

CENTERS OF COORDINATION: A CASE AND SOME THEMES

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Abstract This chapter identifies a class of worksites characterizable in terms of participants' ongoing orientation to problems of space and time, involving the deployment of people and equipment across distances according either to a timetable or to the emergent requirements of a time-critical situation. To meet simultaneous requirements of mobility and control, centers of coordination must function as *centers* to which participants distributed in space can orient, and which at any given moment they know how to find. At the same time, to *coordinate* activities distributed in space and time personnel within the site must somehow have access to the situation of co-workers in other locations. One job of technologies in such settings is to meet these requirements through the reconfiguration of relevant spatial and temporal relations. This general characterization is explored through ethnographic materials from an investigation of the work of airline ground operations at a metropolitan airport on the west coast of the United States.

INTRODUCTION

Recent work within anthropology and sociology includes a growing body of ethnographically based analyses of the place of technologies in human activity and of human activity as grounds for the significance and functionality of technologies. These analyses differ from traditional treatments of "human-machine interaction" within cognitive psychology and computer science in their interest in locating technologies within the socially organized activities and settings of their production and use. Research has proceeded through the study of technology intensive forms of practice that include medicine, science, navigation, office work, machine design, maintenance and repair, specialized worksites such as a city dealing room, and a class

of worksites that might be called *centers of coordination*.¹ Studies of the latter include the research of Whalen (1992, 1993) and Whalen and Zimmerman (1990) on call taking and dispatch in 9-1-1 public safety centers, of Harper and Hughes (1993) and Harper, Hughes, Randall, Shapiro and Sharrock (in press) on air traffic control centers, of Heath and Luff (1991) on line control centers in the London Underground, of Filippi and Theureau (1993) on control rooms in the Paris Metro, and of our own research on airport ground Operations rooms.²

Centers of coordination are characterizable in terms of participants' ongoing orientation to problems of space and time, involving the deployment of people and equipment across distances, according to a canonical timetable or the emergent requirements of rapid response to a time-critical situation. In this chapter, I outline a set of themes that organized and were developed by the analysis of one particular center of coordination. By examining ethnographic materials from this worksite, we begin to get detailed access to the phenomenon of coordinated work activity as the practical reasoning and action involved in maintaining an institutionally accountable spatio/temporal order. My goal is both to provide a guide to the analyses produced

¹ Anyone familiar with this growing literature will recognize the difficulty of an adequate listing. On medicine, see for example Barley, 1986; Dugdale & Fujimura, in prep; Hartland, 1993; Jordan, 1992a. On science, see Clark & Fujimura, 1992; Goodwin, this volume, 1994; Knorr-Cetina & Mulkay, 1983; Latour & Woolgar, 1979; Lynch, Livingston, & Garfinkel, 1983; Lynch & Woolgar, 1990; Pickering, 1992; Star, 1989; Traweek, 1988. On navigation, see Hutchins, 1990, 1991; on office work, Blomberg, 1987; Suchman, 1983; Heath & Luff, 1993; Luff & Heath, 1993; on machine design, maintenance and repair, Bowers, 1994; Forsythe, 1993; Orr, 1990; Sharrock & Anderson, 1993; Star & Ruhleder, 1994; Suchman, 1987; Suchman & Trigg, 1993; on the city dealing room, Heath, Jirotko, Luff, & Hindmarsh, 1993. For more on the relation of the phrase "centers of coordination" to Latour's "centres of calculation" (1987), see Suchman & Whalen, 1994.

² Participants in this research included Francoise Brun-Cottan, Kathryn Forbes, Charles Goodwin, Marjorie Goodwin, Brigitte Jordan, and Randy Trigg. It should be obvious that this chapter is not only indebted to them but is also meant largely as a reference to their work. Paul Drew, Christian Heath, and Emanuel Schegloff all served as invaluable consultants. (See Brun-Cottan, 1991; Brun-Cottan et al., 1991; Goodwin, C., 1991; Goodwin, M., 1995, in press; Goodwin & Goodwin, 1996; Jordan, 1990, 1992b, 1992c; Suchman, 1993, 1996; Suchman & Trigg, 1991.

within that particular project and to contribute to a collective framework within which a larger body of studies might be related.

THE SITE

From 1989 through 1991, we carried out an extended study of the work of ground operations at a metropolitan airport on the west coast of the United States.³ We began the project with a general interest in contributing to analyses of the dynamic structuring of peoples' interactions with each other and with their material environments, and in exploring the relevance of such analyses to problems in design.

We were initially drawn to the airport as a study site by two considerations. First, as a workplace, an airport includes a diverse collection of professions and activities, which in some respects occupy clearly delineated, largely separate territories. At the same time, the coordination of the work requires interaction across territorial boundaries at certain critical junctures. Second, during the course of our study period, a new terminal building was completed and opened. This made it possible for us to learn from the changes involved in moving operations from one work setting to another. We were interested to see how the relations of work and technology established in one facility would be reproduced, or transformed, as they were re-established in a new setting.

Our study focused on the two airlines scheduled to move into the new terminal and, within those airlines, on the work of ground operations: that is, all of the work

³ The research, under the heading The Workplace Project, was funded by Xerox and Steelcase Corporations. Brun-Cottan et al. (1991) presents a video final report on the study.

involved in servicing arriving and departing airplanes.⁴ Within ground operations, we took as a further focus a particular "backstage" area, called the Operations room, charged with coordinating the work of the gates and the ramp. The Operations room proved to be ideal as a setting for our interests. Within the room, we were able to see the working practices of a small group of people co-present to each other and closely attuned to each other's actions. At the same time, the division of labor was such that each person within the room was assigned the task of maintaining communications with some other relevant location outside the room, via various technologies. We therefore were able to see the structuring of these distributed, technology-mediated interactions as well. Finally, we were able to see how these two working orientations – to co-workers within the room and to those outside – were organized in relation to each other.

THEMES

Our project, as analysts of the work of Operations, was to see just what that work comprises within this particular site. At the same time, the materials from the site contributed to a developing understanding of the social and material organization of skilled practice within complex, technology-intensive worksites more generally. The analyses that resulted from the project explore a set of themes that both organized our looking at the site and were developed and elaborated by it:

Technologies as material practice: The inseparability of technologies and the activities of their use. This includes locating the functionality of technological

⁴ The work of ground operations does not include air traffic control, but rather all of the activities involved in servicing an airplane while it is at the gate, for example, loading and unloading passengers and baggage, ensuring that connecting baggage from an incoming plane is moved to the appropriate outgoing plane, replenishing the plane's store of food and fuel. For analyses of air traffic control as a center of coordination, see Harper and Hughes (1993) and Harper et al. (in press).

artifacts not in particular devices, but in densely structured courses of action involving the assembly of heterogeneous devices into a working information system.

Reading a scene: How competency in these settings involves learning how to read a scene, through the juxtaposition and interpretation of verbal reports, visual images, and various forms of text, in real time, into provisional assessments of an emerging situation.

(Re)producing a normal order : How, through their management of everyday contingencies, workers are able to maintain an accountable spatio/temporal order.

Structures of participation: How participants in a multi-activity setting structure their focus of attention and engagement, from moment-to-moment.

Constituting workspaces: How workspaces are dynamically configured through interactions across visible and invisible boundaries.

Acquiring competency: How the identity of competent practitioner is acquired through progressive rounds of increasingly demanding work, supported *in situ* by experienced co-workers.

Authoritative knowledge: Relations between participants' access to technologies and the distribution of knowledge taken to be consequential for the work at hand.

Designing for change: Implications of the analysis for relations between professional design and design-in-use.

Technologies as Material Practice

A central theme of our studies is the intimate relationship between work environments and the structuring of work activities. We take the work environment to include architectural features and furnishings, telephone lines, radio frequencies, computer screens, video monitors, documents and the like. These objects, moreover, assume multiple identities according to their relevance for practice; for example, an airplane may be for one person at one moment a specific aircraft, whereas for another, it is an instance of a flight, a container to be loaded, a machine to be repaired, and so forth (Brun-Cottan, 1991; Goodwin & Goodwin, 1996; Suchman, 1993). There are no uni-directional effects between these elements. Rather people are engaged in a continuous process of making the environment work for the activities at hand. In doing so, they leave the mark of their activities on the environment in ways that set up the conditions for subsequent actions. Along the way, the workspaces, furnishings, technologies, and artifacts are experienced as more and less focal or contextual, negotiable or resistant, enabling or constraining of the work that needs to be done.

Their function as centers of coordination requires that Operations rooms comprise a stable site to which participants distributed in space can orient and which at any given moment they know how to find. At the same time, to coordinate activities distributed in space and time, personnel within the site must somehow have access to the situation of co-workers in other locations. One job of technologies in such settings is to resolve this problem through the reconfiguration of relevant spatial and temporal relations. That is to say, information and communications technologies make it possible to maintain one site as central by providing connections from that

place to activities located elsewhere, and by tracking those activities against a standardized temporal order.⁵

A view of an Operations room shows some of these technologies:



Along one wall of the room is a row of video monitors that feed images from cameras located at each of the airline's gates into the room. By seeing the image of an airplane in a particular monitor, mapping the monitor to a gate, and mapping the gate in turn to a flight number, workers can track the status of arriving and departing flights.

The association of gates with flights is supported through additional representational devices. Located just below the row of monitors is the *complex board*. The complex board is a whiteboard on which is drawn a space/time grid, each cell of which is filled with an arriving and departing flight number, along with its point

⁵ JoAnne Yates (1989) provides a history of the place of information and communications technologies in maintaining centralized coordination and control over increasingly distributed and time critical operations within U.S. railroads and manufacturing enterprises, from the middle of the 19th century.

of origin or destination. As Latour has argued (1990), the creation and use of a device like the complex board involves the alignment, in a two-dimensional, manipulable array, of a number of different spatial relations, temporal orders and heterogeneous objects distributed across great distances. Through its matrix structure, the complex board provides a graphic surface on which operations workers can juxtapose and relate gates, times, flight numbers, and other sites in the airline network. The further association of a clock then makes it possible to relate the order represented on the board to the observable order that can be viewed in the video monitors. Finally, computer terminals provide access to a network of databases shared among the distributed sites of the airline's operations, representing the scheduled order from a variety of views, and continuously updated to reflect the actual course of unfolding events.

*Reading a scene*⁶

A central finding of our analyses concerns the extent to which the work of Operations involves the assembly of knowledge about past, present, and future events through the juxtaposition and relationship of a diverse range of technologies and artifacts. Access to information and its timely communication to relevant others involves interaction not with a single technology but rather with multiple technologies (e.g., forms, computer screens, video monitors) held in relation to each other and read off in ways specifically structured by the task at hand.

⁶ This phrase is due to Goodwin and Goodwin (1996). "Reading a scene" is closely related to what Heath and Luff (1992) describe under the heading of "overseeing the local environment" (p. 83).

The reading of these technologies does not proceed in a unidirectional sequence: rather, they can be juxtaposed as needed in order to add to or elaborate on whatever information already happens to be in hand (see M. Goodwin, 1995; Goodwin & Goodwin, 1996.) Workers address inquiries to these information resources not from some neutral starting place, but always from a position within the midst of an ongoing situation. So, for example, experienced Operations room workers, knowing the schedule for a particular flight, can locate the associated plane on a video monitor and read the activities around it for the flight's progress. Alternatively, with a given plane in view on the video monitor, they can associate that plane with a particular flight in order to make sense of the image they see. Competency in the Operations room involves learning how to read a scene through the juxtaposition and interpretation of verbal reports, visual images, and various forms of text, in real time, into provisional assessments of an emerging situation.

The example that follows is drawn from a paper by Charles and Marjorie Goodwin (1996) where it is extensively and elegantly analyzed. It concerns the work of a position in the Operations room called the Flight Tracker. The Flight Tracker is charged among other things with tracking arriving and departing airplanes, maintaining communications with pilots on the ground via a radio, and clearing their arrival at designated gates.

On the simplest account, the incident begins with a report from an incoming pilot that another plane is already parked at the gate to which he has been assigned.

The report implicitly identifies a problem, and the question locates the solution to that problem with the Flight Tracker⁷:

Pilot: I understand gate fourteen is occupied?
Do you have any instructions for (it)?
Flight (0.3)
Tracker: Uh::m, (0.1)
Should've left ten minutes ago.=
Hopefully:,
(1.0)
They *have* pulled the passenger stairs.
They should be leaving *momentarily*.
Pilot: O:kay, thanks.

In their analysis of this sequence, the Goodwins observe that, to understand the skills that the Flight Tracker deploys in doing her work, we need to begin with her actions as hearer during the course of the pilot's call. We can see this clearly by considering a transcript of the same sequence, this time with an indication of the Flight Tracker's orientation during the exchange with the pilot, as indicated by her gaze⁸:

Pilot: I understand gate [**Flight Tracker's gaze goes to video monitors**] fourteen is occupied?
Do you have any instructions [**Flight Tracker's gaze moves to the radio log, listing flight arrival and departure times, beside her workstation**] for (it)?
Flight (0.3)
Tracker: [**looking through radio log**] Uh::m, [**gaze to a Flight Information Display monitor above her workstation**] (0.1)

⁷ In transcript segments colons ":" indicate prolongation of the immediately preceding sound, italics mark stress. A dot in parentheses "(.)" indicates an untimed pause, numbers in parentheses indicated elapsed time in seconds. An equals sign "=" indicates "latching," i.e. the beginning of one utterance following directly on the end of the prior with no gap.

⁸ Charles and Marjorie Goodwin among others have developed innovative means of indicating non-vocal activity within transcripts (see for example Marjorie Goodwin's transcription of this sequence in Goodwin and Goodwin, 1996, and also Heath and Luff, 1993, and Luff and Heath 1993). Here I have adopted the simple strategy of inserting textual descriptions of FT's orientation within brackets, in boldface, into the transcript.

[gaze back to radio log] *Should've left ten minutes ago.=*

[gaze back to video monitors] Hopefully,;

(1.0)

They *have* pulled the passenger stairs.

They should be leaving *momentarily*.

Pilot: O:kay, thanks.

With the pilot's mention of *gate*, the Flight Tracker is already orienting to the video monitors. In her look to the monitors, we see her beginning a course of action that involves the juxtaposition and relation of multiple, partial perspectives onto the scene. Specifically, she finds the location referred to by the pilot as it appears on a video monitor within her work site, maps the plane that she sees there to an associated flight number by means of a paper record of scheduled arrivals and departures, compares the observable plane and current time with the represented status of that flight in the record and on a flight information display screen in front of her, finds an unreconciled disparity between actual and represented events, gazes again at the monitor, and there finds the actual situation to have changed in such a way (the workers on the ramp having pulled the passenger stairs away from the plane) that she can project a resolution (the plane's imminent departure.) Her vantage point in operations does not provide her with a single master perspective, in sum, but rather with a range of partial information resources with which she can assemble a coherent view.

(Re)producing a normal order

The Flight Tracker's projected resolution to the problem makes reference to an expected sequence of events and brings us into the presence of a theme that is central,

particularly within ethnomethodological studies, to analyses of organizational settings, namely, the accountable (re)production of normal orders. The term *accountability* has a useful ambiguity within ethnomethodology, referencing two senses of the moral grounding of everyday activity. In the most basic sense, our viability as members of the social world turns on our mutual intelligibility; that is, on our ability to make sense of the actions of others and make ourselves sensible to them. In this sense our accountability with respect to our actions means just that we are responsible for their intelligibility in relation to relevant circumstances. This is not to say, of course, that we always do act sensibly, or that questions of sense and significance will necessarily arise, nor that meanings cannot remain highly uncertain and/or contested. It is to say that as social actors we are unavoidably implicated in such practices of sense-making.

At the same time, we are also enjoined within more specific, historically constituted orders of accountability, enforced through more and less explicit regimes of administration and control. Airline operations is one such institutionalized, power-differentiated social world. Within the work of operations, organization members are accountable for the relation of normative rules to observable/reportable events (Garfinkel & Sacks, 1970). On this premise, traditional sociological theorizing takes normative rules, such as the order of flights prescribed by the airline schedule, as explanations for the social order observed in airline operations. Ethnomethodology, in contrast, takes the positing of normative rules not as a resource for sociological explanation but as an (often problematic) resource for members in their interpretation of the activities in which they are engaged. So we see here that the Flight Tracker makes recourse to the schedule, and to an expected order of events at the gate, while at the same time she implicitly acknowledges the kind of order that it is. Specifically,

she notes in her *hopefully* and in her use of the modal *should* that there is no necessary relation between schedules and the timely movement of airplanes, or between stair-pulling and momentary departure. Rather, the normal order is contingent on its faithful reproduction through the artful practices of personnel dedicated to its accomplishment, on each next occasion and across the unique and unpredictable circumstances that each occasion provides. It is on that artful accomplishment that the Flight Tracker's expectation of a projected resolution to the problem relies.

Jordan (1992c) looks at the management of trouble with an interest in the relation between routine and improvisation in the work of Operations. In particular, she develops the notion of a *typified action sequence* as a way of talking about the projectability that organizational routines provide. Her analysis demonstrates that the reproduction of organizational routines is not provided for from outside but rather is a continuous accomplishment from within the local group. At the same time, within the group members' orient to a normal course of events, as the framework into which unexpected contingencies can be absorbed and through which they can be managed.

M. Goodwin (in press) explores in detail the workings of such action sequences as a matter of resources used by Operations workers to design their talk for the specific environment that the room affords, in particular, for the troubles that it presents for hearers. Taking as a case in point the routine delivery of *informings* and *announcements*, Goodwin's analysis shows how workers employ various forms of stylized intonation reminiscent of ritual speech in order successfully to convey these utterances through the "sonic soup" from which their intended recipients must pick them out.

Suchman (1993) takes up the theme of the accountability of practical action and relates it to the use of technologies within the work of Operations. The phrase *technologies of accountability* is meant to take advantage of the term's ambiguities to suggest two senses in which we might pursue the investigation of technologically mediated practice. In the first sense, the competent use of technologies in Operations supports the production of an accountable course of intelligible and effective action. In the second sense, the technologies and actions of Operations incorporate regimes of control designed to administer a particular, institutionalized spatio-temporal order.

Structures of participation

We noted that the social organization of work within the Operations room involves a division of labor that assigns to each position different responsibilities for communication, via various technologies, with other relevant locations. One consequence of this organization is a differentiated structure of attention among workers within the room. The most compelling evidence for this differentiation is the ability of participants to disattend sights, sounds, and events that draw the attention of their co-workers, and to keep on with their business at hand. At the same time, members of the operations room are engaged in the highly integrated, joint task of getting planes smoothly in and out of gates according to specified schedules. This collective responsibility means that they are in some very important sense "in it together," both in the sense of sharing responsibility for the work's success or failure and sharing the facilities through which the work gets done. The coordination required within the center means that Operations room work is characterized by a

strong mutual orientation among co-present workers to each other and to developing situations.

The interactional order of the Operations room is characterized as well by a continuous state of incipient talk. The peripheral monitoring made possible by their co-presence in a shared auditory and visual space means that at any time something overheard in the work of another may be assessed for its relevance and taken up as the business of the hearer. So, for example, a question asked "of the room" or even of a specific co-worker may be answered by anyone who has an appropriate response (Jordan, 1992c). Similarly, people are oriented to the possibility that they or their co-workers may initiate an interaction at any time without any marked pre-announcement or inquiry into the others' availability for that talk (Brun-Cottan, 1991). The multi-activity nature of the setting means that the one who would initiate an interaction needs to do so in a way that is sensitive to the engagement of others, for example, through the utterance's placement or, as an alternative, through its intonation (M. Goodwin, in press).

Another sequence analyzed by Marjorie Goodwin (1995) involves an incident similar to that of Goodwin and Goodwin (1996); that is, an arriving pilot has been assigned to a gate that is already occupied. Again we see the Flight Tracker (FT) receive a call from the pilot and consult the video monitors and complex board to establish, first, that there is an airplane at the assigned gate, and then its flight number and scheduled departure time. In this case, however, the projected resolution of the problem is provided not by what the Flight Tracker can read of the activities around the plane but by a reading done for him by the Ramp Planner (RP), a co-worker in the Operations room responsible for directing activities around the plane. The Ramp

Planner is retrospectively found to be attending to the call-in from the pilot of Flight 1091 and to the Flight Tracker's resulting problem:

Pilot: (via radio) Operations.
Atlantic ten ninety-one's on the ground for gate seven.
RP: **[Turns gaze towards monitor bank]**
(2.5)
FT: **[Looks to monitors]**
(To pilot via radio) Roger, ten ninety-one.
Charlie- Alpha: seven:? uh:::, (0.2) Shoo:: (0.9)
Hold on one second, ten ninety-one.
(Off radio, into the room) Alpha seven,
[Shifts gaze from monitors to complex board]
RP: That plane should be pushin.
FT: **[Re-oriens back to radio]** (To pilot) That aircraft should be
off the gate shortly.
Stand by until seven clears, Ten ninety-one.
Pilot: Roger. Could you tell them we're gonna need ground power
please.
FT: That's affirm. **[Gaze toward RP]** Did you catch that, Joe?
RP: Yeah.
FT: Okay.

In this case, it is the Flight Tracker who, in response to the radio call from the pilot of Flight 1091, discovers, through a look to the video monitors, that another plane is occupying the gate to which Flight 1091 has been assigned. The Ramp Planner evidently sees this problem as well. Moreover, the division of labor in this case provides the Ramp Planner with a different history and consequently different ability to interpret the state of affairs at the gate; this difference is a resource here because he, like the Flight Tracker in the previous example, offers a projected solution based on his reading of the scene. The Flight Tracker, in turn, evidently reasons that the Ramp Planner, having just displayed his attention to the call, will have continued to monitor its course and will hear at its close a request from the pilot for an electrical power source. He figures that, but he is not sure. Given this uncertainty, the Flight Tracker

fulfills his responsibility to pass on the pilot's request to the Ramp Planner not by delivering it as news, but by asking the Ramp Planner to confirm that it has, in fact, been heard.

Workers in the Operations room are sensitive to the environment for communication that the room provides and to changes in that environment from one moment to the next. Much of the time, workers are able to track the activities of their co-workers or to be enlisted into them at the same time that they respond to the demands of their own position. By listening not only for events to which they need to respond but for the responses of others as well, minor troubles in communication are routinely identified and resolved.⁹ In some situations, the supervisor effectively acts as an additional pair of eyes and ears, charged specifically with watching for the possibility that events may be missed (see Suchman, 1996).

Constituting workspaces

The activities of Operations are distributed across spaces separated by distances ranging from several feet to many thousands of miles. With the advent of new information and communications technologies, the composition of the working group no longer correlates just with physical proximity. So, for example, two co-workers seated side by side may at one moment be more closely engaged with parties in other locations than with each other. Our focus on ground operations allowed us to see how a work group distributed in space is tied together through architectural, technological, and interactional resources, as well as the obstacles that such a group must face.

⁹ See Heath and Luff's discussion (1992) of *surreptitious monitoring* and *rendering activities visible* for a related analysis.

A starting premise for our analyses is that workspaces are not simply physical locations but are also actively constituted fields of perception and interaction, continuously maintained over the course of the day's work. Through the spaces they occupy, people identify themselves and their place within the organization. Within Operations, each role in the division of labor is mapped to a specific location in the room, tied in turn to other locales outside. What are called positions capture nicely this double sense of location in the organization of the work and in the arrangement of space. In this sense, the social relations of the work both define the visible and invisible boundaries of the workplace and are defined by them.

The division of labor in Operations is reflected in an arrangement of habitual workspaces, each oriented toward the equipment that ties personnel within the room to their co-workers in other relevant locations. The stability of these workspaces means that members are able to project the location both of their colleagues and of specific pieces of equipment. The projectibility of habitual spaces contributes to the ease with which a task can be taken up or handed off from one co-worker to another.

Although the division of labor in Operations differentiates people's attention, the absence of interior walls or other fixed boundaries within the room maximizes mutual access. And while Operations personnel inhabit habitual workplaces, those places are not in any sense owned by the individuals who occupy them. Equipment associated with one position may be borrowed by an Operations worker at another position. Alternatively, one worker may take up the position of another if the latter is temporarily absent or otherwise occupied. Within the Operations room, boundary markers that mark the line between adjacent territories are notably absent. Boundaries are defined more by the placement of people and equipment and by the dynamic structuring of activity, than by explicit designations of ownership.

Through the application of previous work on multi-party interaction¹⁰, we have engaged in detailed, systematic analyses of just how members of the Operations room coordinate their separate and joint activities. Suchman (1996) examines the interactional constitution of shared workspaces. In the complex ways that members organize their respective workspaces both individually and in relation to the ongoing activity of the room, the Operations room as a single, shared workspace can be more adequately understood as a place for the successive divergence, convergence, and re-alignment of multiple, shifting lines of activity. This is the process we propose to call the *constitution of shared workspaces*. Talk, gaze, body position, gesture, space, furnishings, and equipment all can be viewed as resources in its accomplishment.

Acquiring competency

Our interest throughout the project was to analyze interactions within Operations not by recourse to a master plan or external order, but rather with reference to the activity's ordering from within, through the sensitivities of the participants to each other and to their joint situation. However, to say that social order is produced from within, through the local interactions of participants, is not to say that it is produced without any reference to previous activity. One way in which we can see the presence of a historically and culturally constituted community into which people come is in the process of learning the work (Lave & Wenger, 1991). We can take as an example a routine task within ground operations: that is, the work of establishing what are called an airplane's *weights and balances*. Weights and balances involve a

¹⁰ For example, the constructs *recipient design* (M. Goodwin, 1980; C. Goodwin, 1981; Schegloff, 1972) and *participation structures* (Goodwin & Goodwin, 1989) underwrite almost all of our analyses. (See also Atkinson & Heritage, 1984; Heath, 1986.)

relation between the plane's total complement of passengers, baggage, fuel, and other cargo and the settings required for the stability of the aircraft, e.g. the wing flaps. On many newer aircraft, the final weights and balance calculation is taken by the pilot directly from a computer in the cockpit. For older aircraft, however, the numbers are called up on a computer screen in the Operations room, then radioed out to the pilot in an exchange called a *radio close-out*, a routine part of the Flight Tracker's work.

Charles Goodwin (1991) analyzed a case involving an apprentice in the work of Flight Tracking doing her first radio close-out, supported by an experienced co-worker. In his analysis, Goodwin draws attention to the exquisite coordination of apprentice and teacher in the course of the call. Specifically, he shows how the more experienced co-worker momentarily "redesigns" the computer screen for the apprentice in response to her demonstrated difficulty in finding her way through, by directing her reading of it with his finger. Goodwin's analysis shows how, through their precise attunement to each others' place in the course of action and its possible problems, apprentice and teacher together achieve a successful reading.

Competent participation in the work of operations involves learning how to see one's environment in an informed way. Whether in situations of explicit instruction or embedded within interactions among co-workers identified as peers, members' ability to bring their differentiated expertise to bear on the situation at hand is tied to their access to each other's activities and interactions. In this sense, the overall effectiveness of the working group is tied to the relations between its members, and to the opportunities for teaching and learning that the common environments of their work provide.

Authoritative knowledge

Through a comparative analysis of an American obstetrics ward and the Operations room, Jordan (1992c) explores the relation between access to and control over technologies, and the forms of knowledge taken as authoritative: that is, as "grounds for legitimate inference and action" (p. 1) within a given situation. In contrast to the highly specialized and power-differentiated order of the hospital setting, she finds familiarity with relevant technologies to be distributed across participants in Operations, with a corresponding distribution of knowledge required to get the work done.

As an example, Jordan traces the work on a particular afternoon in Operations required to effect a switch of airplanes between gates, in order to enable mechanical repairs to one of the planes. This involves towing an airplane that has arrived at one gate to a different gate for departure, as well as a complex re-assignment of crew and transfer of passengers and baggage. Jordan points to the relatively "horizontal" distribution of knowledge with respect to the work required to accomplish this rearrangement, including the use of relevant technologies. She argues that this distribution of knowledge is both produced by and helps to explain the frequency of "out louds," or apparently undirected comments on the situation, and questions asked "of the room," over the maneuver's course (see also M. Goodwin, in press). That is, workers recognize more or less implicitly that information about events may be relevant to any one or more of their coworkers at any given time, just as one or more of their coworkers may have answers to a question, given their distributed access to available information resources and social networks. Jordan concludes by proposing

an agenda of comparative analysis of the distribution of authoritative knowledge across different settings, involving differently privileged or accessible technologies.

Designing for change

Our findings on relations of work and technology imply that, in order to design any one aspect of a working order, one needs to understand that aspect's relationship to the extended system of activities and technologies of which it is a part. At the same time, products of professional design will always be based in partial, specifically situated and historically constituted projections of the circumstances of an artifact's use. As a consequence, professional design needs to be understood not as an end point but as a starting place, or platform, for the ongoing processes of design-in-use that are both inevitable and necessary for an effective working environment.

The specific processes of change that we observed in the Operations rooms illustrate more general characteristics of workplace design. Rather than developing according to a single master plan, changes in facilities and work practices arise from participants' emerging and, to some extent, idiosyncratic appreciation for the problems and possibilities that a particular setting affords. First impressions of a facility change as one goes to work in it. Requirements are discovered through the contingencies of everyday use.

At the same time, a change in any one aspect of a working environment will usually have repercussions elsewhere. At the airport of our study, moving ground operations to a new location implied transformations in other sites, in technologies, and in the structuring of work activities. In the case of the airline's Operations room for short range, commuter flights, for example, the move to the new terminal involved

a shift from the management of arriving and departing airplanes within a large, open parking area to their maneuver through a relatively narrow roadway into and out of the gate area. The requirements on moving planes through this roadway led to a change in the schedule of flights for the entire airline, as it became necessary to reschedule in order to avoid simultaneous arrivals and departures for commuter flights at this particular airport. Brun Cottan et al (1991) provides further examples.

The interconnectedness of systems means that design of any one aspect of a particular worksite potentially implicates an open horizon of other aspects of that site, as well as that site's relations to a more extended network of settings and activities. However comprehensive and well-founded our analyses as researchers or designers, new understandings and new requirements will continue to emerge for those who actually do the work. It follows that they are the ones best qualified to carry forward and fine tune the design of the workplaces they inhabit. Design in use is always a process of improvisation, of making the best of what you have. The role of professional design is to lay the groundwork for that process, to provide the tools that support it, and to learn the lessons that are taught by it.

CONCLUSION

The analyses reported here draw on a rich set of materials that make evident the dynamic, moment-to-moment structuring of coordinated work activities in a complex, distributed, technology-intensive workplace. The accumulation of studies that locate regularities of everyday interaction within specific sites of work practice provide the materials from which richer tapestries of research and theorizing can be woven. Moreover, others engaged in the study of what I am calling here centers of

coordination have proposed generalizations that intersect with those that I have presented. There is every indication that comparative analysis across such sites would more than repay our efforts. For example, we might compare and contrast workers' relative expectations regarding the identity and circumstances of callers into the center in the cases of the Operations room and a 9-1-1 public safety center, and the consequences for the problem of turning calls into organizationally relevant objects (Whalen 1992, 1993; Whalen & Zimmerman, 1990; Suchman & Whalen, 1994).¹¹ An orientation to the problems of turning calls into organizationally relevant objects, correspondingly, might lead to different requirements on the design of communications and documenting technologies in the two settings. Similarly, common practices across all of these sites include overhearing, outloud comments and mutual monitoring, the recipient design of announcements, what Heath and Luff (1991) term *rendering tasks visible*, various ways of structuring one's own attention and directing the attention of others, and the intricate structuring of talk and other forms of activity. We might also compare the central artifacts of these sites, for example, forms of various kinds and the dynamics of their creation and use across paper and digital media. We might explore how workers in these sites employ available artifacts to maintain an accountable relation between normal orders as represented by schedules, protocols, and the like and the contingencies of actual events. Finally, we might compare processes of change in technologies and associated divisions of labor across these sites and their implications for those interested in professional design.

¹¹ Thanks to Randy Trigg for suggesting the interest of this particular line of comparison.

The listing offered here is meant only as a preliminary suggestion of what the fruitful lines of comparison might be; it is a listing that, I trust, could easily be elaborated by any readers familiar with the research. A wider reading of these studies in relation to each other could yield a reconciliation of topics that organize the cumulative findings. I hope, by enumerating the themes of one particular project, to contribute at least indirectly to that larger synthesis.

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