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Chapter 4

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

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4.1 INTRODUCTION

The investigations which we will be presenting here form part of a research programme whose objective is the design of computer systems in terms of support systems for users. This research programme was initiated eighteen years ago by an investigation aimed at designing a system for a data collecting and coding station (Pinsky 1979; Pinsky and Theureau, 1982). Since then, it has been developed in various work situations: offices, hospitals and other services, control of sequential and continuous industrial processes, air and urban traffic control, agriculture and fishery. Such a design involves: helping the user to understand the situation and take action himself, including the search for information; relieving the user as much as possible (within technical and economic limitations) of the details of data supply and action, in so far as these are unnecessary for an understanding of the situation. The computer system is thus considered as an element of the support system among others, like documentation, training, organisation, and other sources of information on the situation here and now.

This design approach is an alternative to the design in terms of cognitive prosthesis which emerged at the beginning of computerisation and is still dominant (see Woods and Roth, 1988 for its criticism). A computer system designed as a cognitive prosthesis is supposed to concentrate the intelligence of experts (hence the commercial name "expert systems" for the most sophisticated of these systems). Ideally, the role of the user is that of a cognitive invalid: to provide data for the system in so far as the latter is unable to acquire them in other ways (within technical and economic limitations); to understand the instructions of the system and to act accordingly, in so far as the latter cannot act alone (within technical and economic limitations). Such systems generally reveal they have not attained the desired ideal by also allocating another role to the user: to manage on his own when the system fails. Hence a contradiction which can entail a heavy price to pay, for both the actors and the quality and quantity of the production: on the one hand, if the user thus accepts to lose, under ordinary circumstances, his decision-making powers and the means to implement them, he plays the role of a cognitive invalid at the high risk to become one; on the other hand, he is called upon to play the role of a super-expert in certain isolated circumstances.

Designing support systems for users in specific situations is not an easy task. It requires a creative and future oriented synthesis of three kinds of analysis:

1) analysis of the global activity of specific users, having a specific culture, in the situations that are concerned, non-computerised or comprising an unsatisfactory computer assistance (for the definition of what must be assisted by computer);

2) analysis of the global activity of assistance supplied to the user by other more competent users in these situations (for the inspiration provided for the design of computer support through the knowledge of human assistance);
3) analysis of the global activity of users in other situations with a more satisfactory computer support (in order to define the computer support using the highest technical possibilities).

Therefore, this research programme has been essentially concerned by the theoretical notions and methods which are needed to make these three kinds of analysis in the current constraints of design processes, with sufficient accuracy and validity for the design of support systems (see Theureau, 1992; Theureau, et al., 1994). We will be concerned here by the first kind of analysis in presenting a recent study which highlights the relations between this research programme and others.

4.2 THE RER A LINE CONTROL ROOM

This investigation was part of a wider research programme[1] which linked the analysis of public announcements to the analysis of traffic control in order to guide the modernisation of the different technical and organisational components of 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. First, computerisation was progressing: it

1 M. Grosjean and I. Joseph, with a more ethnomethodological background, studied other aspects of this work setting. Different theoretical and methodological discussions took place with them and also with Heath and his colleagues, who have been developing a similar research in the London Underground (see Heath and Luff, 1991). Refer to Filippi (1994) for more details.

2 The RER (Réseau Express Regional) is a high speed suburban branch of the Paris metro.

concerned the rolling stock follow up, new functions of signalling and automatic calculation of train delays at each station. Second, the control room was moving to a larger room because of the extension of the line towards Euro-Disneyland, which was the occasion to modify its general layout. With 70,000 passengers per hour at rush hours, the RER A line has one of the highest traffic densities in suburban rail transportation in the world. Its operation is made fairly complex because of two forks at both ends of the line, of its connection with the French railway company (SNCF) and the use of two different kinds of rolling-stock incompatible with one another (see figure 4.1).

FIGURE 4.1

Figure 4.1: The RER A Line

Every train is identified by a name which indicates its route (such as ZHAN 07 or NAGA 12). Once the train movement has been completed upon arrival at the terminus, this name and the corresponding route and sequence change (for instance, RUDY 12 becomes ZHAN 23, the name of the return route of RUDY 12).

The equipment installed in the control room was not designed as an integral system. It has been extended on a piece-meal basis, in line with traffic growth. It consists of communication facilities (telephone and radio), a fixed-line diagram giving real-time information on traffic, computer terminals displaying the same sort of information, but with more details and on several computer images, along with various working documents (timing graph, empty coaching-stock (ECS) diagrams, train crew rosters, etc.). Traffic control is a collective exercise involving a dozen or so operating staff located in the control room, consisting of a team of three controllers, each responsible for one of three geographical sectors of the line (western sector, Paris sector, eastern sector) each assisted by two signalmen, and also an information assistant and, in the event of a major incident, the line manager (Figure 4.2).

FIGURE 4.2

Figure 4.2: The RER A Line Control Room

Signalmen identify the trains, check the times at which trains enter their sectors and notify the controllers of any delays. They supervise stock movements and issue instructions concerning ECS movements, all of which are logged. They also check the timetables displayed in the stations, which they alter when necessary. Controllers supervise these various functions, take decisions affecting traffic control with regard to supervision of drivers and keep an eye on stock workings, to ensure that units get back into the depot for maintenance and repairs. One of their main responsibilities is to return traffic to normal after an incident (fairly serious incidents are quite commonplace during rush-hours, but passengers are hardly ever aware that anything has happened). What we have here, therefore, is a work situation in which team-work is regarded as essential, something which is reflected in the importance both of verbal communication and body language between the various staff in the control room and of contact made over the telephone or the radio with people outside, such as drivers, station masters, depot managers, the emergency services etc.

4.3 THE RER A LINE CONTROL ROOM AS A COLLECTIVE ORGANISATION OF MULTIPLE COURSES OF ACTION

Let us consider the system constituted by the RER control room , its actors included. It is fairly complex: it involves many different components, which are linked in many different ways. Besides, many of these components cannot be observed directly. Most of the physiological processes can be observed only in the laboratory, and can be analysed only with very simple tasks and environments. But this complexity is not the main difficulty. It can be overcome by finding a level of the system which could be analysed in the natural situation. The main difficulty is that this system involves autonomous systems. The system formed by each actor and his environment (including the other actors) is autonomous. This autonomy is, according to the cognitive paradigm known as ‘constructivist’ or ‘enaction’ paradigm, initiated by Maturana and Varela in biology, a fundamental characteristic of human actors, and more generally of living systems. It is the capacity of such an actor or living system to exist as a unit and to make a relevant and significant, while not pre-defined in advance, world to emerge (Bourgine and Varela, 1992; Varela, 1980; Varela, et al., 1991). The important consequence of this autonomy is that, at a given moment, an actor interacts with a situation to which the emergence and relevance his internal structure has itself contributed. This internal structure is a product of his physiological and neuro-physiological constitution, of his personal history up to that moment and of his interactions with the immediately preceding situation. Therefore, neither spatial or temporal boundaries nor content of this situation can be determined a priori. They depend on the actor and on his personal history, and vary with his interactions with the immediately preceding situation. Evidently, in the case of the control room, a part of the personal histories of its actors is shared and constitutes a common history. Therefore also, these boundaries and content cannot be determined by an observer alone. This determination needs to be made from the point of view of the actor's internal structure. A correlated difficulty is that the system formed by each actor and his environment (including the other actors) is open. It changes from day-to-day, not only because of the interactions which occur inside itself, but also because of the interactions of the actor with other situations: other work situations, the characteristics of which can be very different from the former difficulty, and the situations of his different practices of leisure, household, etc. The control room, with its multiple actors, is a multiply open system.

Although requiring a detailed methodology, the simplest and most natural way to deal with the autonomy and openness of the system formed by each actor and his environment, includes the point of view of the actor's internal structure, is to reduce the study of the actor's activity to the study of what we call his (her) course of action: *the activity of one specific actor, actively involved in a specific situation, belonging to a specific culture, which is pre-reflexive, or, otherwise stated, which is significant for him (her), or can be shown, related and commented on by him (her) at any moment to an observer-interlocutor, under favourable conditions for observation and interlocution.*

The aim of the study of a course of action is to understand its intrinsic organisation and its extrinsic constraints and effects in the state of the actors, their situation and culture. The description of the intrinsic organisation of the course of action articulates two complementary descriptions: a description of its global dynamics, characterising the units of the course of action and the relations of sequencing and embedding between these units; a description of its local dynamics, characterising the underlying structure of the elementary units. These units include in various ways actions and communications, but also other elements: interpretations, feelings, changes in focus, perceptive, proprioceptive and mnemonic judgements, commitments of the actor to the situation and his use of past experience in the present course of action. All these elements, including the less public ones, belong to the actor's interactions with his situation. However we must take due note of the fact that this notion of interaction differs from the usual notion of interaction, which is defined from the point of view of an observer of the actor and of his (her) physical and social environment, as human-human, human-machine or human-environment interaction, and not from the point of view of the actor.

A given course of action is collective, yet from the standpoint of a particular actor. It is both social and individual, like the activity in Vygotsky's (1962; 1978) approach and Engeström (1987). To deal more thoroughly with this collective aspect, as was necessary in this RER control room study, we had to study the collective organisation of multiple courses of action: the synchronic and diachronic relations between the intrinsic organisations of the courses of action of the different actors of the control room, and their constraints and effects in the state of the actors, their situation and culture.

4.4 Data on the Courses of Action in the Control Room

As a first stage, we carried out an analysis of the courses of action of the various staff members in the control room: controllers, signal men, information assistants. The purpose of that stage was to clearly follow the course of action of each person concerning the traffic control, while seeking to understand what the actions of the other colleagues mean to this person. Doing so facilitated the cooperation of the actors to the study, by showing them that this study was aimed, not only at improving the performance – which is evidently collective – but also at supporting the activity of each individual. We could then consider collective action as such, as several individual courses of action which take place synchronically, so as to see how they are linked to each other to constitute a coordinated collective activity. It is this analysis of the collective organisation of multiple courses of action, which we realised as a second stage.

The choice of data to be collected was induced by this interest in the cooperation between officials in the course of their traffic control activity. But it was also induced by the possibilities offered by the work situation. It was by considering these possibilities that we decided to observe moderately disrupted situations, i.e. all the usual incidents that occur nearly every day at rush hours (inopportune use of emergency brakes, delayed trains, etc.), rather than to focus on major incidents. These major incidents are fortunately rare, and their study, with a few exceptions, can only been made a posteriori. Also, as they imply very heavy individual responsibilities which the persons involved must account for to their superiors, we took the engagement to stop the data collection in case of their occurrence in our presence. This choice therefore depended just as much on methodological criteria as on criteria linked to the social organisation of work.

The data collected covered: continuous observations of the behaviour of action and communication of diverse chief controllers and signal assistants in the control room which consisted of recordings (by tape recorder and video camera), completed by notes on the events taken into account by each actor and the actions of the others when related to his course of action; different kinds of instigated verbalisations from the actors, in particular those arising in self-confrontation interviews (the operator is shown a video recording of his behaviour and he is asked to comment on very specific aspects of this behaviour). The purpose of such a self-confrontation interview is not only to obtain a description of the actor's activity and situation from his own point of view, but also to probe more deeply into the problems encountered by the actor.

During the first stage, with a view to analysing the courses of action of each individual, we made several observations, with a camera focused 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 two kinds of 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; a traffic controller and the signal men of his geographical sector, who have to work together concerning their part of the line. These observations were made with two video cameras and two tape recorders. The duration of the observations was about three or four hours, corresponding to the rush hours and their preparation, that is to say, roughly from 6. 30 a.m. to 10. 00 a.m. and 3. 30 p.m. to 7. 00 p.m. The choice of these observation periods corresponds to the times during which the common incidents which we wished to study were likely to occur.

4.5 Analysis into Significant units of the Courses of Action in the Control Room

The theoretical framework, which we have coined as 'semio-logical', makes it possible to describe courses of action in general structural terms, expressing underlying regularities. It allows on the one hand, such a description of the global dynamics of the courses of action, and on the other hand, such a description of their local dynamics. It also links these two descriptions. Here, we will limit our analysis of the collective organisation of the courses of action to the analysis of its global dynamics. More precisely, we will deal with its local dynamics only in a narrative way using the framework given by the analysis of its global dynamics. Then, of this semio-logical framework, we will present only the two general hypotheses which were considered in this particular study, the ones which concern the global dynamics of the courses of action of the different actors and the relations between these global dynamics. The first hypothesis is that the units of courses of action are significant units for the actor (or actors) which are classified by more abstract structures, significant structures of different ranks; a significant unit, and also the significant structure which classifies it, expresses a coherence through time between the ranges of the possibilities open for the actor at every moment of the time span of this unit. Consistent with this first hypothesis, a given course of action is composed of a stratified set of significant units and this composition gives depth to the range of possibilities for the actor at every moment. The second hypothesis is that the actors in the control room share significant units, at certain ranks. In other words, they share parts of the ranges of the possibilities open for each one at every moment. This sharing is the key to their coordination.

The analysis of data in significant units for a controller (or signalman) provides a particular description of the incidental situations observed. It is a matter of dividing the continuous development of the course of action of this controller (or signalman) into significant units by replying to the question: 'What is this about, from the point of view of the controller (or signalman)?' By naming each of these units, an account is built up which gives meaning to the rough data. This analysis clarifies the temporal organisation of the actions and events and provides elements on their sequencing. Thus, the intricacy of significant units, that is the interruption of significant units by other significant units, reflects the fact that several preoccupations are handled simultaneously by the controller (or signalman).

The significant units at a given moment can be separate for the different actors of a subset of cooperation. But they can also overlap on all ranks or on certain of these ranks. Along with the second hypothesis above, such overlappings witness that these actors share parts of their ranges of possibilities. This sharing is more or less developed depending of the ranks where the overlappings take place.

After showing, through an example incident, the characteristics of the synchronic collective organisation of the courses of actions in the subsets of cooperation, we will make more precise, through the example of another incident, the diachronic collective organisation of the courses actions and its relations with the synchronic one. We will finally present the directions for the design of a support system for coordination which this analysis allows us to formulate.

4.6 SIGNIFICANT UNITS AND THE SYNCHRONIC COLLECTIVE ORGANISATION OF THE COURSES OF ACTION IN THE CONTROL ROOM

Let us, for example, present the following extract from the handling of an incident, which has been observed during the second stage of the study (Figure 4.3)[3]. This incident and its handling can be described using also the rest of the transcript and the self-confrontation interviews.

FIGURE 4.3

Figure 4.3: an extract of the transcription of data about the courses of action of CR W and CR E during the handling of the breakdown of NAGA 12 in Joinville

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 east controller, in charge of the Joinville sector, understands there is a breakdown concerning platform 1, he directs the next train, RUDY 12, onto platform A, letting it wait in the station. The solution viewed by the controller is to ask NAGA 12 to go back a hundred meters in order to free the station exit point (see Figure 4.4).

3 In this figure, CR W, CR E and CR P are the three chief controllers, respectively in charge of the West sector, of the East sector and of the Paris sector of the line. Sig is a signal assistant. Man is the manager of the control room.

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FIGURE 4.4

Figure 4.4: NAGA 12 blocking Joinville station

This solution allows trains following behind to pass NAGA 12 by platform A. It stems from a very precise knowledge of the configuration of the platforms and tracks at Joinville, and also of the possibilities of movement often left to the train in case of such a breakdown. But it may fail and its implementation is rather difficult because the controller cannot communicate directly with the NAGA 12 driver, who is busy trying to repair his train and is therefore not in the front cabin: the controller has to pass on his message to the RUDY 12 driver, who is stopped along the other platform.

Considering the uncertainty of a rapid outcome of this solution, the controller launches another solution which is more costly insofar as it requires trains to run on the opposite track. But, eventually, NAGA 12 driver succeeds 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 processing time leads to overlapping problems to be solved: other incidents are tied with that of the NAGA 12 breakdown and must be handled simultaneously.

The analysis of the handling of incident also reflects the importance of colleagues for each controller's activity. A high number of persons involved in an incident (drivers, station masters, signal assistants, other controllers) have 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 way we have presented the extract of the transcript in figure 4.3 already shows in its centre part of the collective synchronic organisation of the courses of action in the subset of cooperation formed by the west (CR W) and east (CR E) controllers. The left part of the figure concerns CR W and the right part his east colleague (CR E). A central column is created when they are involved in the same, usually collective, communications. The analysis of this extract of the transcript makes this collective synchronic organisation of the courses of action more precise (Figure 4.5).

FIGURE 4.5

Figure 4.5: analysis in significant units of the extract of the transcript presented in figure 4.4

The significant units resulting from this analysis belong to three ranks, namely Story, Theme and Sequence. The analysis shows that the shared sequences, though named identically at the lower rank, are named differently on the higher ranks. For example, the sequence 1 of CR W and the sequence 2 of CR E correspond to a discussion with CR P: CR E informs the two other controllers about his intention to ask the driver of NAGA 12 to drive back a hundred meters, in order to free the end point of the station this train blocks, and they collectively evaluate the idea. For CR E, this discussion makes him immediately prepare his action, which will consist in beginning to undertake this first solution by asking the driver to try to drive back.

This analysis into significant units for the different subsets of cooperation constitutes a frame for different findings concerning the collective organisation of courses of action. Various forms of cooperation emerge during such disrupted situations. Relative to a story like the breakdown of NAGA 12, the different significant units for a given actor can be classified into four categories: he is responsible; he is co-responsible; he follows up in the background; or he is busy with other stories and ignores it. While a controller solves the core of an important incident, the other controllers and signalmen 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 go into the field. 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 rush 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, whilst the other controllers handle the upstream and downstream traffic. Finally, they anticipate the repercussions of the incident and of the actions performed to handle it in their own sector, as can be shown by an extract from the transcript and self confrontation interview presented in Figure 4.6.

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FIGURE 4.6

Figure 4.6**: an extract from the transcript and self-confrontation interview**

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

4.7 SIGNIFICANT UNITS AND THE DIACHRONIC COLLECTIVE ORGANISATION OF THE COURSES OF ACTION IN THE CONTROL ROOM

To characterise also the diachronic collective organisation and its relation to the synchronic one, we will take another example, an incident which proved to be a repercussion of the breakdown of NAGA 12 in Joinville, which has been submitted to the same kind of analysis into significant units. 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 east controller, a problem appears concerning track 2 at the other end of the line: one of his signalmen reports to the west controller that three ZHANs (return journey of the RUDYs) and three XILOs (return journey of the NAGAs) 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 ZHANs are semi-fast to St Germain en Laye. From the self-confrontation interviews of the controllers, it appears that the origin of this erroneous sequence of trains is an error of the signalman in charge of the Fontenay fork (see figure 4.1). The many manipulations of trains made by the east controller to make up for lost time after the breakdown of NAGA 12, 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 reintroduced, confused this signalman.

The west controller is immediately able to connect together this sequence of three ZHAN and three XILO with the breakdown of NAGA 12 which happened an hour earlier (Figure 4.7). It is a consequence of the synchronic articulation of his course of action with the course of action of the east controller. In particular, he had kept up with its management by the east controller, in particular when the latter had found a replacement train for ZHAN 23, which consequently was running behind schedule. Thus, the synchronic organisation of the courses of action during the core of the handling of the breakdown of NAGA 12 and its repercussions contributes to the diagnosis of the incidents which follow.

FIGURE 4.7

Figure 4.7: an extract from the continuation of the transcript

But, this synchronic organisation has not enabled the controllers and the signal men to manage all the repercussions. Apart the numerous manipulations of trains already considered, there are three more reasons for that: first, there is a co-existence of two logics in the sharing of the handling of an incident, which, in certain cases, can be contradictory; second, the handling of the breakdown of NAGA 12 and of its repercussions has taken place in a multi-disrupted situation; third, the shared feeling of success after the good conclusion of the breakdown of NAGA 12 in Joinville. Let's consider the two first reasons more thoroughly.

The first logic, which corresponds to the prescribed allocation of roles, is *geographic*: each controller manages the disruptions occurring 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, can be called *historic*: it postulates tacitly 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 breakdown of NAGA 12, the signal assistant who mixed up the trains is in charge of the Fontenay fork, which is at the border of the east and Paris sectors. Following the geographical logic, both controllers were liable to supervise what was happening at the junction. But, at that time, the Paris controller happened to be dealing with another incident on his sector and had not paid attention to the details of the arrangement made by his colleague in relation to NAGA 12 return journey. The east controller was busy evacuating the defective NAGA 12 out of Joinville station and he did not consider there could be a problem for the signalmen to follow up the return route of the trains.

In fact, the handling of the breakdown of NAGA 12 has taken place in a multi-disrupted situation. Three important incidents have kept the officials busy: the breakdown of NAGA 12, handled principally by CR E but which has been followed more or less by everybody; the breakdown of OLAF 12 which has been handled by the cooperation between CR W and CR P, and also the ZHAN 27 stuck in Auber station, handled principally by CR P. To these important incidents, we must add many small or medium-scale incidents, such as an alarm concerning the electric power supply of the tracks, the non-display of the ZHANs in Rueil station, the presence of passengers on the tracks in the direction of Joinville station, and the bad succession of ZHAN and XILO we have already described. 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 functioning of the group because neither of the two logics can be efficiently followed.

4.8 THE DEFINITION OF A COORDINATION SUPPORT SYSTEM

Such an analysis of the courses of actions of the different officials and of their collective organisation orients the reflection concerning the modernisation of the traffic regulation apparatus toward the design of a coordination support system (see Winograd and Flores, 1986). The proposals for the design of tools supporting coordination we put forward after this analysis were along three complementary directions: developing the current computer support; improving the fixed-line diagram and the spatial design of the control room; and improving the tools for communication. We will briefly present these directions and stress one of the proposals along the first direction, which stems directly from the examples we presented above, whilst the others stem also from the analysis of other disrupted situations.

4.8.1 Three Directions for Design

The first direction is developing the current computer support. Different proposals have been made, with a decreasing order of importance. One of the proposals along this first direction concerns the synchronical/diachronical and chronological aspects of the traffic which we will present further in more detail. A second proposal concerns the display of the reordering of the trains. At present, when an agent updates the computer, his actions are not visible enough for the other agents. A simple solution would be to display the number of a reordered train with a different colour, so that an agent who has not followed the actions during the handling of an incident is immediately informed about the resultant modifications. A third proposal concerns computer support to the supervision of drivers. One of the imperative criteria when handling an incident is to respect the schedule of the drivers. To enforce this criterion when the mission of a train is changed, the controllers aim at restoring, as rapidly as possible, the tie between drivers and missions. They use standby drivers and replace the drivers as soon as they reach the station where their mission begins. Therefore, the controllers must know which drivers are tied to which trains. At present, they write down the drivers' numbers on the timing graph, but it is difficult to find on this graph the different missions of a given driver, because the relationship between drivers and trains is unstable. Hence, when there is a change concerning this relationship, the controllers are obliged to consult the train-crew roster. In order to harmonise the multiple sources of information used when handling an incident, we proposed to make the drivers appear on the computer display, in two different modes: for each train, the train-crew which is really assigned; and for each train-crew, the succession of its trains. The final proposal is for computer support to estimate the number of passengers. When handling an incident, the controllers try to transport the maximum of passengers, at the risk of penalising the passengers, less important in number, who are at the end of the line, or who go in the opposite direction to the main flow. But they work blindly. An apparatus detecting the approximate number of passengers in certain key stations would allow them to refine their decisions.

The second direction is improving the fixed-line diagram and the spatial design of the control room. The analysis of the collective organisation of the courses of action in the control room shows that there is a necessity for mutual visibility, mutual listening and for a common referent. The proposals along this direction concern the interior design of the control room and also improving the fixed-line diagram. Against the present international tendency to exclude fixed-line diagrams and to rely on computer terminals, the fixed-line diagram must be kept and improved. All agents can see at a glance the state of traffic, which is scattered in the different images displayed on computer terminals. When positioning their body in the direction they are looking at, they make visible for every body the focus of their attention.

The third complementary direction is improving the communicative tools. Many proposals stem from the analysis. The first is to improve the quality of the present system, which is responsible for many communication failures, some of which have dramatic consequences. To facilitate the communication by the radio-telephone and prevent confusion, the agents need also an automatic display of the name of the train the driver of which is calling. To facilitate the multiple communications which occur between the driver, the station master of the station where the driver is assigned and the controller, a multi-communication device would be useful.

4.8.2 Computer Support Concerning the Synchronical / Diachronical and Chronological Aspects

The proposal we present in more detail is a device that enhances the present computer system. It is aimed at supporting the individual handling of an incident, and also the cooperative supervision of train movements.

FIGURE 4.8

Figure 4.8: A page from the timing graph

We have first to consider more precisely the present means of handling an incident. The three main devices of permanent use, the fixed-line diagram, the computer images and the timing graph, are different maps representing the same territory, the RER A Line. The timing graph is a reference document indicating the routes and sequences of the trains (figure 4.8). Its graphic presentation makes it possible to follow a given train (where does it come from? what was its previous route? where does it go? what will be its future route?). It also allows a comparison between several trains. Compared to the fixed-line diagram, or to the computer images, the timing graph is not a representation of what is going on here and now. It is the basis on which controllers continually refer, as a tool to evaluate the present situation. In this sense, it is a map of the 'normal' situation, from which amendments can be made on the route and sequence of a train. When perturbations occur, information given by the computer system is meaningful only with reference to any discrepancies with the normal situation seen on the timing graph. However, it is not easy to draw a correlation between these two information sources, because they do not relate to the same level of information. On one hand, the graphic is about the dynamics of the normal traffic, as a whole. It is a very rich tool, which shows several aspects of the traffic. The first is the diachronical aspect: each train has its past and future route. The second is the synchronical aspect: 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 and diachronical aspects: on a given portion of the line, there is a set of trains going in the same direction but having different routes. By considering this set of trains, it is possible to replace a defective train by another train with a similar route. The last aspect is the chronological aspect: at a given location, one has all the trains passing from the beginning of the day. On the other hand, the computer images give in real time, a precise view of all trains at a given moment, or in other words, of only one aspect, the synchronical one, through a succession of snapshots.

This design proposal is optimising 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 timing graph, 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 they currently are. For instance, a changed route should be displayed one way or the other on the terminals so that any member of the staff knows immediately of modifications of the traffic even if he or she is unaware of the details of the handling of the incident.

4.9 DISCUSSION

The empirical and practical results presented in the sections above give an idea of the fecundity of the constructivist or enaction paradigm and of its methodological consequences in the terms of the course-of-action approach. This course-of-action approach is part of the French-language ergonomics tradition which, contrary to other ‘human factors’ and ‘ergonomics’ traditions, has – since Ombredane and Faverge (1955) at least – considered that ergonomics development and design absolutely requires analysis of the activity of operators in real work settings. It is also part of a larger international research trend which includes the interactionist approach of work situations and the socially-distributed-cognition approach.

For example, along the interactionist approach, the studies of Suchman (1996a) and Goodwin and Goodwin (1996) describing communications in an airline operations room, or Heath and Luff's (1991) study of coordination in London Underground control rooms stress the construction of context by the partners, the importance of verbal and body language in the coordination between individuals. These investigations, systematising 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, emphasising 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 achieve specific objectives constrained by the work environment. This may explain that most of these investigations tend to focus only on relatively short periods of interaction (about 5 min), leaving aside the global dynamics of longer and more complex incidents.

The socially-distributed-cognition approach consists in considering the group, rather than individuals, as the unit of analysis, that is to say, as a functional cultural unit. Thus, to describe how the crew of a large ship fixes its position, or how pilots manage the take off of an aircraft, Hutchins (1995) 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 individuals participating in the collective activity.

If course-of-action analysis can be characterised as the implementation of what can be called a 'situated methodological individualism', then these last two approaches can be characterised as implementing a 'situated methodological sociologism or collectivism'. By going through the analysis of the courses of action before addressing that of the collective activity, one takes account of certain phenomena that are difficult to appreciate by means of these two approaches. In summary, by considering the pre-reflexive aspect of the actor's activity, that is the actor's course of action: (1) one specifies the links that public communication and action have with private emotions and interpretations; (2) one looks for more than simply the current definitions of 'tacit', 'implicit', or 'non-propositional' to characterise the competence of the actors; (3) one can thus be more certain of the relevance to the actor's internal structure of the description given of his activity and of his situation; (4) one can express recommendations concerning both the individual situations and the collective situation. In the example of metro traffic control, to understand what is happening it is especially important to know how the activity and the competencies of each of the actors (Signalman Sig, Controller CR W, Controller CR E, and the signalman of the Fontenay fork) are constructed. In addition, the work situation of each of them has specific features that must be taken into account in the design recommendations.

However, the constructivist or enaction paradigm does not exclude the possibility of studying collective activity directly – i.e. without going through study of individual activity. If agents are autonomous, collectivities or even cultures can be autonomous. A study of the collective construction of the activity can give rise to theoretical objects and data collecting and analysing methods which are more parsimonious than the ones of the study of courses of action. These theoretical objects and data collecting and analysing methods sacrifice phenomena of the individual construction of the activity – or at least some of them – to acquire easier access to its collective construction. Let us add here that the study of the collective organisation of multiple courses of action developed in the study presented above is based on an interpretation, obviously in connection with the constructivist and enaction paradigm, both on what was learnt in previous research on courses of action and on research carried out in accordance with these two other sorts of approaches.

Were we to leave things there, the interactionist studies and studies of socially-distributed-cognition would simply appear to be more parsimonious and therefore faster approaches that are more limited than studies of the collective organisation of multiple courses of action, but which are sufficient in certain cases and for certain aspects of the activities. But they are much more than that. In fact, as Heath and Luff (1991) point out, these interactionist studies and studies of socially-distributed-cognition also consider relatively subtle phenomena of spoken and body-language interactions which are not appreciated by the study of the collective organisation of the courses of action, due to the limits of the pre-reflexive phenomena appreciated through self-confrontation interviews. If the description and explanation of these pre-reflexive phenomena allow us to produce and validate theoretical notions which go beyond them, they are nevertheless limited by them. Evidently, these limits can be overcome using notions produced through the other approaches.

In all, we feel that in the current scientific context of abandonment of the 'computer image of mind' (or paradigm of 'man as an information-processing system'), with his methodological individualism, in favour of a concept of cognition as embodied, situated, cultivated, and implacably individual and collective, the course-of-action analysis, the interactionistic approach, and the approach of socially-distributed-cognition, in conjunction with other resembling approaches which it is not our purpose to list here, are currently building the various facets of what could be called cognitive anthropology or empirical praxeology and the methodology for the corresponding technical and organisational design. This methodology could be coined ‘activity-centred-system-design’, as it makes more precise and operationalises the user-centred-system-design proposed by Norman and Draper (1986).