Proceedings of the Third European Conference on Computer-Supported Cooperative Work
13-17 September, 1993, Milan, Italy
G. De Michelis, C. Simone and K Schmidt (Editors)

Analyzing Cooperative Work in an Urban Traffic Control Room for the Design of a Coordination Support System.

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Abstract: A recent approach to computer technology aims the design of support systems as opposed to tools conceived as prostheses. However, most studies developping this new design paradigm consider the interaction between a stand-alone user and his technological environment. Focussing on an Urban Traffic Control Room, we explicate how work analysis should take into account the course of action of individuals and their interrelation. The design proposal sketched in this paper illustrates how a *coordination support system* should be capable of simultaneously supporting individual and cooperative work to meet the needs of complex and crisis-prone work situation.

Introduction

Recent advances in computerizing of work environments renew the methodological and theoretical issues traditionnally treated by ergonomics in French-speaking countries. The design of these situations must take into account the technical environment as a whole, i.e. not only the computer system but also other sources of information on the situation, communication devices, documentation, organization and training. Similarly, while ergonomic design was mainly concerned by the individuals up to now, the need to study work environments in all its complexity leads to studies taking into account cooperative work.

The investigation which we will be discussing here is part of a programme aimed at the design of computer systems in terms of *support systems for users.* Since Norman (1986) showed the need to develop a "user centered system design", many authors (Pinsky &Theureau, 1987; De Keyser 1988; Falzon 1989;

Haradji 1993) agree that the success of the introduction of an expert system depends on its capability to provide good advice rather than technological capacity to solve a problem.

Most computer systems are designed as "cognitive prostheses" (Woods & Roth, 1988; Visetti,), insofar as they are supposed to concentrate the intelligence of experts. The user is considered as the system's "servant": he supplies data which the computer system is unable to acquire in other ways and he is supposed to follow the system's instructions. However when the system fails, the user must manage on his own. Paradoxically, the user is assigned a passive role under ordinary circumstances, whereas he is suddenly called upon to play the role of a super-expert in troubleshooting circumstances, where he has to actively contribute to a diagnosis process. An alternative approach is to consider computer technology as support system helping the user increase his understanding of the situation while letting him manage by himself the problem solving process.

In order to actually support activity in complex process control settings, the developments of technology must take into account the preponderance of the cooperative aspects of work. This paper shows how the analysis of a particular cooperative setting, a Paris underground Control Room, orients the design of devices supporting both individual and collective activity.

Background of the study

This investigation is part of a wider research[1] which links public announcement to the analysis of traffic control in order to study the complete chain of traffic supervision, starting from the Control Room and ending up with the passenger.

It concerned the Control Room of the RER[2] A line which was, at the time of the study, undergoing important changes. On the one hand, computerization was progressing: it concerned the rolling stock follow up, new functions of signalling and automatic calculation of train delays at each station. On the other hand, the Control Room was moving to a larger room because of the line's extension towards Eurodisneyland, which was the occasion to modify it's general layout.

With 70 000 passengers per hour at peak hours, the RER A Line has one of the world's heaviest trafic density in urban rail transport. It's operating is relatively complicated because of two forks at both ends of the line and of it's connexion with the French railway company (SNCF) and the two different kind of rolling stock incompatible with each other it entails. Every train is identified by a name which indicates its itinerary (such as NAGA 12).

[1] M. Grosjean and I. Joseph studied other aspects of this work setting.

[2] The Reseau Express Regional is a high speed suburban branch of the Paris metro

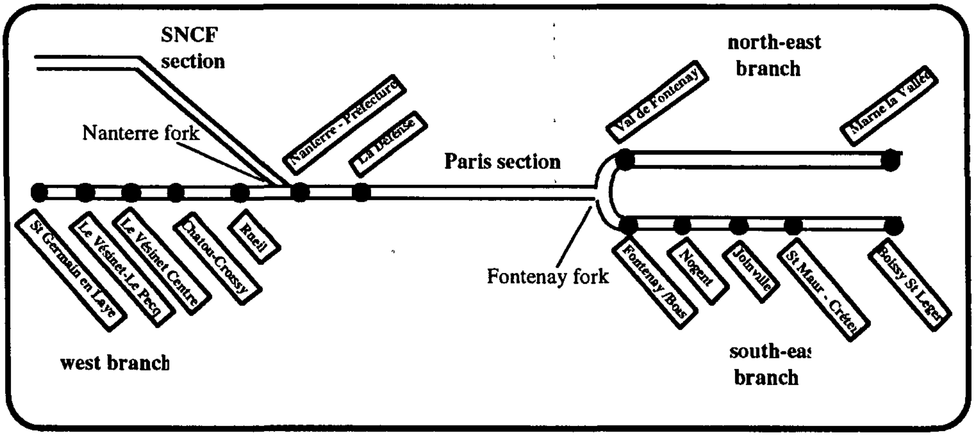

Figure 1: The RER A Line

Technical facilities available in the Control Room have been added gradually with traffic growth and were not designed as a coherent apparatus. This includes means of communication (telephone and radio), a *fix-line diagram* representing traffic movement in real-time, *computer consoles* showing the same kind of information but in greater detail, and working documents, including the *graph of train movements*, the duty roster for drivers, etc.

Controlling the RER's traffic is a collective activity which involves about a dozen operators in the room: a team of three Controllers in charge of the different geographic sectors of the line: West, South-east and North-east., each having two Signal Assistants under their responsability, an Information Assistant and, in the event of disruptions, the managerial staff of the line. (Figure 2) The *Controllers* are responsible for ensuring the smooth running of the trains in case of disruptions (small and moderate disruptions are usual during peak hours), implementing actions to control traffic by taking into account the supervision of drivers, following the rolling stock and handling their entry into the depots (maintenance and repair). The *Signal Assistants* establish the itineraries, check the times the trains passing through their sectors and inform the Controllers of any delays, they control the movement of the rolling stock by carrying out the instructions for the trains to be shunted in or out of the sheds and by keeping an accurate account of the shunting positions. They also check the time-tables posted in the stations and make amendments when necessary.

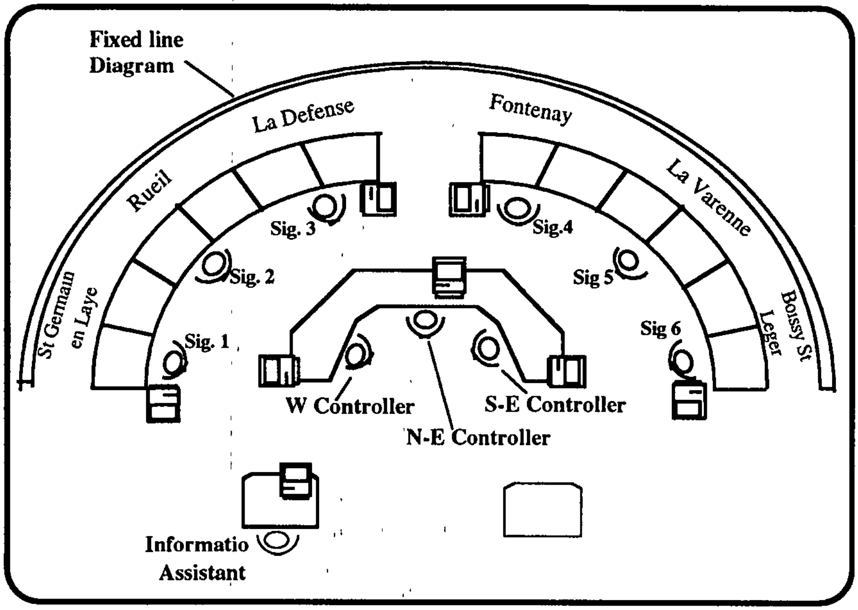

Figure 2: The RER A Line Control Room

We therefore have a work environment with teamwork considered as fundamental, which is immediately reflected by the importance, on the one hand, of the verbal communication between the various Control Room officials, and on the other hand, of the radio and telephone links with persons external to the Control Room, such as train drivers, station masters, depot managers and other operators.

Work analysis to understand activity

Wether one is concerned by its individual aspects or it's collaborative aspects, traffic control is an extremely complex activity. Giving a full account of the entire reality as such would be an utopian view and would turn out to be useless. What knowledge is required to design a good support system? The classic knowledge of "human factors" is useful but insufficient. It consists of generalities on persons divided into segments: cognition (itself divided into planning and problem solving, in turn sub-divided into diagnosis and solution, etc.), action, perception (itself divided into hearing, sight, etc.), reactions to separate elements of the environment (lighting, ventilation, etc.).

To obtain a full view of an actor taken as a whole, one must analyze his global activity in its own specific work situation. For instance, the identification of what should be assisted by computers requires a previous understanding of the activity of users in their non-computerized (or unsatisfactorily computerized assistance) work environnement as well as knowledge on the global activity of users in other similar situations with a more satisfactory computer support.

With the theoretical and methodological framework developped by Pinsky and Theureau (1987) it is possible to approach these global activities by studying the *course of action* of users i.e. to determine what in the activity of one or several actors belonging to a specific culture and engaged in a specific situation, is significant for the latter, i.e. that can be related or commented by him (or them) at any moment..

Activity in work situation is creative and is continously constructed anew: a person's action is not merely a response to the constraints of the environment. Likewise, no action is completely isolated from other actions, but is incuded in groups of actions or units which are organised in a way that is meaningful to the actor.

The study of the course of action produces two kinds of descriptions: the first one concerns the *intrinsic organization of activity,* i.e. the description of action and communication here and now representing an inside view of cognition; the second one shows how the work environnement (procedures, rules, etc..) and the actor's culture (training, past experiences) are *extrinsic constraints* to his activity. Analyzing an actor's behavior only the basis of the extrinsic description, in other words on the basis of what we, observers, see of the situation, we are liable to attribute improperly to an actor an organization of processes which does not belong to him, for instance in terms of deviation from what we, observers, consider as being required by the situation. As in fact demonstrated by various ergonomic studies (Montmollin, 1972), the identification of an actor's "abilities" outside his work activity is limited and leads to scientific errors with negative practical consequences. To show an "error" in reasonning is useless if we don't know the cognitif process of production of this error.

Studying the course of action helps consider essential issues for the design of computerizedwork settings but it is not sufficient for the understanding of cooperative work environments which requires complementary contributions of other theories.

Analyzing cooperative work

Distributed cognition and analysis of human interaction

There is a recent trend in micro-sociology and andthropology to study the collaborative aspects of working with computer environments. One approach consists in considering the group, rather than individuals, as the unit of analysis, that is to say, a functional cultural unit. Thus, to describe how the crew of a large ship "fixes" it's position, or how pilots xxxxan aircraft, Hutchins (1988) traces the movement of information through the joint cognitive system composed of the team and technical artefacts. The notion of "distributed cognition" he proposes offers a promising approach to study large groups, but it deliberately does not cope with the individuals participating to the collective activity.

Another approach is inspired by the detailed analysis of human interactions provided mainly by Goffman's (1974) work and by conversation analysis (Sacks

& all, 1974; Goodwin, 1981). The studies of Suchman (1991) and Goodwin & Goodwin (1991) describing commmunications in an airline operations room or Heath & Luff's study of coordination in London underground control rooms (1991) stress on the construction of context by the partners, the importance of verbal and body language in the coordination between individuals. These investigations, systematizing the use of video recordings as a methodological principle, explore the way participants show one another the meaning of what they are doing or saying. Yet, emphasizing the role of communication as if the whole of cognition was included in the communicative interaction itself may lead, in some cases, to neglect the fact that individuals interact during their global course of action in order to acheive specific objectives constrained by the work environnement. This may explain that most of these researches tend to focus only on relatively short periods of interaction (about 5 mn), leaving aside the global dynamics of longer and more complex incidents.

The interrelation of courses of action

The study we are presenting here, emphasizing a rather different conceptual point of view, is concerned, on the one hand, with the activity of each individual, and on the other hand, with the collaborative activity itself.

The analysis of individuals brings out the extent of cooperation in terms of a *social course of action:* the action of each person depends on the action of the others, it is linked to and can have a bearing upon that of the others. The analysis of the *interrelation of multiple courses of action* underscores the nature and the components of the coordinated collective activity. This deliberate choice of a simultaneous and integrated approach to the working group and to its indivdual members directly serves the practical ergonomic objective: designing the physical setting of workstations and technical devices to meet both individual and collective working needs.

Thus, as a first stage, we carried out a detailed analysis of the individual activity of the various staff members in the Control Room, mainly Controllers and Signalmen. The purpose was to clearly show the reasoning of each person concerning the activity of traffic control on their line, while seeking to understand what the action of the other means to a given operator. This first stage tackles the collaborative issue through the point of view of each individual.

In a second stage, we have considered collaborative work pratices as such, i.e. as several individual practices which take place simultaneously so as to see how they are linked to each other to constitute a coordinated collective activity whose characteristics were then defined. This second stage takes on collective activity as a whole on its own, i.e. which can not be considered as the mere addition of the individual activities making it up.

However, we are not postulating the primacy of individual on the group, even though we start with the analysis of individuals. But, following methodological considerations, to understand a complex collective work setting such as the metropolitan traffic control room, it is easier to study individual courses of action before dealing with their articulation.

Method of collecting and analyzing data

A specific method was developped to study the course of action to collect in natural situations, the data required for the description of the dynamic organisation of actions and communications, allowing a reconstruction of the operator's reasonning process. The data collected covered:

- *continuous observations* of the behaviour of action and communication in a work situation which consisted of recordings (by tape recorder and video camera), with a wealth of communications completed by notes on the events taken into account by the operator and the actions of the others when related to his course of action;
- different kinds of *instigated verbalizations* from the actors, in particular those arising in self-confrontation interviews: the operator is shown a video recording of his activity and he is asked to comment on very specific aspects of his behaviour. The purpose of such an exchange is not only to obtain a description of the operator's activity from his own point of view, thereby eliminating the risk of the observer making erroneous interpretations, but also to probe more deeply into the problems encountered by the actor..

Two stages of data collection

During the first stage, with a view to analyzing the courses of action of each individual, we made several observations, with a camera focussed on a Controller and a microphone in the middle of the team of Controllers.

Likewise, during the second stage, in order to perceive the synchronic linkage between individual activities, we collected systematic data on "subsets of cooperation":

- three Controllers belonging to the same team who are constantly coordinating their actions in order to control the line's total traffic (Figure 3, subset A),
- a traffic Controller and the Signal assistants of his geographical sector, who have tio work together concerning their part of the line. (Figure 3, subset B),

These observations were made with two video cameras and two tape recorders.

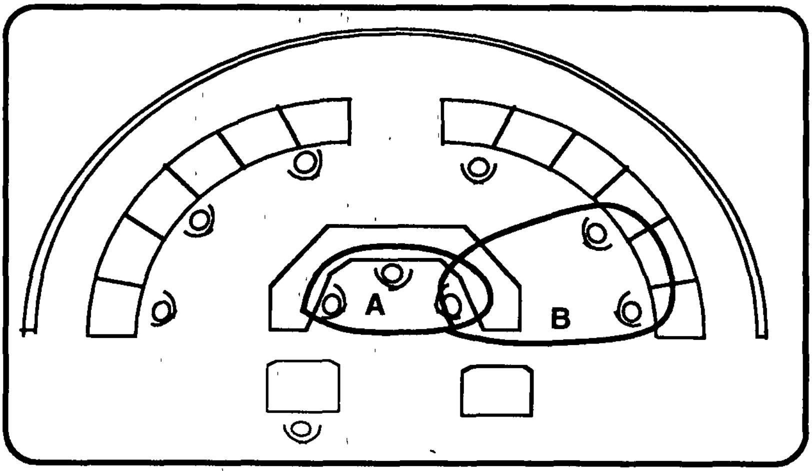

Figure 3: The subsets of cooperation defined for data collection on the articulation of courses of action

Specific methodological aspects

Video recordings

Because of our desire to understand the collective nature of the work, and the complexity of the situation, we had to face specific methodological problems. With respect to the use of the video, the time/space and organizational constraints of the work situation prevented the installation of several cameras which would have produced different kinds of images, such as images focused on the behaviour of the operator, precise images of the contents of the screens and the fix-line diagram, images of the other operators. We therefore chose to install a camera in a fixed position, placed in such a way that its field of vision was a little wider than the post of the person under observation, in order to have data on the interactions with his immediate neighbours while retaining a fairly clear picture of the person himself, as well as an idea of the technical apparatus at his disposal without having the exact content. The data collected with the camera were always completed by the tape recordings described above.

Self- confrontation verbalizations

It should be noted that if in one respect the fundamentally collective nature of work makes the gathering of data more difficult, it is also endowed with a methodological interest for the researcher: in fact, many actions and telephone communications are spontaneously related and justified by the operators for the others who need these for their own courses of action. However,this cannot take the place of self-confrontation vebalizations because these verbal communications only partly give access to the signification of actions and events for the actor:

In the case of the process of complex work, the self-confrontations based on transcriptions, either of an audio tape or a video film, were of definite relevance: the researcher, having himself assimilated the incident during the transcription, had time to spot the critical moments that merited closer questioning. Thus, self-confrontation does not serve principally to create an understanding of the work process for the researcher who is unfamiliar with the situation, this would be lengthy and could tire the operator. In addition, the written transcription gives temporal reference points to the operator during the self-confrontation sessions whereas watching the video tape does not always enable an accurate chronological reconstruction of the actions and events.

Data analysis

The analysis of data in *significant units* for the actor provides a particular description of the incidental situations observed. It is a matter of dividing the continuous development of the course of action into significant units by replying to the question: "What is this about, from the point of view of the controller?" By naming each of these units, an account is built up which gives meaning to the untreated data. This analysis clarifies the temporal organization of the actions and events and provides a few elements on their sequence. Thus, the insertion of significant units reflects work carried out in divided time during which several preoccupations are handled simultaneously by the officials.

Handling disruptions

The detailed analysis of data collected during the first stage gives prominence to the complex planning of their actions by the Controllers, required to handle disruptions in the Control Room's collective context. An important part of the Controller's activity while dealing with an incident consists in *defining the situation as the events occur* rather than finding immediately an adequate solution. Likewise, there is *not one best solution* nor a precise or complete procedure to follow in order to solve an incident, even though there are bits of procedures, most often expressed in the form of safety regulations. Consider the example of the NAGA 12's disrupted situation to understand the individual course of action of Controllers.

NAGA 12 a train running in the direction of Boissy St Leger, breaks down at the exit of Joinville's station stopping all trains eastbound. As soon as the S-E Controller, in charge of the Joinville sector, understands there is a beakdown concerning platform 1, he directs the next train, RUDY 12, onto platform A, letting it wait in the station. The solution viewed by S-E Controller is to ask NAGA 12 to back a hundred meters in order to free the station's exit point (see figure 4). This solution allows trains following behind to pass NAGA 12 by platform A. But its implementation is rather risky because the Controller cannot communicate directly with NAGA 12's driver, who is busy trying to repair his train and is therefore not in the front cabin: the S-E Controller has to pass on his message to RUDY 12's driver.

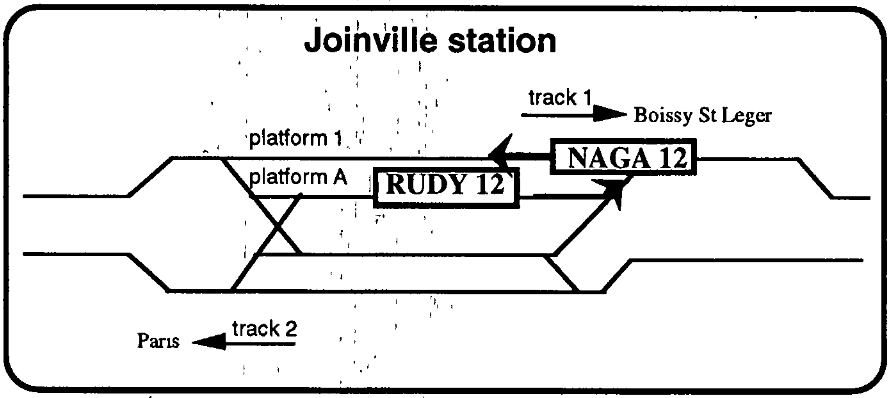

Figure 4: NAGA 12 blocking Joinville's station

Considering the uncertainty of a rapid outcome of this solution, the Controller launches another solution which is more costly to put up insofar as it implies to run trains on the opposite track. But, eventually, NAGA 12's driver succeds in reversing his train and the Controller is able to cancel the second solution.

Once the core of the problem (i.e. NAGA 12 blocking the Joinville station) is solved, the Controller has to deal with the other problems resulting from this disruption such as using RUDY 12 to ensure the rest of NAGA 12's journey up to Boissy St Leger, and also finding replacement trains and standby drivers for the return journey of these two trains.

The *implementation of a decision is gradual and shifted in time*, that is to say that the handling of the incident is dependent upon the time needed to manoeuvre the trains as well as the possibility of communicating with the drivers. In the meantime many other problems have cropped up and some have already been solved.

The relatively long time - about twenty minutes - needed to sort out the breakdown makes it very difficult to turn back once a decision is launched. Consequences of the decision must, therefore, be evaluated in advance. Furthermore, this type of relatively long process time leads to solve overlapping problems: other incidents are tied with that of the NAGA 12 breakdown and must be handled simultaneously.

The analysis of the handling of incidents also reflect the importance of colleagues for each Controller's activity. A *high number of persons involved in an incident* (drivers, station masters, Signalmen, other Controllers) are to be informed. This creates an additional difficulty for planning the actions of the Controller, for he must ensure that everyone has completely understood what it is about and what has to be done.

The coordination of Controllers activities during a disruption

Data on the interrelation of courses of action show *various forms of cooperation* emerging during disrupted situations.

Synchronical interrelating courses of action

While a Controller solves the core of an important incident, the other Controllers and Signal Assistants often carry out secondary jobs to help their colleague, such as holding back, in a station, the trains following behind a defective train to avoid jamming them under a tunnel; or informing station masters of a breakdown; or searching for a line manager to ask him to the train's driver.

They also participate in the background to the solving of an incident by giving advice to their colleague in charge of it and by showing him aspects of the problem he may have overlooked. In this sense, they play a role of guardians of the smooth handling of an incident. When the Controller's attention is focused on a specific problem, the intervention of others makes it possible to "de-focus" on the general context when this is necessary. Or else, when a breakdown occurs at peak hours, the urgent nature of the situation immediately generates an implicit sharing of the work: the Controller concerned by the core of the incident tries to solve it with the driver, while the other Controllers handle the upstream and downstream traffic.

However, when the general situation in the Control Room is too disturbed because of the accumulation of incidents, every body tends to focus on his own problem solving, and nobody can play the role of collective guard anymore. The result is often a lack of coordination in the passing on of information towards colleagues outside the Control Room.

Diachronical interrelating courses of action

Part of the Controllers' competence consists in their ability to actively listen and pay attention to the details of the solving of an incident by their collegues, to be able to anticipate delays and amendments which they will have on their own sector. The repercussion of the "NAGA 12's brekdown" for the W Controller ilustrates how his courses of action is diachronically linked to the S-E Controller's course of action.

About an hour after the stopping of NAGA 12 in Joinville station, i.e. quite a long time after this incident had been settled by the S-E Controler, a problerm appears concerning track 2 at the other end of the line: three ZHAN (return journey of the RUDY) and three XILO (return journey of the NAGA) are following each other without their usual spacing. The consequences are important for passengers because the XILOs stop in all stations up to Le Pecq whereas the ZHAN are semi-direct to St Germain en Laye. (See Figure 1)

The origin of this erroneous sequence of trains is an error of the Signal Assistant in charge of the Joinville sector who had updated the computer system cancelling RUDY 12's return journey. The many manipulations of trains made by the S-E Controller to make up lost time after NAGA 12's breakdown, and in particular the change of decision concerning ZHAN 23 (the return journey of RUDY 12) which had first been cancelled and eventually had been rescheduled, misled the Signal Assistant.

The W Controller is immediateley able to connect together the sequence of three ZHAN and three XILO with NAGA 12's breakdown which happened an hour earlier, for he had kept up with its management by the S-E Controller, in particular when the latter had found a replacement train for ZHAN 23, which consequently was running behind schedule.

The two logics of work sharing

The sharing of the handling of a disruption between Controllers follows two logics which may be contradictory in certain cases. The *first logic*, which corresponds to the prescribed allocation of roles, is *geographic*: each Controller manages the disruptions occuring in his own sector, even though, the sectors' borders are loose and giving a hand is a tacit rule. The *second logic* which follows the dynamics of train movement postulates that the person who starts handling a disruption is responsible for it during its entire course, because he knows all the surrounding circumstances and the consequences of his own decisions.

The co-existence of theses two logics is implicit to the coordination of the Controller's action, the choice of one or another depends of how each person is involved in the situation: a Controller may make way for his colleagues depending on their receptiveness at the moment and on the fact that they have participated in the background to the beginning of the incident's solving.

In the case of the repercussion of the NAGA 12's breakdown, the Signal Assistant who mixed up the trains is in charge of the junction, which is at the border of the N-E sector and the S-E sector. Following the geographical logic, both Controllers were liable to supervise what was happening at the junction. But, at that time, the N-E Controller happened to be dealing with another incident on the North-east branch and had not paid attention to the details of the arrangement made by his colleague in relation to NAGA 12's return journey. The S-E Controller was busy evacuating the defective NAGA 12 out of Joinville station and he didn't consider there could be a problem for the Signal Assistants to follow through the return journey of the trains.

From this evidence, it is clear that multi-disrupted situations, when Controllers and Signal Assistants are busy with several incidents at the same time, affect functionning of the group because neither of these two logics may be efficiently followed.

Directions for design

To be of real help to the activity of the Control Room staff , modernization of the traffic regulation apparatus must take into account the importance of the collective nature of the job. It is then essential to conceive the whole technical environment of the Control Room as *a support system for the coordination of actions,* even it has not been thought as such. In reality, all the tools used by the staff (the fix-line diagram representing the trains, the paper documents and computer terminal) indirectly support cooperation: each person regularly looks at the fix-line diagram, certain sheets of paper pass from one to person to another, etc.

In this paper, we briefly present one of the proposals for the design of tools supporting coordination we have put forward after the analysis of the interrelation of courses of action during traffic control work. It is a device, to enhance the present computer system, liable to support the individual handling of an incident, but also, the collaborative supervision of train movements.

We have first to consider the present means of handling an incident. Three main devices are of permanent use: the fix line diagram, the consoles' images and the graph of train movements are different maps representing the same territory, the RER A Line.

The graph of train movements is a reference document indicating the journeys of every train. Its graphic presentation makes it possible to follow a given train (where does he come from? what was his previous journey? where does he go? what will be his future journey?). It also allows a comparison between several trains.

Contrary to the fix-line diagram, or to the computer consoles, the graph of train movements, is not a representation of what is going on "here and now", but is the basis to which Controllers permanently refer, as a tool to evaluate the present situation. In this sense, it is a map of a "normal" situation, from which modifications are defined (for example: the amendment made on a train's itinerary). When perturbations occur, information given by the computer system is meaningfull only in reference to its discrepancies with the normal situation seen on the graph of train movements.

However, it is not easy to draw a correlation between these two information sources, because they are not related to the same level of information. From one side, the graphic is about the dynamics of the *theoretical* traffic, as a whole. It is a very rich tool, which adresses many aspects:

- *diachronical*: each train has it's past and future route;
- *synchronical:* at a given time, the location of all the trains is defined. What the Controllers are actually interested in is a combination of the *synchronical/diachronical* aspects: on a given portion of the line, there is a set of trains going in the same direction but having different itinerary. By comparing this set of trains, it is possible to replace a deffective train by another train with a similar journey.

- *chronological*: at a given location, one has all the trains passing from the beginning of the day.

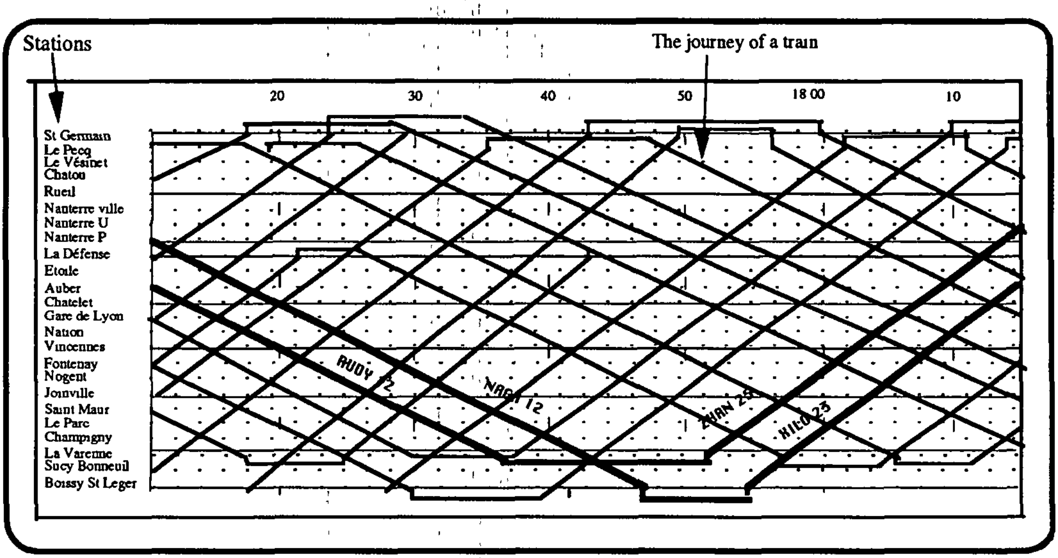

Figure 4: The synchronical/diachronical aspect of the graph of train movements

The computer consoles give in real time, a precise view of all trains at a given moment, in other words, the *synchronical aspect:* it operates like a succession of snapshots.

Our design proposal is optimizing the current computer system for the follow-up of train movements which should give *the historical background* of all the trains by providing equivalent information to those of the graph of train movements, but applied to the real running of trains. Hence, this dynamic tool would hold concurrently the synchronical/diachronical and the chronological aspect of train movements which is now lacking.

When the computer system is updated, this tool would also support the coordination of actions between the staff by rendering the amendments made on trains more visible than it currently is. For instance, a changed intinerary should be displayed one way or the other on the consoles so that any member of the staff knows immediately of modifications of the traffic even if he is unaware of the details of the handling of the incident.

The research reported here is an exploratory study: It primarily served to understand the global work practice of the RER Traffic Controllers, and it was not integrated in a specific design process even though some of its findings are being implemented to optimize the RER Control Room.

Other directions for design were concerned with the use of the fixed line diagram in connection with the problem of information sharing, communication devices, and additional functions for the computer system. These directions should be worked out for specific design projects with users and computer scientists.

Aknowledgements

The study on which this paper is based benefited from discussions with our research partners, Michèle Grosjean and Issac Joseph, and also with Christian Heath and Michèle Lacoste. We also thank the members of the "Ergonomics and Cognitive Antthropology" seminar for their comments.

References

De Keyser V. (1988): " De la compétence à la complexité: l'évolution des idées dans l'étude des processus continus. Quelques étapes clés." *Le Travail Humain*, 51, n° 1, pp. 1-18.

Falzon P. (1989): "Analyser l'activté pour l'assister."*Actes du Congrès de la Société d'Ergonomie de Langue Française*, Lyon, pp. 167-174.

Garfinkel H. (1967): *Studies in Ethnomethodology*, Englewood Cliffs, N.J. Prentice Hall.

Goffman E.(1974): *Forms of talk*, Blackwell, Oxford.

Goodwin C. (1981): *Conversational organization: interaction between speakers and hearers.* New York: Academic Press.

Goodwin C. & Goodwin M. (1991): "Formulating planes: seeing as a situated activity" in Y. Engestrom and D. Middleton (eds.): *Cognition and Communication at work*, Sage , in preparation.

Haradji Y. (1993): *De l'analyse de l'aide humaine à la conception d'une aide informatique à l'utilisation de logiciel*, Thèse de Doctorat d'Ergonomie, Conservatoire National des Arts et Métiers, Paris.

Heath C., Luff P. (1991): "Collaboration and activity and technical design; task coordination in London Underground Control Rooms," *Proceedings of the Second European Conference on Computer-Suported Cooperative Work*, September 24-27 . 1991, Amsterdam.

Hutchins E. L. (1988): "The Technology of Team Navigation", in J. Galagner, R.E. Kraut, and C. Egido (eds): *IntellectualkTeamwork: the Social and Technological Foundations of Cooperative Work* , 1991-221. Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Montmollin M. de (1972): *Les psychopitres*, PUF, Paris.

Norman D. A. (1986): "Cognitive Engineering" in D.A. Norman and S. W. Draper (eds): *User Centered Design System.* New perspectives o Human-Computer Interaction, London, pp. 31-62.

Pinsky L and Theureau J. (1987): *L'Etude du Cours d'Action. Analyse du travail et conception ergonomique.* Collection d'Ergonomie et de Physiologie du Travail n° 88, Conservatoire National des Arts et Métiers, Paris.

Sacks H, Schegloff E. & Jefferson G. (1974): "A simplest sytematics for the organization of turn-taking for conversation." *Language* 50: pp.696-735.

Suchman L. (1991): Constituting Shared Workspaces in Y. Engestrom and D. Middleton (eds). *Cognition and Communication at work,* Sage , in preparation.

Theureau J. (1992): *Le cours d'action: analyse sémio-logique,* collection Sciences de la Communication, Peter Lang, Berne.

Visetti Y-M. (1991): "Des systèmes experts aux systèmes à base de connaissances: à la recherche d'un nouveau scéma régulateur", *Intellectica,* 2, 12, pp. 221-279.

Woods D.D. and Roth E.M. (1988): "Cognitive systems engineering" in Helander M. (ed): *Handbook of Human - Computer Interaction,* Elsevier Science Publishers.