from one shot to another were to be found in OOTW, or other transition effects. RB also took on a responsibility for inspecting and ensuring vision quality. For example, before the stagger through RB observed that brightness and colour were being lost and demanded that this be attended to.

Much of RB's work must be understood in terms of attempting to establish and maintain a 'working division of labour' (see Martin *et al.* 1997, Hughes *et al.* 1992) between her and other crew members (especially camera operators). For RB, this in part consisted in creating what she called 'the chain of command'. For example, she instructed the camera operators: 'Even if one of the performers says something is about to happen, you wait 'till I tell you. Don't you go to the next arena merely because JW has said to the audience that we are about to'. However, this had to be delicately balanced on other occasions when appropriate by allowing the camera operators their initiative and trusting their skills. During the more free-form action components of the show, 'camera operators shouldn't wait for me to cue them they should just go. I can cut it off if it gets unintelligible'. RB's chain of command was also moderated by the demand to 'get informed on a need to know basis'. When discussing the Wobblespace software with JM, its main author, RB said: 'I don't want to know other people's problems. I only want to know if something's not working. If it's vaguely not working that's OK. I needn't know.' To which JM replied to RB's approval: 'I'll only tell you if it's broken beyond repair'.

In the terms of Hughes *et al.* (1992), workers commonly simultaneously maintain an *egological* orientation to the division of labour (what is there for *me* to do? what shot should I select?), and an *alteriological* orientation (what can I do to make the work of *others* easier? how can I help operator 2 get a good shot?). RB's directorial responsibilities, then, did not stop her from helping with other pieces of work—especially 'coordination work', for example, helping to ensure the cans on talkback were at the right levels or pointing at people to get them to speak when assisting the sound engineer in setting sound levels. In short, RB collaborated with everyone else in collectively managing the contingencies, which arose, while nevertheless maintaining a sense of 'her job'. Equally, others maintained a sense of what they should be doing, while doing it in such a way as to make RB's job as smooth as possible.

6. Camera work

Benford *et al.* (1999) describe the camera control software used in OOTW in some detail. Essentially, it supports a number of different kinds of shot and sequence. Shots can be composed centred on various subjects (team-leaders, the centroid of the positions of each of the teams, environmental features). Preprogrammed shots and sequences can be stored and retrieved. Operators can disengage from direct control, perform multiple operations as a short sequence to define an endpoint, with smooth animation then being triggered to the endpoint as direct control re-engages. In addition, a 5DOF (five degrees of freedom of movement) 'flying vehicle' mode is offered for more 'free-form' camera work. To work with the software, RB allocated the four camera operators to different basic tasks. One operator was to follow the activities of one team, another was to follow the other. A third was to get overall views of the environment ('geography shots'). A fourth was, in many respects, given a freer rein, instructed to seek out 'relationships of interest like the hand held camera would do'. Interestingly, this division of labour maps well to the different forms of camera control provided for in the design (see Benford *et al.* 1999). The fourth operator, for example, would be expected to utilize the flying vehicle mode, while the team-oriented operators would be expected to use the facilities to target team-members and leaders. Finally, the operator seeking geography shots can adopt positions capitalizing on interpreted hints in world definitions which allow, for example, a central location in one of the game arenas to be the object of a shot. Interestingly, RB divided up the labour of camera operation in this fashion not because she saw these as the constraints built into the camera control technology but because this would be a standard division of labour for real television analogues of OOTW, a division of labour which was appropriately embodied in the software.

Broadly speaking, the use of functionality in the software followed these allocated tasks. However, during the later performances as the operators' experience in virtual camera control increased, all operators were observed using the less constrained modes (e.g. the flying vehicle) more commonly. A manually controlled shot in pursuit of a team-leader might even be preferred over automatically targeting them. Several reasons can be suggested for this. First, manual control can give the right amount of 'camera shake' as the target slips to one side or even momentarily out of shot. This can be more appropriate to convey a sense of frenetic activity than a shot locked to its subject. Second, manual control can enable the operator to follow the action in more flexible

ways. For example, if a team member is about to come close to a frog who will then jump away (a theme of one of the games), an appealing shot is one statically targeted on the frog (rather than the team member) in which the team member looms ever closer before finally causing the frog to move, the frog's subsequent movement being caught in a quick pan or cut. In short, it is often possible to convey action by focusing on the objects in the environment and not just the active subjects. This kind of shot was not directly supported by the camera control software (avatars but not frogs could be the centres of shots), but was commonly requested by RB, and had to be set up manually.

One should not get the impression from this that as operators become more experienced they have less need for specific support for camera control. On the contrary the kind of controlled and preprogrammed shots we have discussed remained useful. Two particular junctures were notable. First, when there were more scripted and recognizably repeatable moments in the action. For example, just after each game, the reactions of team leaders were asked for by the show's host. Clearly, having standard methods at the camera interface to obtain such predictable shots is appropriate. Second, as RB said in a briefing meeting for the camera operators: 'If it all goes pear-shaped, I can always say go back to your terms of reference'. Having a known responsibility for each operator and a series of standard shots associated with it enabled the operators to emerge more or less unscathed if chaos ensued. In other words, the camera controls enabled 'escape routes' and provided a 'safety net' in times of trouble which wouldn't be available from higher DOF navigation vehicles alone.

One of RB's 'worst nightmares' was that all cameras at a specific moment would head for the same shot and that she would have 'nothing to cut to'. From time to time this can happen in real television and even with experienced camera operators. A particular fear was that this might happen at the moment a director would least wish for it: if something especially remarkable at a particular location had caught the eye of all operators. In real television, the physical embodiment of the cameras and their operators militates against this to some extent. If a camera physically moves in a certain direction to get a shot, it is often clear to others what is going on. However, in OOTW, it was decided not to graphically represent the cameras in the game worlds for other, good reasons (e.g. to avoid distracting the participants or occluding their views). Conventional cameras also have facilities for operators to check out the views from other cameras without having to release their own current shot. Furthermore, operators typically have visual access to a TX monitor showing the transmitted shot commonly placed on the studio floor. In this way, operators can have an awareness of what each other are doing and check on the status of what's being transmitted. This can all help find an optimal shot or angle and avoid the director's 'worst nightmare'. However, in OOTW, the only way the operators could see what others were capturing was by physically looking over to their workstations. Additionally, the operators had no TX monitor. This led to a number of occasions where RB had a sub-optimal selection of shots available to her, especially during the more free-form action components of the show—particularly the games where the trajectories and positions of participants were least predictable.

I have mentioned a number of times that RB was training the camera operators on the job and that how the camera control software was used changed across the four shows. Equally, even though she had directed an earlier experiment in I-TV (*Heaven and Hell–Live!* for details of this see Benford *et al*. 1999), RB was also learning on the job. Specifically she was learning how to direct I-TV, how it differed from conventional live television, how it was similar. Notably, she made a number of changes in how she directed OOTW between the Saturday and Sunday performances, making it clear to me that she had been 'thinking long and hard over what wasn't quite right about it'. Certainly, a number of audience members on Saturday complained that the cutting from one viewpoint to another had made it hard for them to enjoy the show.

When the crew reassembled on Sunday, RB briefed the camera operators. She played back videotapes of the Saturday performances and made numerous comments and suggestions about the camera work. She complimented the operator with responsibility for searching out relationships on the quality of his shots and encouraged the others to learn from what he had done. She urged the operators following the teams to 'get more involved with movement and follow the action'. She asked everyone to 'think about framing', the internal composition of shots, and amongst other things to offset their views more so that they were not so fixed on a centre point. She suggested strategies for dealing with problems so that, not only might the operators correct themselves, they would still be giving her useful shots while they were so doing: 'if you hit nothing by going left, peel back and widen while you come back, then zoom when you have something'.

For her part, RB resolved, as she explained to me later, to make fewer cuts in the Sunday shows. Especially if the camera work was improving she could stay with individual operators longer before cutting away to another. That is, the overall show would be 'cut slower' with the content of shots rather than rapid editing being used to convey the action. Additionally,

she had decided to 'give up on TV convention and cross the line'. Let me explain this.

A common feature of editing practice in both TV and film is to ensure that successive shots maintain a consistent spatial sense with the participants mutually oriented to one another in expectable ways. For example, in filming a dialogue between two actors (X and Y) facing each other seated on opposite sides of the table, it would be common to set up two cameras one 'favouring' X (i.e. taking X to be its main subject) but over the shoulder of Y, and another favouring Y over the shoulder of X. As a pair these cameras would typically be sited on the same side of the notional line between the face of X and the face of Y. Cutting from one to another will ensure a form of spatial consistency in that X (whether full face or from the back) will appear on the same side of the screen in successive shots, Y appearing on the other side. For similar reasons, cameras at a football match, say, will typically be all along the same side of the pitch, ensuring no matter how much they pan or zoom, that the flight of the ball and the direction of play of the teams will be consistent across cuts. Departures from this either seem anomalous (e.g. if a goal keeper's kick upfield suddenly flies in the opposite direction as a cut is made to a camera sited on the opposite side of the pitch!) or experimental, trading on the wilful disruption of conventions. A cut from a camera sited one side of the action to a camera on the other is a cut which 'crosses the line'.

RB had deliberated for a long time about whether it was possible to cross the line in virtual reality and I-TV in ways, which it was not in conventional television and film. While she was worried that crossing the line might seem just as jarring, RB was beginning to be tempted by the possibilities for 'getting into the midst of the action'. Furthermore, for some of the games in OOTW, it was often hard to see where the line of action was anyway (if any). Much of the action was distributed as, for example, multiple participants chased multiple frogs. Even when a clear direction to the action was present (e.g. in the final race game), it was a common experience that the camera operators were giving her a set of shots which would often necessitate crossing the line anyway. Each of the camera viewpoints being mobile, it was not uncommon for the four shots to be taken from virtual locations all around the environment. So, sometimes there was little choice but to cross the line.

Overnight RB began to convince herself that crossing the line might be no bad thing in I-TV and that she would not pass over well composed or interesting shots merely because cutting to them would disrupt a conventional sense of spatial consistency. This together with the other changes in editing style and camera practice yielded two shows free from any further audience complaint about disruptive editing (they complained about other things instead!—see Benford *et al.* 1999). RB expressed it to me in confident terms when I visited her the week following OOTW: 'I think the reason why most directors are so hung up on not crossing the line is that they can't get close to the action. But when you can get close, why not? It can be very effective. I think this is especially true in VR where there are no physical obstacles to you viewing things close to'. For RB, the realization that the line could be crossed was a significant advance in her understanding of how to direct I-TV reflecting some unique opportunities for picturing action in virtual reality.

7. Sound

A significant set of difficulties, confronted by RB and her camera crew in OOTW which often inhibited effective camera deployment, concerns the quality of the virtual world sound. As RB expressed it: 'In TV sound leads vision'. It is commonly audio events which cue the director and camera crew as to what should be the subject of a shot and which shot should be selected. Someone starts to speak, a cut to them is usually expected. Being able to practically act upon the basis of sound in this way was compromised in OOTW.

First, the packetised audio quality was not always high. Digital distortion could occasionally be heard and the MASSIVE-2 audio management system gave limited support for the dynamic grouping of sounds and real-time mixing that would be common in real television. RB again: 'In TV sound levels would go up and down with cuts. We need sound balances to change in line with image changes'. Second, even if a sound could be identified as coming from a specific speaker, finding the avatar that speaker corresponded to was not always easy. Furthermore, team-member avatars were not especially discriminable, all sharing a similar basic design, and visual features upon them which signified that they were speaking (i.e. the appearance of a graphical speech bubble above their head) appeared at a delay. Finally, as both director and crew only had visual access to the worlds through what the cameras were picking up, there was no way to 'have a quick look round' to see who was speaking. To address these problems related to sound as best she could and to help the camera operators in turn, RB suggested that men and women be split between the two teams: 'I have a major problem with audio. If I am showing alien and I get robot sound. I split boys and girls so I could get the relationship from the vocal quality'. The sex differentiation, now matter how controversial for other reasons (see Benford *et al.* 1999), enabled RB and her camera

operators to get the team right if not the individual. In addition, performers and inhabitants were encouraged to refer to themselves and others 'by name' more often than might otherwise seem natural: 'Auntie Astra' (the name of the alien team leader), 'number one', 'number two' and so forth.

This interesting dependency of vision on sound had not been appreciated fully in advance and no particular feature of MASSIVE-2, the audio server, the event management or camera control interfaces had been explicitly designed to support the 'integration of the senses' in the practical work of TV direction. As RB put it: 'Everyone's got set into the visuals. This happens in TV too'. Indeed, the only people associated with the production crew with some professional musical or sound engineering experience were either invited in at the last moment (the composer who provided the soundscaping for the worlds, itself a late addition to OOTW) or whose attention was more devoted to other tasks (the author of the current paper, then devoted to field observation!).

The difficulties with sound were manifest in several other ways. For example, audio level setting was highly problematic for the crew and required the skilled intervention of the venue's own resident engineer. The audio sources in OOTW, each with their own characteristics and relevant senses of 'too loud' or 'too soft', were very many. There was sound within the CVE to be made available to inhabitants and appropriately 'overheard' by the audience. This consisted of numerous voices (team-leaders and team, the host), sound effects, the synthesized soundscapes, the sound from the VT and title sequence music. Achieving the appropriate relative source-to-destination balances for all these different kinds of sound is a considerable practical problem. The front of house sound for the audience does not need to have the same mix as the sound for the inhabitants, as the sound for each of the performers, as the sound for the production crew and so forth. The host needed to be on talkback so as to receive specific instruction from the director while no other world inhabitant needed to be. While (ideally) the front of house mix would relate to the cutting of the show as noted above, one would not want those mix fluctuations being heard by the inhabitants. In short, the highly dynamic definition and mixing of sound groups would need to be supported.

However, in OOTW, this could not be fully achieved. To integrate with various features of MASSIVE-2 (e.g. the display of speech bubbles) inhabitant-sound had to digitally pass through an audio-server. While this–working with the event management software–permitted the definition of audio-groups, setting levels was achieved on a per-phase (see Benford *et al*. 1999) not on a moment-by-moment basis. On the audio server, problematic sound could not be remedied by digital sound equalisation ('EQ-ing': the adjustment of different frequency bands within a source to enhance clarity). Male voices remained 'boom-y', female voices 'thin'. In contrast, the performers' voices were taken through the house PA system and appropriately EQ-ed. The clarity of the performers markedly contrasted with the inhabitants. For SB, this was tolerable giving the audience an audible impression of the different kinds of participation in the event: 'After all in a real inhabited TV broadcast, they'd be coming in over the Internet with all kinds of poor sound'. While the inhabitant sound could be excused in the name of TV simulation, this led as we have seen to critical problems for direction and camera work. Attending to sound quality and usage in CVEs for I-TV is not merely an aesthetic matter, it has profound consequences for the work that people have to do.

8. Participation in OOTW: inhabitants

Just as JW introduced the audience to OOTW and shaped their expectations before the show, so did SB (the other credited producer of the show) brief the team members (or 'inhabitants' in the preferred I-TV terminology). The show was introduced as an experiment in I-TV: 'if this was for real in the future you'd be connected on the Internet'. The division of the teams in men and women was explained. It was explained how they can move using the joystick but that at certain moments control will pass from them as they will be moved to a new location, the screen flashing red as this happens. They were encouraged to 'joggle around a bit if you are not doing anything' as moving around 'makes for better TV'. It was explained that they cannot see the virtual camera operators so they should not expect to. They were urged 'don't fiddle with mikes' (extraneous noise from headsets being another problem with sound) and briefly taken through the running order with an overview of each game. 'We are not expecting you'll be perfect but we'd like you to be amusing'. RB emphasized that they should be prepared to initiate talk with their team leader 'not just stand around and wait to be told or be spoken to, if you don't understand say it's number 2 here, tell me what to do' (note too how this manner of referring to oneself would also facilitate the deployment of a camera to capture a view of number 2 and the selection of the right shot, see above).

Volunteer teams were sought before each show from the arriving audience members. There were considerable risks involved in this. The audience may be too small to yield the 8 volunteers required. Too many people might refuse. It might not be possible to recruit all 8 in time

and brief them for the show to start promptly. For this reason, a number of crew members and friends were asked to stand by to make up numbers if necessary. Even so, SB typically had to start his briefing without a full complement of inhabitants and could not be very detailed in his instruction. The fixed performance time created a dilemma here: the longer SB waited, the less detailed he could be. Furthermore, very little time anyway was available to the inhabitants to try out the controls and get to know each other after SB's briefing yet before the show started—typically less than 10 minutes.

In this regard, the box office delays in the first show had a desirable side-effect once all 8 team members were assembled. Between 18.30, when SB finished his briefing, and 18.47 when RB gave the one minute signal before the start, the inhabitants were free to chat and experiment with the controls. Indeed, one of the inhabitants, who characterized himself to me as 'a ringer' as he knew SB and the Nottingham team very well, spontaneously organized 'line dancing' amongst the avatars! The humour of this and the dexterity required served very well in 'warming up' the inhabitants, the volunteers contributing to the show when it started in a manner which RB, SB and several others thought to be notably stronger than other groups.

9. Participation in OOTW: performers

Performing in OOTW raised some novel challengers for the actors who participated in the production. I have already noted how one of the performers, the leader of the aliens team, said she felt more at ease with scripted material and character development as opposed to the improvisation that OOTW required. Even taking this into account OOTW (and *a fortiori* many related I-TV possibilities) would raise challenges for actors skilled in 'impro'. For example, the immersive equipment was difficult to perform in due to its weight and unwieldy design. Carrying an HMD for the 45 minutes of OOTW was very tiring for both the male and female performer. Keeping the arms raised for long periods of time to, e.g., gesture extensively with the pointing device was also very tiring. Indeed, keeping the hands physically distant from the performers' physical bodies was necessary as hands held close to the body disappeared as separate recognizable entities within the CVE. Doubtless more fine tuned calibration of the local physical body space with the local coordinates of the performers' avatars would have helped here. However, in the rush of producing OOTW on site, there was not enough time to solve these problems technically. Instead, SB–working with JW and the performers—identified 'rest moments' during the show, where the actors could lower their arms and be less conscious of their body movements (real or virtual) as the focus of interest was likely lie elsewhere. This was one of the main reasons why the moments before and after each game where the host discussed the progress of each team with the team leaders were introduced. If the alien leader was being asked about how confident she felt that her team's lead would stay intact, the robot leader could physically rest.

The specificity of I-TV also exaggerated the problems of gesture and how tiresome sustained body movement can be. While an on-stage physical gesture from the performers would be available there and then for the audience to see, getting its virtual correlate on screen was a somewhat hit and miss affair. The virtual gesture would have to be noticed and framed by a camera operator *and* the director would have to select it for transmission. Only then would an avatar making a virtual gesture appear on screen alongside the physical performer making the corresponding real world gesture. These dual conditions were not met often enough in rehearsal before the on-stage performer relaxed or moved onto something else. For much of the time the on-stage performers could be seen gesturing but with no obvious correlate on screen. To try and correct this for the shows, the performers were enjoined to adopt gestures which were larger, more flamboyant than they might normally think of, and could be held and repeated so as to increase the chance that they'd be caught on camera and selected for transmission. SB specifically rehearsed bigger more expansive gestures with the performers and their helpers a number of times between run throughs: 'It's not just you doing it, it's getting it noticed'. However, this clearly *further increased* the physical demands encountered by the performers, something already found problematic, as well as occasionally putting delicate equipment at further risk. Nevertheless, the performers persevered, carefully considering when their rest moments would be, and in other ways artfully patterning their physical exertions within the shows.

Other real-world contingencies imposed themselves on these supposedly 'immersed' performers. For example, much time was spent trying to resolve contradictions between the orientation of performers with respect to the audience, each other and the on-screen image. The theatrical staging of the show might suggest an alignment of performers' (real physical) bodies to address the audience or each other, but this mutual orientation very rarely corresponded to the orientation on-screen, depending as it does on the particularities of the orientation of the avatars and the deployment/selection of cameras. Equally, there were many moments of a performer strongly gesturing 'to the wings' while

their avatar was full face-on to the audience or facing the other way. In many respects, these phenomena relate to an issue highlighted earlier: reconciling a TV simulation (complete with large screen) with theatrical staging. Later discussions with audience members suggested a common strategy for reconciling this tension: ignoring the physical presence of the performers! As a final instance of the real-world impacting on the immersed performers, it is important to note the crucial role of the two helpers. The helpers assisted the performers with putting the equipment on and taking it off. They were able, e.g. when the audio of one of them failed in performance, to mediate between the performers and the production crew. They were able to stop the performers inadvertently overstretching cables or walking into the audience. In all these respects, extra human help was required *precisely because* the performers were immersed and, being so, could not always help themselves in the face of *real-world* contingency.

10. Participation in OOTW: audience interaction

In OOTW, the theatre audience had one main opportunity during the course of the show to interact with and influence the performed events and this was through their use of Wobblespace. A booklet of coloured sheets of paper was placed on each seat in the auditorium and, by waving these, audience members could 'vote' for their favourite member of the losing team in the gameshow—the team members' avatars rising up coloured columns in the CVE depending on how much paper-waving in their favour had been detected so far (for details see Benford *et al*. 1999). As briefly noted above, Wobblespace works by measuring the variation in intensity of the various colours as they are detected in a video signal from a camera trained on the audience. Calibrating Wobblespace was problematic requiring much work from the two personnel devoted to it, one adjusting the software, the other—at various times before the first show—running between the auditorium and the mezzanine to find out Wobblespace's performance and to reposition or wave coloured paper.

To get a bright enough video image the house lights had to be raised but they illuminated the auditorium dimly and unevenly. Detecting a region near the rear of audience was especially troublesome. The low house lighting contributed to the misidentification of colours and of some colours more than others. Persistently, the quality of identification was in trade-off with the level of 'noise' (false identifications). What was especially irksome was that this trade-off itself varied with different parts of the auditorium. For example, the exit sign at the rear caused identification false alarms but, for JM, this was hoped to be a small in its overall contribution. In the work prior to the stagger-through and between the rehearsals, the testing of Wobblespace had to be interleaved between all the other technologies calling for controlled access to the auditorium and experimentation with its lighting conditions. Scheduling these tests, then, was itself an affair requiring practical management.

Even though Wobblespace required a full, real audience to properly test it and this would only be available in the very first show itself, JM and his colleague kept a cool nerve. Anticipating these contingencies and suspecting that it would not be possible to configure Wobblespace optimally in the time available, they had designed in several 'manual overrides'. The update rate could be varied so that the effect of waving the coloured sheets could be controlled. This allowed the overall amount of time in the show taken up with Wobblespace to be influenced. If, as happened in the first performance, Wobblespace was slow to compute 'a winner', the update rate could be increased. Furthermore, at the extreme, Wobblespace could be overridden and the interactive determination of the race up the coloured columns replaced by animated processes (a facility, which did not need to be used in the shows).

Making Wobblespace work was a complex, contingent and heterogeneous affair—not just a matter of calibrating the technology, but also of careful adjustments to camera settings and house-lighting levels, of the artful management of its functioning in use, and of ensuring that audience members behaved appropriately (as well as being enjoined to wave vigorously by the host, they were reminded not to take the sheets of paper away at the end of the show!). In many respects, the practical activities of making Wobblespace work are emblematic of the heterogeneous problem solving (cf. Bowers 1994) required throughout OOTW.

11. Some conclusions and implications

An impression should be developing by now: for all its experimentalism, technical innovation and aspirations to bring a new medium into existence, the production of 'Out of This World' was a worldly affair—an affair very much *of this world*. It called upon people's ordinary everyday skills and expertise locally deployed in managing complex contingencies. It was constrained by such recognizable matters as finite budgets and the aches in performers' arms. Technologies for enabling mass interaction were troubled by an exit light. The fluency of virtual world inhabitants was facilitated by box office delays. A lesson in TV

professionalism was occasioned by slow service in a pizza restaurant.

In many radical ways, virtual worlds and interaction within them are contingent upon work in the real-world and interaction within it (cf. Bowers *et al*. 1996). If anything, the contingencies, real-world troubleshooting and ad hoc improvisation of solutions to problems required in I-TV are increased in number and annoyance over a conventional TV or theatre production or a research 'demo'. When *all* the work is taken into account, virtual reality often signals an intensification of real-world engagement, not an escape from it.

Let me now consider some implications that the ethnographic study I have presented might have for future inhabited TV technologies and practices, and for VR in CSCW in general.

11.1. *Camera control and resources for direction*

Most of my analysis of the camera control software in use indicates not faults in the software but the necessity of fitting it into an integrated cooperative working environment so that, for example, the working division of labour between camera operators and between operators and director could be more effectively supported. This requires a broadening of design-perspectives for VR as we are not merely designing camera interfaces but cooperative work applications. In this regard (1), it is suggested that the awareness that camera operators have about the status of their and others' work could be enhanced so that, for example, they know what others are doing and where they are in the CVE, and what shot currently forms TX. This may also require, in contrast to OOTW, giving the cameras some embodiment within the CVE. However, it would not be necessary to render those embodiments in all views. Thus, the cameras could be invisible for the inhabitants or on TX (if their presence was thought distracting) while still being present 'in the viewfinder'. As another design suggestion (2), there are good reasons for giving camera operators and the director visual access to the CVE independently of the cameras as such, so that operators can have a look round before composing a shot or the director can have her own view to enable more precise instructions to be given to operators. (3) RB expressed the need for more direct support for conventional TV framings of shots, e.g.: 'I want to be able to say to a camera operator give me the alien leader and her team favouring the leader'. It is quite possible that geometrical methods might be explored to algorithmically find such shots or, rather, preliminary framings of them, which an operator could manually refine or overturn. Finally (4), I have also noted how camera work and direction have a practical relationship with sound. This clearly needs attention.

In other respects, the features embodied in the software mapped on well to the different roles camera crew needed to take and their different activities within those roles. Importantly, the design strategy to facilitate manual control rather than to automate shots and transitions has seemed appropriate. In particular, preferring enhanced manual control at this stage of research has allowed the director we have worked with to experiment with different ways of directing I-TV. She can vary the pace of cutting, give different sets of instructions to the crew, get into the midst of the action or view it from the side, and so forth. As we have seen, she consciously experimented with different direction styles during the course of the OOTW shows. It seems appropriate to design software at this stage which will enable such experimentation from television personnel, permitting them to address issues about the nature of I-TV from their own professional viewpoint (e.g. how should one cut between virtual cameras?) rather than mandating an answer through excessive automation in software design.

In OOTW, the director's 'interfaces' were those of conventional TV (vision mixers, monitors etc.) even if what they were displaying was unconventional (robot and alien avatars within a CVE). I have already indicated that this may need extension for fully enabling I-TV by, for example, giving the director camera-independent CVE access. In the hurly-burly of directing work, though, it is questionable whether a fully navigable 6DOF viewpoint would be appropriate either to a director's needs or possible to fit into all the other tasks she needs to perform. What seems more appropriate is to give the director some representation of *the activity* within the CVE, where things of visual interest might be located, so that cameras can be deployed accordingly. Such representations need not be views of the CVE of a conventional (i.e. avatar-associated) sort. For example, Sandor and Jää-Aro (unpublished) have proposed 'activity maps' of CVEs, computed (as appropriate) from avatar displacements, gestural activity and text/speech input measures, showing 'where the action is'. Appropriately designed visualizations might enable at-a-glance perception which could resource direction without adding a considerable overhead. Especially for very large-scale CVEs with several hundreds of inhabitants (indeed, *Heaven and Hell—Live!*, an earlier experiment in I-TV, had a population of 135), such visualizations might usefully aid direction and camera work and support making action (and not just entities like avatars and environmental features) the subject of shots.

Together with Kai-Mikael Jää-Aro and Sten-Olof Hellström and at CID, KTH in Stockholm, the author has developed prototypes for the support of camera control and direction along these lines. We are also exploring 'sonifications' of inhabitant-activity as a step to enabling sound to serve as a direction resource. We see our work as facilitating a further paradigm shift in concepts of navigation for VR. While conventional VR systems support *avatar-centred navigation* (through the control of the position of the embodiment of the user), and while Benford and his colleagues (e.g. 1999) have argued for *object-centred navigation* (so that movements can be made in relationship to entities in the field of view), we are proposing *activity-oriented navigation* (so that deployment in space can be influence by the activity within it)—a concept of general interest, we believe, to VR and CSCW. (Papers reporting on this work are in preparation at the time of writing this one.)

11.2. *The working culture of inhabited TV*

I-TV currently lies at the intersection of a range of working cultures and raises challenges for each of them. For academic researchers, there are challenges creating technologies, which need to be not merely 'demo-ed' but performed with robustly in front of live audiences drawn from the general public. For performers, there may be specific challenges for improvisational skills, (physical and virtual) bodily deportment and cultivating a gestural vocabulary, which can be caught on (virtual) camera. For TV personnel, there are professional questions to do with how to direct and produce for and in VR. We have seen OOTW's director come to the conclusion that some aspects of conventional TV and film practice can be revised in the face of new opportunities for picturing action in VR—maybe you *can* cross the line. For technical staff, there are yet more cables.

In the words of one of OOTW's producers: 'There's a structure of professionalism in TV which enables teams to come together quickly and do complex things'. While I-TV does not yet have its own *structure* of professionalism, *local practical relations between working cultures* were seen to be established around OOTW testifying to its *social-practical-organisational viability* as a 'new medium'–and such viability is the minimum necessary to complement working technology if I-TV is to have a future. While OOTW's team did complex things, they did not yet do it with the speed and fluency of conventional practice. Inhabited TV is a hybrid non-conventional technology and has a hybrid non-conventional working culture to match. This, of course, for an ethnographer can be an advantage as practical affairs get explicitly debated and laid bare for all to see. I hope the reader has found this account of the lived contingencies of practice refreshing when compared with the enigmas of much contemporary cultural, media and film theory. Right now, I believe it is important for social scientists to also be in the midst of the action, documenting new media experiments while having a stake in technology development, crossing some more lines.

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