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User Interface in the Control Room of the Copenhagen S-Lane:

Evaluation and Analysis

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Abstract

This thesis focuses on the contribution of the current user interface in the management the train traffic system on the Copenhagen S-Lane. The contribution is designed in a form of evaluation, looking at three aspects of the user interface. At first, it evaluates the different characteristics and configurations of the user interface in terms of usability. Secondly, It is also looking at the different means offered by the user interface to enhance collaboration and communication in the control room. The final aspect is the ability of the user interface to respond to critical situations on the S-Lane. The theoretical approach is built upon usability, *ANT* and *CoP*, including principles for risk management in relation to the management of critical situations. The evaluation led to the conclusion that the user interface contributes in the management of the train traffic through the detailed information it displays on the screen about the position and situations of trains, the situation on tracks and at the different stations. The information is collected and distributed consistently during the use of the interface. Such information helps performing tasks related to the management of the train traffic. The user interface contributes also by providing tools to perform actions efficiently, through the variety of interactive commands, and effectively, through the impact it has on the traffic system. The user interface also offers a margin of flexibility in the control and organization on the S-Lane traffic system.

Resumé

Denne afhandling fokuserer på det bidrag, som den nuværende brugergrænseflade bringer i forvaltningen af togtrafikken systemet på Københavns S-tog linjer. Afhandlingens beskrivelse af bidraget er designet som en form for evaluering, hvor der ses på tre aspekter af brugergrænsefladen. For det første, evalueres til de forskellige karakteristika og konfigurationer af brugergrænsefladen med hensyn til brugervenlighed. For det andet, kigger afhandlingen på de forskellige midler, der tilbydes af brugergrænsefladen til at styrke samarbejde og kommunikation i kontrolrummet. Det sidste aspekt der undersøges er brugergrænsefladens muligheden for at stille funktioner til rådighed som kan blive brugt til at reagere på kritiske situationer. Den teoretiske tilgang er baseret på brugervenlighed, *ANT* og *CoP*, herunder principper for risikostyring i forbindelse med håndtering af kritiske situationer. Evalueringen førte til den konklusion, at brugergrænsefladen medvirker i forvaltningen af S-togs trafikken gennem de detaljerede oplysninger, der vises på skærmen. De detaljerede oplysninger er specifikke oplysninger om tog, om spor, stationer. Oplysningerne er indsamlet og distribueret konsekvent ved brugen af grænsefladen. Disse oplysninger hjælper med at udføre opgaver i forbindelse med forvaltningen af togtrafikken. Brugergrænsefladen bidrager ved at tilbyde værktøjer til at udføre handlinger effektivt, ved en række interaktive redskaber og ved at påvirke tog, spor og stationer. Brugergrænsefladen bidrager også til en fleksibel anvendelse i forbindelse med kontrol og organisation af S-togenes traffiksystemet.

Résumé en Francais

Cette thèse porte sur la contribution que l'interface de travail, en cours d'utilisation dans la salle de contrôle du réseau de trains S à Copenhague, apporte à le contrôle et la gestion de ces trains. Cet rapport presente cette contribution sous la forme d'évaluation, en examinant trois aspects de l'interface utilisateur. Dans un premier temps, l'évaluation porte sur les caractéristiques et les différentes configurations de l'interface utilisateur en termes d'utilisabilité. Deuxièmement, la thèse se penche sur les différentes ressources offertes par l'interface utilisateur dans le but de renforcer la coopération et la communication dans la salle de contrôle. Le dernier aspect pris en considéreration est la possibilité de l'interface utilisateur de fournir des fonctions qui peuvent être utilisés pour répondre à des situations critiques. L'approche théorique est basée sur l'utilisabilité, textit (ANT) et textit (CdP), y compris les principes de gestion des risques dans les situations critiques. L'évaluation a conduit à la conclusion que l'interface utilisateur contribue à la gestion de la circulation dans le réseaux des trains S à travers les informations détaillées affichées sur l'écran. Les informations détaillées sont des informations spécifiques sur les trains, sur les rails ainsi que les gares. L'information collectée et distribuée est compatible avec l'utilisation de l'interface. Cette information aide à effectuer les tâches associées à la gestion des mouvements des trains. L'interface utilisateur contribue aussi en fournissant des outils pour effectuer des actions de façon efficace en présentant un certain nombre d'outils interactifs qui sont utilisés affecter le traffic des trains sur le réseaux ferroviaire et dans les gares. L'interface utilisateur offre aussi une marge de flexibilité dans le contrôle et l'organisation du traffc des trains S.

Contents

List of Acronyms

The following acronyms are the list of commands being used in the report:

AFBRYD: stands for cancel, in English.
AFSLUT: stands for terminate, in English.
AG: stands for Automatisk Gennemkørsel, mode of operation of the interlocking.
AS: Automatisk Stationsdrift, operating mode of the remote control system.
ASMRK: is used to set an automatic route of a train from a signal starting point.
ATS: stands for *Automatisk Trafikafviklings System*, used for automatic routing.
Ch: stands for Charlottelund.
GEO: is used to display a geographical overview of the train network system.
Kl: stands for Klamperborg.
KPL: stands for *Køreplan*, in Danish, or roadmap, in English.
KSTRM: stands for *Kørestrøm*, in Danish, or driving force, in English.
LA: stands for *Lokalaflås*, in Danish, or .
OPM: stands for *Opmærksomhedsmarkering*, in Danish, is used to mark a reminder on a signal with special conditions.
SIA: stands for *SIkringsnAlægsdialog*, in Danish, or interlocking dialogue, in English.
Slet: stands for delete, in English.
SNR: stands for *Sporskifternes numre*, or track change number, in English.
SP: stands for *Sporspærring*, in Danish, or track blocking, in English.
UDFØR: stands for execute, in English.

List of Figures

All the figures used in this report have been provided by BaneDanmark.

Chapter 1

Introduction

1.1 Sketching the field

BaneDanmark (BDK) is a Danish company in charge of the management of the train traffic on the railways system in Denmark. The management of the train traffic is done from a control room, where operations are performed in a system of transactions. Transactions are exchanges or interactions by means of collaboration and communication following the model Controllers - System infrastructures - Train traffic. In fact, controllers send signaling messages through the system infrastructures, in order to regulate the traffic. On the other hand, the train traffic situation is represented via the system infrastructures on a control panel for the judgement of controllers.

In 2006, BDK underwent some renovations of their system infrastructures on the S-Lane traffic system in the Copenhagen area, shifting from a *two-buttons*[1] control to a computer-based control following the current development of Information Technology (IT). The renovation involved mainly the change of signaling systems and traffic rules for train drivers. The focus on this report is on the user interface, as part of the human-computer interaction, being adapted in the renovation. In fact, the user interface at the front-end development serves as a controlling tool for traffic controllers and as an element for reporting traffic situations following the new traffic rules and paradigms.

The purpose of this thesis is to evaluate the user interface of the traffic management system used in the control room for the S-Lane in the area of Copenhagen. The evaluation will be documented as an analysis report of such user interface in relation to the computer-based infrastructures (or IT infrastructures) built and its daily use for managing the train traffic system. The perspective is the improvement of the user interface designed in relation to the technology used in control rooms that will count to BDK's next project, on the renovation of the entire Danish railways system.

[1]The *two-buttons* control was a manual control system of the traffic implemented in 1972. The first button was representing the track to control and the second button was referring to the action to be undertaken.

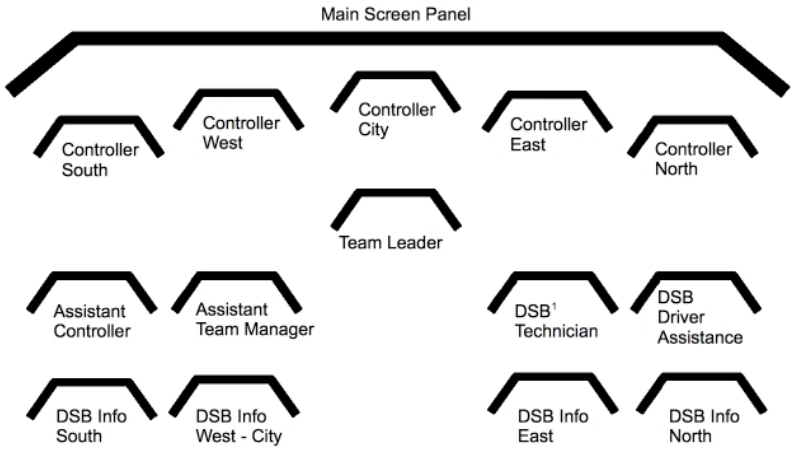


Figure 1.1: S-Lane Control Room Configuration.

1.2 Theoretical Approach

The evaluation in this report is a collection of data from empirical investigations with their analysis and interpretation within different aspects of the management of the traffic system in a control room centre. It will provide an overview quality of the effectiveness, the efficiency and the flexibility of the user interface in relation to the tasks being performed. The evaluation will be performed following three major scopes of evaluations:

- Evaluation of the usability of the user interface
- Evaluation of the collaboration and communication in a control room using the current user interface
- Evaluation of the management of the critical situations in terms of user interface configurations and functions.

The evaluation of the usability can be defined as an evaluation of the ability of the user interface to fulfil the user's requests following the functions displayed and their settings. The term usability here is used following Jacob Nielsen and Ben Shneiderman approaches. In fact, Nielsen presents usability as a property of the user interface associated with five attributes: learnability, efficiency, memorability, errors and satisfaction (Nielsen, 1993, p. 26). The same attributes are also carried by Shneiderman and Plaisant when it comes to perform a practical evaluation of the usability of a user interface (Shneiderman & Plaisant, 2005, p.16). An evaluation of the usability will be an analysis of the user interface used to execute tasks following the characterization related to the aforementioned attributes.
Nielsen believes that usability should not been disconnected to the principle of acceptability (Nielsen, 1993, p. 3). Therefore, the approach in the evaluation of the usability is mainly how the people working in the control room accept the different tools that are provided in the user interface in response to a task execution.

An evaluation of the collaboration and communication in a control room serves as an evaluation of

the participation of the different actors involved in the different activities that can be encountered in a control room. In fact, a control room at BDK for the S-Lane management traffic is a set of 14 people following the descriptive figure of figure 1.1. Each member of a control room has a particular function and collaborates with the other actively in a form of contribution to the management of the entire traffic system. In the context of the use of the user interface designed, the evaluation looks at the opportunities offered by the user interface to exchange data among controllers (including other members[2]) in the control room and between controllers and train drivers out in the field.
In the evaluation, the theoretical approach followed will be on a two-level range. The first level will be with of Etienne Wenger's Community of Practice (CoP), with a special focus on the sharing of knowledge using the design provided. In fact, the CoP approach contributes to the management of information on an organizational perspective; it facilitates as well learnability in terms of updates and critical situations management. On the second level, I will be using Bruno Latour's Actor Network Theory (ANT). The focus will be on the interactions structuring the work in the control room using the interface. In fact, the purpose is the evaluation of the work performed in a system of *unicity* where actors are controllers in the control room together with the system used to manage the traffic system. The theory does not look at the user interface directly, but how by using the interface the work in the control room environment is achieved. Both theories are supplementing each other in terms of participation, collaboration and communication. For CoP, the collaboration and communication is dealing with the aspect of knowledge sharing, mainly how the information is obtained, processed and distributed. On the other side, ANT focuses on task sharing, mainly how the interaction with the user interface is organized together with controllers in a form of network on a strive to achieve one goal; in our case, the management of the train traffic system.

The evaluation of the management of critical situations is looking at the management of problems on the S-Lane tracks using the interface provided. The model of evaluation will be based on Barry Boehm's model for risk management in software practical use. In fact, the model, on six steps level, suggests that risk situations should be managed by means of assessment and control of the risks or critical situations. The assessment involves risk identification checklist, risk analysis and risk prioritization. The control involves a risk management planning, a risk resolution and monitoring, which includes a documentation of the risk to manage. The evaluation of the management of critical situations serves as an evaluation of the means offered by the user interface to respond to major problems in its correspondence with the actual traffic. It can also be looked as an evaluation of of the user interface to manage the traffic safely and efficiently.

1.3 Problem field formulation

Following the three scopes of evaluation mentioned above, the present thesis is framed within the following central question:

How does a user interface of a control room system contribute to managing

[2]Other members refer to members in the control room as shown on Figure 1 not being called controllers

transportation in the train traffic system - using as a case study the current control room system for the Copenhagen S-Lane area?

In order to answer that question, several questions should be approached:

1. What characterizes the user interface designed for a computer-based system in a control room for managing a train transport system?
2. How is the relationship among people working in the control room and the user interface?
3. What are the challenges such user interface is exposed to in the management of the train traffic?

1.4 Methodology

This thesis report is written with the support of BaneDanmark (BDK) that has a special interest on the usability in terms of user satisfaction. The (End-) User Satisfaction theory is not central in the evaluation approach in prospect in this report but will be touched succinctly following the scope of usability since it has to do with acceptability, or the satisfaction by accepting the user interface as a working tool on a daily basis.

The evaluations will be performed on a two-step phase starting by a sequence of observations at BDK control center for the S-trains located in Copenhagen. During the observations, short interviews will be performed to have an understanding of the different situations controllers are exposed to in a control room environment and their use of the user interface to cope with any of those situations. The observation sessions will also be a mean of familiarization with the user interface in question, and an understanding of the different signals in response to the management of the traffic on the actual S-Lane. The outcomes of the observation will be used to build elements for structured interviews. The interviews in the second step will be on an individual basis looking at the three scopes described earlier. A survey on user satisfaction will be conducted in parallel, in order to measure the level of acceptability of the user interface by traffic controllers.

As one may see from Figure 1, there are people from DSB, Denmark's train transport company, that are having also some activities in the control room, mainly focusing on the trains operation and maintenance, including its passengers. Their work is performed following a user interface quite different from BDK since the interests are different. DSB's user interface is not part of this report. In fact, it requires the knowledge of their work in general, same as BDK, and an understanding of the activities that are being performed using their user interface in response to traffic situations. Most of the times words such as controllers and traffic controllers will be referring to BDK controllers, unless there are precisions over DSB as controllers as well.

1.5 Structure of the report

The following report will be divided into four parts. The first part will be on a description of the theoretical approaches, that will model the evaluation. It will be divided into three chapters

characteristics of the theories introduced earlier. The second part will mainly be focusing on the evaluation, and the third part on the analysis and deductions in relation to the tools for evaluating emanating from the first part. During the analysis, there will be a special stress on elements that captivated the attention in terms of efficiency, effectivity and flexibility. This report will end with a conclusion which will set the stage for some suggestions using small prototypes in relation to the improvements that can be made on the current user interface.

Part I

Theoretical Approach

Chapter 2

Usability Evaluation of a User Interface Design

This chapter gives an understanding of usability through its attributes, namely learnability, efficiency, memorability, errors and satisfaction. It follows by presenting the approach in which the evaluation will be performed in relation the case of control rooms based on those attributes. Before doing so, let us start by a general understanding of usability.

2.1 Usability in User Interface Design

A user interface provides tools that facilitates the interaction with a computer-based system. For instance, the airline traffic on control towers is managed safely over a user interface; facilitating the interaction with a computer-system that follow the air traffic. Similarly, children can learn many languages over a user interface that facilitates the interaction with a computer-system that manages those languages; the same goes as well for computer games. One of the main challenge in designing user interfaces is the ability of the interface to interact more closely with humans. Examples such as Microsoft Windows 7 shows the focus on interactivity with the fluidity on the manipulation of the items displayed; or Apple Systems, where the interface design is quite innovative with the technology of touchscreen making the user having the feeling of being more close in the interaction with the computer.

2.1.1 User Interface Configuration and Functions

"Users are often faced with a tremendous amount of problem in the interaction with their computer" (Schneiderman & Plaisant, 2005). The purpose of designing a user interface is to improve the user experience related to the use of computers by providing elements in the configuration that will enhance the familiarity with the IT tool. Appreciations of a newly designed interface come from how people using the interface are coping with it in their daily activities. Functions related to the use of the interface should be designed following a task analysis. Schneiderman and Plaisant claim that a task analysis is necessary to make decisions over the functions that will constitute the user interface manipulation tools (Schneiderman & Plaisant, 2005). Such exercise will erase the fear of having inadequate functionalities that could frustrate users and leading

to the user interface configurations being rejected or some of its functions being underutilized. However, the inadequacy of the functions should not always be related to the user interface failing to respond to the user demands; in other instances the user's learnability of the system can also be a consequence of failure in its usability. In fact, a newly designed user interface should primarily provide rooms for learnability. The learnability of a user interface can be viewed as the capability of the user interface to enable the user to learn how to use it. The learnability period is a period where the user goes over the different functionalities in the different tasks for which the system is aimed at. For instance, companies such as Danske Bank[1], provide an interactive user interface tool simulating the system in use. The use of the simulator is similar to the actual system, apart that it has no impact in the system running the Danske Bank, but provides instructions related to the use of the system by means of learning while interacting. The user interface configuration should also provide rooms for maintenance and adjustment since technology is a never-ending development process. Updates on the user interface should carefully be undertaken since differences between interfaces can enhance problems in the use of the user interface and eventually lead to errors. The usability evaluation and testing are steps in which the user interface is reviewed in its ability to satisfy the users following some established criteria.

The interest on the evaluation of the usability of a user interface design arises from the growing acknowledgement of the poor design of many user interfaces and the benefit elegant user interfaces could bring to users (Shneiderman & Plaisant, 2005). In control rooms, the user interface configuration should be a characteristic of the elements that controllers should have their hands on. For instance, in the train traffic, controllers should have their hands on trains; in air the air traffic, the focus will be on planes or any other human-made flying object in the air. The functions included in the user interface configuration should be related to the management of the traffic by the controllers. The user interface should provide rooms for interactivity enabling the controllers to feel at ease in their interaction with the system and their collaboration with people on the actual field/air.

2.1.2 Usability of an Interactive System

An interactive user interface should be simple and easy to use. The simplicity can be defined through the interaction features in which the dialogue messages, the signs and symbols play an important role in the visual communication between the user and the user interface. Nielsen believes that "information objects and operations should be accessed in a sequence that matches the way users will most effectively and productively do things" (Nielsen, 1993, p.116). Thus an efficient and productive task performance using an interactive system is consequence of a good graphic design, and good choice of colors' representation on the graphic. The simplicity of the interactive messages (information on the screen) reduces the memory information load, and provides some flexibility in the changes or updates in the system.
An interactive system should be consistent in the display of information. In the case of train traffic, the user interface should represent a train on the user interface in the same location as it

[1] A Danish bank, specialized in banking, insurance and investment management, with its headquarters in Copenhagen

is in real. The information messages characteristics of the train situation in the traffic should be consistent among each other, in a way to facilitate recognition and further plannification when it comes to rescheduling by traffic controllers. The consistency is not only on the display of information but also between the functions, the name given to the functions, and their use. For instance, in our control room, a button showing **SP**, normally used for blocking tracks, cannot also be used to set support on a track. Error messages should be representative of a bad action, or a mistake in the use of the functions. The consistency in the error messages helps identifying the exact errors and correct them instantly, sometimes without a need of help.
The feedback response seems to be crucial in an interactive system. In fact, it is the response to an action, that could be positive, meaning that the action went through in its execution, or negative in case a problem occurred in the execution phase. Nielsen pointed that 0.1 second should be the time limit for users to have the feeling of a direct impact on the system after an action (Nielsen, 1993, p.135). In case the response time is longer, the user interface should provide rooms to perform other tasks while waiting the current task set to be accomplished. In case of a negative response in the feedback, an interactive system should provide rooms for exits that does not influence the other processes running.
An important tool in the usability of an interactive system is the use of shortcuts. In fact, shortcuts prevent a procedural[2] access to a functionality on the user interface. A shortcut is a direct access to a command, without the need to open or close other items running on the user interface. Shortcuts reduce the load of items to learn, and enhances efficiency in terms of speed of work.

2.1.3 On Ergonomics

Ergonomics perhaps is not the most important part in the evaluation of a usability of a user interface, but somehow plays an important part in defining the user satisfaction in the features of usability mentioned above. In this section, the ergonomic will be considered as the design of the tools having a direct influence on the user interface to suit the comfort of the user. It takes into account the diverse human perceptual, cognitive and motor abilities that could influence the use of a user interface. Those variations in physical abilities can be adapted to the use of the computers in connection to the task to perform. An example of ergonomic considerations could be the choice of keyboard design being accommodated to the physical abilities of users. On the keyboard, there should be a consistent choice of the hot-keys representative of some shortcuts, for instance, the zooming, the minimization and maximization of windows. In the case of train traffic controls, some of the frequently used signals can be represented on the keyboard. Another example is the design of the screen that stands as the canvas in which the tools used to work with are represented. The bigger the screen is, the easier it is to manipulate items on the user interface. The number of computer screens can also influence the visual analysis of the items displayed. For instance, using two screens gives more rooms for management of applications on the interface than one. Other ergonomic considerations will involve the human response time in connection to the visual perception, such as the choice of the lightning over the user interface, the human capacity to identify an object in different context on the user interface, or to determine

[2]By procedural, I mean a step by step access to a function.

the hearing for audible cues, and speech input or output (Shneidermann & Plaisant, 2005, pp.27-29).

An external element to the user interface being part of the ergonomic is the room layout. In the special case of our control room, figure 1.1 shows the display of users of the interface. The main screen panel gives an overview of the entire train traffic to all the controllers being present, opening ways of a mutual contribution for any situation in relation to the train traffic system.

2.2 Usability Evaluation

The role of the usability evaluation is to assess the design and test the user interface to ensure that it actually behaves as expected by meeting the user requirements (Shneiderman & Plaisant, 2005). The evaluation is not just a single phase in the usability management, it is a set of activities that entails the use and the performance in return of a system. In other words, an evaluation of the usability is an analysis of the different modes of use of an interface, based on the area in which it is used, the people using it and the changes or updates the user interface is subjected to.

2.2.1 Five Attributes for the Evaluation

A practical evaluation, as suggested by Shneiderman and Plaisant (Shneiderman & Plaisant, 2005, p.16) and by Nielsen (Nielsen, 1993, 26), is an analysis of a user interface with the following questions:

Learnability

How long does it take to learn the actions relevant to perform a task, and how easy it is for the user interface to be understood?
In other words, learnability deals with the ability of the user interface to facilitate the understanding of a novice user when introduced to the system. It establishes a level of support for the novice user, which will be determine by his/her future use of the user interface (Dix et al., 2004, p.261). Learnability is also with the familiarity the novice user has with the system and to which extend the user will relate it to his/her own world.

Efficiency

How long does it take to carry out the tasks?
It refers to the performance of a user over a certain time. It is also a way to measure the experience of a user in front of a user interface (Nielsen, 1993, p.30).

Memorability

How well do users maintain their knowledge after some time away?
The memorability tests the ability of casual users (Nielsen, 1993, p.31-32). In fact, they are users that use the interface intermittently. The point with this attribute is to judge their level of learnability. A user interface that is easy to learn is also easy to remember claims Nielsen.

Errors

How many and what kinds of errors do people make while performing a task?
An error can be defined here as an action that has not been completed the way it was intended. It can also be an action that leads to an error message. This attribute identifies any incorrect user actions in relation to the user interface configuration.

Satisfaction

How much do users like all the diverse aspects of the interface?
This is the subjective satisfaction, aimed at getting the user interface to make users feeling a certain comfort during its use. It is also related to the experience, the perceived values and the attitudes of the users in relation to the interface.

These characteristics will form the elements that will be guiding the evaluation of the usability in the evaluation process. However, such characteristics need to be embedded in a method of evaluation. Dix et al. identify two techniques of conducting a usability evaluation (Dix et al., 2004, pp.320-357) . The first technique is an evaluation performed through expert analysis or an evaluation performed by an evaluator him/herself going through the system user interface. The second is an evaluation through user participation where the evaluator perform the evaluation following a user in the manipulation of the user interface. The latter is also known as an evaluation with a user participation. In other words, while the first focuses on the system performance, the second focuses on the user performance. Both can be undertaken simultaneously; in a way that the first will gather elements of evaluation on a list and the second, similar to a qualitative method of interviewing, will provide more information about the why's and how's in relation to the user's daily routines. An example of expert analysis can be a Heuristic Evaluation, in which evaluation is performed following a heuristic list of performance checking of the user interface. A method focusing on the user participation is the Thinking-Aloud where the user is asked to tell what he/she is doing while performing a task. In the evaluation process of this current project, I choose to focus on the user participation technique, due to my very low knowledge in the domain of control rooms or train traffic management system. An advantage of choosing such technique is that it helps following traffic controllers in their daily routines, including their use of the interface as a tool in their work.

2.2.2 Usability Evaluation on the User Interface of a Control Room

The choice of an evaluation technique depends on the characteristics presented by the technique and the data the evaluator is expected to gain from such evaluation (Shneiderman & Plaisant, 2007). The evaluation of the usability of the user interface used in a control room is an evaluation of the diverse elements such as the graphical configurations and the functions the user interface contains. It is also an evaluation of the use of the user interface in its ability to respond to the user's demands.
The user interface of BDK is quite vast with several functionalities mostly based on the management of the train traffic system. Thus, there is a primary requirement of the knowledge of train traffic system, to understand basic rules, signs and symbols, just as it is in the car traffic

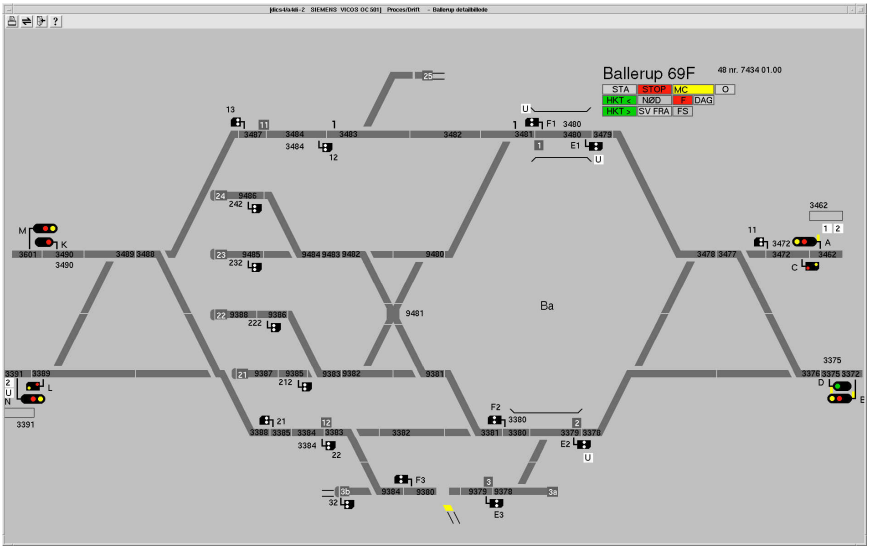


Figure 2.1: A window displaying the train station of Ballerup

system. Those rules, signs and symbols are displayed all over the user interface as shown on figure 2.1. In order to manage those characteristics, the evaluation can be made by following users in their active use of the interface in their real environment. Opposed to Shneiderman and Plaisant focusing on the development of a system for evaluation during active use (Shneiderman & Plaisant, 2005, pp 163-167), the evaluation method in this case is set to be carried within two steps. The first step is the observation of users, aimed at a familiarization with the environment. The second step is through a set of qualitative method of interviews to get the users understanding of the interface while using it. The questions in the qualitative interview are being made following the attributes prescribed earlier and follow up questions, "by looking at the interface and trying to come up with what is good and what is bad" (Nielsen, 1993, p. 155).

2.3 User Satisfaction Measurement

The success of an interface is measured over the satisfaction users attribute to it in relation to their tasks (Bergersen, 2004). Based on the satisfaction results, one can establish the level of acceptability of the interface. The satisfaction can be grounded at any place on the user interface. It could be the choice of the colors, the size of the windows or the misunderstanding in the different messages. Another reason is the experience of using the user interface. In fact, some users may like the design and aesthetic surrounding the user interface, but not the speed of performance of the system.

The user satisfaction measurement will be based on the Likert 5-scales type. In fact, it is a five-scale questionnaire, which has the ability to provide an uneven distribution in an opinion survey. The answers could help scaling the opinions of the users about the user interface being visually appealing, confusing, easy to use or untrustworthy. It is also providing valuable data on whether or not the user interface has reached the expectations of the users in their daily routines.

Critics emanating for such method are based on the fact that it does not take into account

users that do not care about the survey and users that care, since both can chose the third item. However, the focus here will be on all the tendencies (including users that will consider the survey as a waste of time) since the problem of the usability evaluation is to judge the user interface, and to find inaccuracies in its ability to perform tasks in the control room.

Chapter 3

Collaboration and Communication in Group Work

The collaboration and communication refer to the different interactions established in a group in order to accomplish a task following different patterns of communication. In this chapter, I am intending to bring two aspects of interactions in which information sharing plays an important role in the management of a task. The first aspect is the Community of Practice that contributes to an horizontal sharing of information as sharing of knowledge. The second aspect is the Actor-Network Theory, that has a vertical contribution in the management of the task, as the focus in the theory is the sharing of task. I choose to represent on a vertical prospect to signify the general ascendance in the task sharing from which each constituent of the task is part of the network that help managing the task. The horizontal representation of the share of information stands as a mutual engagement by the people involve in the task, based on their mutual interest and their goal to succeed in the task to perform.

3.1 The Community of Practice

The Community of Practice (CoP) at the basis is a conceptual tool for learning. It takes its assumption from knowledge, as well as learning, following four central elements that are key concepts behind the establishment and the evolution of a CoP:

1. The human being as a social agent.
2. Knowledge as a matter of competence with respect to valued enterprises.
3. The act of knowing as a matter of participating with an active engagement in the pursuit of such enterprises.
4. Meaning as an ultimate product of learning.

(Wenger, 1999, p.4)

From those four elements, the human aspect appears to be central in CoP. Thus, CoP is a social interaction of humans, where knowledge plays an important role in the development of

the enterprise. Learning on the other side produces meaning in the practice the enterprise is trying to achieve. The CoP is therefore about knowledge and the different participations that contribute to the emancipation of that knowledge through learning.

In the expression *Community of Practice*, there are two keywords *Community* and *Practice*. *Community* refers to any human group identified with some characteristics related to our human existence and identity. *Practice* is meant to be the activity that constitutes those characteristics in which the communities are identified. Thus, the *Community of Practice* refer to a group of humans involved into a practice or an activity. We then are all members of a CoP depending on where we are and the relationship we have to the surrounding people that are involved in our lives. At home, to establish an habitable way of life, families are developing their own practices by creating ways of dealing with each other. At work, a task is organized among workers and customers to achieve the necessary requirements for the company or organization survival. Communities at work are organized into smaller set of people according to the task completion in which constant agreements and disagreements in the working process shape the practice of the group. In our daily lives, we are gathering together with the main purpose of learning from others, sharing our understanding of the nature, the world, our existence. In other terms, far from the central concept of CoP, there is a sharing of knowledge in the expression *Community of Practice*. Learning plays an important part of that sharing of knowledge. In fact, learning is a process of psychological identification of images, texts and gestures; it is also including apprentice in that process. The learning is also a participation of the different actors in the community in order to build a knowledge that will map the commonality of the community. Such knowledge can evolve and grow in order to create many other communities; it can also evolve and die, meaning the end of the community.

3.1.1 The Concept of Practice

Practice can be assumed as the daily activity from which the human being is bound to. A common practice by a group of people is then consequence of a community over such practice. According to Wenger, practice could involve any human activity such as:

- Providing solutions to conflicts into institutions.
- Supporting a communal memory, allowing workers to do their work without the need of knowing everything.
- Generating specific perspectives and terms to enable accomplishment what needs to be done.
- Making the practical atmosphere to be enjoyable.
- Helping new comers joining the community by participating in the previously mentioned practices.

(Wenger, 1999, p.46).

These practices will sound a little more general in the CoP, since they are meant for "exchanging information, making sense of situations, sharing new tricks and new ideas, as well as keeping each other company and spicing up each other's working days" (Wenger, 1999, p.47). In CoP, the people involved in the practice are aware of their interdependence in the accomplishment of a task. Such task is structured in a historical context and the social environment of the CoP. During practices, the communication taking place can be looked as an opportunity to explore different opinions and engage in a process of reflexion needed in the answering of questions related to the practice. The participation in the practice should be enjoyable, delicate, active and socially negotiated.

In this section, three aspects of CoP will be investigated; meaning, community and learning. The point of building an approach upon these aspects is to characterize the interaction among them and their contribution in the participation modeled by the CoP in the approach of sharing of knowledge.

Practice as Meaning

As meaning, practice is looked as an experience coordinated by the human brain analysis. Wenger is basing the approach on meaning in CoP following three concepts:

1. **The negotiation of meaning**: It is the social relations where conversations play an important part in the process of reaching an agreement including expressing a disagreement. It is a productive process since the conversation involves all members of the practice. Such conversations take into account any element that could affect the practice. The negotiation of meaning thus lies into conversations where "meaning exists [...] in the dynamic relation of the living world" (Wenger, 1999, p.54). Meaning in this concept is part of the interaction process between human intelligence and its surrounding environment where it is created and negotiated.

2. **The participation**: It is the process of taking part, whether it is active or passive, in an activity. Since CoP is also looking at the social experience, the participation is an active involvement in social activities by talking, thinking, basically showing a sense of belonging in the community. The participation can also be seen as a mutual recognition, where ones become part of others in a form of a zodiac constellation. More explicitly, it is a collaboration via different means of communication with each member contribution having an effect on other members.

3. **The reification**: It is the concretization or the realization of an abstract thing. In order words, it is the different processes that "include making, designing, representing, naming, encoding, and describing, as well as perceiving, interpreting, using, reusing, decoding, and recasting" (Wenger, 1999, p.59). The reification is an activity that entails the signs of conceptualization following the human mind description.

According to Wenger, Reification and Participation can complement each other (Wenger, 1999). In fact, the reification needs the participation in terms of interaction, for an actual conceptualiza-

tion of the abstract thing, whereas the participation requires instruments or abstracts elements that are tools for participating.

Practice as Community

By practice as a community, Wenger believes that a practice that is characteristic of a community. For instance, football players could form a community of football players, computer programmers could form a community of computer programmers. In this prospect, he points out three dimensions in the term community:

1. **A mutual engagement**: As elaborated earlier, the practice is the participation of people in activities where meaning is negotiated among those people. The participation is in a form mutual engagement that influences one another in the group. The engagement in itself defines a sense of belonging, thus a constant work within a community. Diversity contributes in enhancing the productivity of the community since it provides different understandings through the members cultural differences. The mutual engagement also involves a mutual share of competences, that could also help in the distribution of the different roles in the community, generating a complementary contribution of the different members. Helping each other in the community is also part of the mutual engagement and also contributes to the survival of the CoP. "The mutual engagement does not entail homogeneity" (Wenger, 1999, p.76). Rather, it is a mean of establishing relations among members of the community through collaboration and communication. "Disagreement, challenges and competition can all be forms of participation. As a form of participation, rebellion often reveals a greater commitment than does passive conformity" (Wenger, 1999, p.77). The mutual engagement can thus be viewed as a complex form of interdependence which cannot be sometimes pleasurable. The focus instead should be on the different efforts provided by the community to establish a relationship in which members find satisfaction in the different interactions and practice that define the community.

2. **A joint enterprise**: It is a joint of resources that helps the members developing a mutually justified action and a mutual trust specified by the goal to attain. The goal to attain is defined by what is reflected by the enterprise, which could be the making of money or the search of proficiency and efficacy. A joint enterprise gathers all the elements that enable productivity in the community.

3. **A shared repertoire**: Each community develops a routine that is characteristic of its practice. Such routine is identified by Wenger as a repertoire since it represents typical signs and symbols that are identifiable by the community. The routine can involve words, tools, ways of doing things and even "actions or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice" (Wenger, 1999, p.83). It is the negotiated meanings from which the community can find and express itself, as a form of membership or identity in its belonging.

Practice as Learning

A community of practice is created following a common practice and a shared interest among its member. Its existence is structured over the active participation of its member following a practice that can be similar to the time of its creation or different based on the different fluctuations that has entailed its existence. The sustainment of a community of practice is done through learning. Therefore learning plays an important role in the community as a way to keep the community alive, and manage the different structures of the community to attain the goal aimed by the shared practice. Such learning is guided over three aspects:

1. **Memory, as source of continuity and discontinuity**: Wenger claims that practices evolve as a matter of shared histories of learning (Wenger, 1999, p.87); meaning that learning is part of the practice through the historical events in which the community has been engaged. The history referred by Wenger here is a collection of memories that entails the existence of the community and from which, through participation and reification, the communication is structuring a continuous learning. Learning thus stands as a practice in the engagement and contribution of the community to ensure a form of continuity in the practice.

2. **Learning produces Practice**: Taking the example of students in a classroom; they are gathered through learning following an interaction among themselves together with a teacher in a form of mutual engagement. Such engagement is established by a mutual help in assignments and classwork. They may have different understanding of a method to use in order to achieve a goal, but always tune their expertise in the group enterprise. They develop their own repertoire, styles and discourses. They are also negotiating meaning through various elements, such as recording events, storytelling, and even inventing new terms to create new routines. Learning in such process characterizes the practice in terms of CoP. Learning is looked as a method to improve the different practices of the community and keeping those practices alive.

3. **Discontinuity in learning**: In CoP, there is a generational discontinuity since members are not set to remain forever in the community. Since only the practice remains, a discontinuity in learning is characterized by the departure of old members, taking with them what they learned, and the venue of new members, that have to learn. Criteria of selection in the membership is therefore required to become part of a CoP. The reason is to insure the sustainability of the practice and the active participation of the new members same as the old members in the activities of the CoP. The selection session is then followed by a training or learning session, similar to the previous aspect from which potential members will be treated as active members. Learning is a way of preserving the different communities of practice making it effective and valuable in its practice.

Controllers in a control room are working in teams, similar to a group or a community, where the common practice, as mentioned in earlier chapters, is the management of the train traffic. An evaluation in terms of CoP will be an identification of the elements that constitute the practice. By taking the example in the case of organization, I will demonstrate the impact of CoP in organization by drawing the focus on knowledge.

3.1.2 Knowledge as an essential element in CoP

From the Oxford English Dictionary, Knowledge can be viewed as a theoretical or practical understanding of things surrounding our existence; such things could be art, science, industry characterized by the information gathered in those things. Knowledge thus can inferred a state of being informed, synonym to the state of having information. CoP is built over a common practice following different aspects as presented in the previous section. In the sharing of meaning, the central element in the interaction over the negotiations, the participation and the reification is the sharing of information or knowledge over the practice. The interaction over that knowledge goes through argumentation which is a presentation of a knowledge and a discussion over that knowledge, the participation in terms of knowledge presentation, and the reification over that knowledge in the process of negotiation to create meaning.

In order to build that meaning, there is a need of a community of practice. In the community, characteristics to create that meaning will develop over the competence of the members of the community. Such competence is taken upon the mutual engagement, a joint enterprise and a shared repertoire. The mutual engagement deals with the ability to establish a relationship with other members based on the actions engaged in the community practice. The joint enterprise follows "the ability to understand the enterprise of a community of practice deeply enough to take some responsibility for it" (Wenger, 1999, p. 137) with the purpose of contributing to the different negotiations being taken in the search of meaning. The shared repertoire deals with the participation of the members in the repertoire of the practice by engaging in the history of community. Such history is meaningful in a sense that it contributes to the monitoring and the experience map of the community. In fact, it is by practice "that a community establishes what it is to be a competent participant, an outsider, or somewhere in between" (Ibid.); thus a competence of a member is defined by the knowledge the member has and how it can contribute in the history of the community.

Learning can stand as the act of acquiring knowledge. In the CoP, learning is a matter of competence and experience in meaning (Wenger, 1999, p. 138) based on the fact that the learning process as explained earlier is characterized by a mutual engagement in the practice, such as learning, in a sense that members of the community learn from one another. The experience in the learning process defines the activity of the community as a joined enterprise and the elements in the process defines the shared repertoire. Such shared repertoire is part of the memory of the CoP, that will serve in the leading directions of the CoP, and may drive the newcomers into their practice in such a way that they could fit in the regime. Whereas old members could use the historical prospect to set up new goals of the CoP and therefore create new knowledge in the current practice.

"Knowledge cannot be separated from the communities that create it, use it, and transform it" (Allee, 2000, p.5). "Communities are defined by knowledge, rather than task" (Allee, 2000, p.5). People organize around domain of knowledge that gives members a sense of joint enterprise and brings them together. People function as a community through relationships of mutual engagement that bind members together into a social entity. It builds capability in its practice

by developing a shared repertoire and resources such as tools, documents, routines etc, that embody the accumulated knowledge of the community.

3.1.3 Knowledge Management in Collaboration and Communication

Knowledge management is about the way knowledge is collected and distributed for the purpose of collaborating, co-operating and communicating. In CoP, knowledge connect people in order to exchange information following the negotiation of meaning, the participation and reification over a commonly shared repertoire with a mutual engagement on the activities in a community. In fact, CoP can offer collaborative work in terms of communication, coordination and co-operation by means of several tools to support knowledge management such as electronic mail, message boards, instant messaging, chat rooms, screen sharing system, shared documents, work-flow system, electronic calendar and many more. "Communities of practice exist in any organization, because membership is based on participation rather than an official status, these communities are not bound by organizational affiliations; they can span institutional structures and hierarchies" (Wenger, 1998, p.3).

In the following, I will start by giving an overview of the impact of CoPs in organizations or structured based communities with an hierarchy. The purpose is to establish a relationship between companies and/or organizations together with the CoP following the approaches of practice as meaning, practice as community and practice as learning. This overview will be followed by a particular focus on control rooms which is the main focus in this report.

CoP in Organizations

An organization is not by definition a CoP (Wenger, 1999). Looking at it in the prospect of meaning, if there is a negotiation of meaning in decision making, the participation instead is not the same, since organizations are structured over an hierarchy. Therefore, the participation is not the same for all the members of such community (or organization). In the prospect of community, organization are defined by a mutual engagement based on the fact members of the organization are working together to grow assets for the organization. This can be evaluated through the level of involvement in projects or activities of the organization. Moreover, there is a joint enterprise, since organization members joint their efforts for the same interest, being the interest of the company; however the discussions could evolve over a shared repertoire, or a shared routine, based on the negotiation of meanings. Many companies have their routines defined by a board or a selected group of members in the organization. Moreover, organizations routines are directed at practice, because it is through that practice they can define their existence, establish a level of knowledge and the competence required (Wenger, 1999, p. 241).
A community of practice differs from institutional entity on several dimensions:

1. The meaning is negotiated among members of the community, whereas members of a company are constructing such meaning based on institutional prescriptions.

2. CoP are bound together via the learning practice, whereas organizations arise, evolve, and dissolve according to their own learning sometime bound to institutional events.

3. In CoP, members are bound to a shared repertoire, whereas in organizations are institutional hierarchies where the routine is not bound to a common practice, but to the level on the hierarchy.

CoPs can contribute to an organization by developing a common competence and through learning maintain the organization evolution following the aspects of sharing of knowledge.

New technologies have increased the amount of resources available to develop CoP's and the sharing of knowledge among its members. For Wenger, "Communities experience new resources in many activities that are often mediated, supported, or enhanced by technology" (Wenger et al., 2005, p.4); such resources involve interacting using emails, forums and blogs for discussing issues, brainstorming, working on tasks, asking and answering questions. The next section will introduce some aspects of ANT. The point is to show how in a networked communication, similar to the network characteristic of the interaction among controllers, ANT supplements CoP by integrating tools relative to the spread of the knowledge over the network.

3.2 The Actor-Network Theory

The Actor-Network Theory (ANT) can be viewed as a form of inter-relations between and among groups following an ever-shifting process of connections (Latour, 2005). Actors are identified as humans and non-humans essentials to the achievement of an activity. One of the main issues in ANT is the settlement of groups following a common experience; in other words, ANT looks at the society in a form of social aggregates, where each component in a group contributes in the social association. In terms of uncertainty, ANT looks at the unpredictable role played by actors in the social associations by the traces left behind through their activities of forming and dismantling. ANT is thus about group formation following three reasons. The first reason is to provide a portrayal representation of a group, despite if it has to be created from scratch or simply refreshed. In the second reason, ANT researches definition or elements of identification, such as the aim and the boundaries, in group formations since "actors are always engaged in the business of mapping the social context" (Latour, 2005, p.32). The third reason for ANT research looks at when group are formed and redistributed over time and space.

The ANT is about actors connected all together by a network of activities including elements contributing to those activities. ANT differs from CoP in the instance of sharing of knowledge since it is about social associations. In ANT, there is a productive interaction between a computer and a human since the computer can provide any kind of information. In CoP, such interaction is limited since computers cannot participate in a negotiation of whatsoever meaning, thus cannot share knowledge. Nevertheless, it participates in the sharing of information since a computer can stand as a database of information, where one can get it whenever required. Since a computer cannot negotiate a meaning, it is not looked in CoP as active actant in the sharing of information; rather, it is looked as an actor in the social association that participate in the sharing of information. The purpose of using ANT is then to supplement the interaction process being limited to humans in CoP by integrating tools or other actants in the interaction, as essential in the collaboration and communication.

In this section, the focus will be on the reason why other elements than humans can be considered as elements in the interaction process in a social context within the steps of ANT. The definition of the interaction is looked here as an association of actors by means of mediations and intermediations through actions and objects.

3.2.1 Mediations and Intermediations in ANT

According to the Oxford English Dictionary, a mediator is an intermediate agent, in other words, it is an agent that serves as a link between two entities. Thus, an intermediary is also part of the mediation at a certain level. In ANT, the mediation is viewed as a transformation, a translation, a distortion, and even a modification of a meaning including element characteristics to that meaning. For a mediation to occur, there should be more than one entity in which any kind of banal interactions such as conversations or touches, could involve passions, opinions, and attitudes related to the context of the interaction. The intermediation is the transportation of the meaning without transformation, by means of inputs and outputs (Latour, 2005, p.39). While considering once again our late example with the computer; for a mediation to occur between a human and a computer, the computer should for instance break down, in response to a human action like the press of a wrong key on the keyboard. The intermediation on the other side will be the direct representation of the data intended on the computer screen after a key has been pressed. With mediations, causes do not allow effects to be deduced as the effects depends on the occasions and the circumstances in which the causes were produced. In case the effects are ordinary response to the cause, then the elements used as a source for the effect is an intermediator; reason why a mediation could hide an effect of intermediation.

As a form of association, the intermediation is characterized by different means actions and reactions that could be a consequence of a group forming, where the reactions are consequences of the actions. Thus, an intermediary could be a train, as long as the train responses to the driver are accorded to the train manipulations. On the other hand, a mediator opposed to an intermediary is not a good predictor of outputs based on the inputs. It can lead lead into several directions that can eventually modify all characteristics of the intended role in which passions, opinions, and attitudes changes at each turn.
In ANT, groups are made, produced, reproduced, or constructed over social mediations and intermediations, by means and tools of actions with the impact of several objects such as symbols, signs and even social emblems. The role of the mediators and the intermediaries, and the impact they have in the network of actors, is defined by the inputs and outputs.

3.2.2 The Impact of Actions and Objects in ANT

ANT is dealing with a routine state of affairs from which binding plays an important role in the connection between actors and actions. Actions can be viewed as consequences of the behaviors of actors mobilized together in a form of assembly. In ANT, it appears as knots, nodes, or a conglomerate of many surprising sets of agencies (Latour, 2005, p.44). In other words, an action is meant to remain in a form of surprise, mediation or event.
As mentioned earlier in this section, the ANT research focuses on groups construction, but it

also has a particular interest on the controversies surrounding the groups. Such controversies are factors of the relationship between actors and their actions. Objects are also subjects of investigations since they play a role as tools for mediation or intermediation.

Actions in ANT

The controversies over the role of actors in ANT are defined by the actions undertaken in the group constituency. In ANT, actors are assembled and act as a single entity. Their actions are not located on a precise position; in fact, they are borrowed, distributed, suggested, influenced, dominated, betrayed and even translated (Latour, 2005, p.46). An action is thus characterized as doing something or providing an influence in a state of affairs. Moreover, Latour looks an action as figuration, meaning that the action is characteristic of a form and a shape, even if it is vague. Latour points figuration as a shape or the representation of the different contributions on an activity that led to such form or shape:

> "No one knows how many people are simultaneously at work in any given individual; conversely, no one knows how much individuality there can be in a cloud of statistical data points. Figuration endows them with a shape but not necessarily in the manner of a smooth portrait by a figurative painter".
>
> (Latour, 2005, p.54)

The figuration is thus a representation of the different actors and their actions in a form or shape. The representation provided by a figuration helps answering the question of group formation using four elements:

- The structural trait, where figuration focuses on general abstract concepts on the actor.
- The corporate body, in which figuration represented by a unified body, an associated group of people.
- The individual, when the associated group is reduced to a single abstract person;
- The aggregate set of individuals, being the assembly of actors.

The focus on the issue of figuration is how abstract elements can be used in the constituency of a group.
Another action stressed in ANT is the engagement of actors in criticizing other agencies accused of being fake, archaic, absurd, irrational, artificial, or illusory (Latour, 2005, p.56). On the other hand, "actors are also capable of proposing their own theories of action in order to explain how agencies impacts are carried over" (Latour, 2005, p.57). Being more active means generating more mediators for the reason that "individual human action is always intentional, individuality, if used to carry meaning as an intermediary, will do less than the more abstract, and global state of productive forces, provided that this agency is treated as a mediator" (Latour, 2005, p.58). For Latour, an actor "is not the source of action but the moving target of a vast array of entities swarming toward it" (Latour, 2005, p.46). It is a source of mutual engagement.

Objects in ANT

The point here is to demonstrate the role played by objects as part of the association of actors in ANT. There are two types of interactions in ANT; a local one, that is face-to-face, naked, unequipped, and dynamic interactions; the second one being "a sort of specific force that is supposed to explain why those same temporary face-to-face interactions could become far-reaching and durable" (Latour, 2005, p.65). ANT follows actors in their ever-shifting interactions. Objects also play an important role in the course of interaction; in fact, objects are transporting actions further through modes of mediations and intermediations. In the transportation, objects intervene in the domain of relations in terms of cause materials and are reflexive by symbolic domain of social relations. In other words, objects are establishing an inter-relation between the actor and the action. Objects are also actors in the sense that they participate in the course of the action provided by a figuration. It does not mean that as participants, they determine the action, rather, they stands as elements in the course of an effect produced through a human action. Objects in ANT help in the extension of the list of actors involved in the modification of the shapes and figures of those assembled as participants. Objects are not an origin of social activity; they only participate in the social interaction. Because objects exist naturally, and are not source of thoughts, they live on the margins of the social doing (Latour, 2005, pp. 75-74). In fact, objects help tracing social connections in an aspect human-to-object or object-to-human relations, not bound to reconciliation, or attachment, but relations aimed for a special purpose. Both need each other to perform a task in which objects depend on a connection to the humans, either as a mediator or an intermediary.

In a control room, the collaborative network is made of actors, that are controllers and objects, being tools used to influence the network train traffic. Using ANT in control rooms is to define the level of association among actors and objects, and the mediations and intermediations that structure such association.

3.2.3 The Association of Actors through a Task

An actor in the concept of ANT, is not the source of an action, but the moving target of a vast set of entities along actions and objects. The relationship between actors is made over a set of mediators and intermediaries. For intermediaries, there is no mystery since inputs predicts outputs in a straight forward manner, opposed to mediators, the present in effect is not part of the cause. The association of actors refers to the the different interactions among actors (humans and objects) to each other, from a local aspect, to a set of actors or on a global prospect. Moreover, an interesting part in such association is the distribution of the tasks in the figuration, or how each actant is represented in the network of actors; not only by the denomination as object, intermediary, or mediator, but also by the actual identification in the sharing of task.

From Local to Global

The association of actors take its starting point on a local prospect from which we have a translation or mediation in the delegation shaping the network by the transformation occurring in the different actants on the activity. Such translation or mediation between the actants and

their activity establishes a network. One of the major question is what is the relationship that characterizes the move of an action from a single entity to a chain of a network?
"As soon as the local sites that manufacture global structures are underlined, it is the entire topography of the social world that is being modified" (Latour, 2005, p. 176). In fact, Latour is pointing the fact that a global network is a set of small local networks having a connection to each other through some medium transporting specific types of traces. Taking the instances of organizations, all positions are connected to each other making the network of connections as a form of a living transportation system, where cables, vehicles, people and so on, constitute the linking system. The system is made in such a way that one element in the link, such as cables or vehicles; if being cut could not really influence the entire transportation system. On the other side, in case a structure in the system, such as a local entity, made of people, cable and vehicle, altogether bound by an activity, is being cut from the connection, then the system may stop being operational. ANT can therefore be drawn on a landscape where local interactions can be defined in a global context.

A Collective Distribution of Tasks

A collective action in terms of ANT is an "action that collects different types of forces woven together because they are different" (Latour, 2005, p.74). For the purpose of task sharing, ANT investigates how the different associations gathered around a task can renew our sense of togetherness in the collective.
A task can be distributed into several activities divided into sets of practices. It involves on a local aspect, a connection between actors and the different objects associated to a practice; for instance, a human and a computer. The interaction between a human and the computer defines the local network in which the practice is being set to occur. As a set of many practices, a task could involve many others human-computer networks in other to accomplish the task, in reference to the move from local to global. In a set of many tasks, the same concept of local to global can be applied in terms of local connections, being global connections for other local connections. The distribution of the task over the network is then extended to small set of connections.

3.2.4 Task Management in Collaboration and Communication

Following the steps of Latour, a collaboration is an interaction that involves intermediaries and mediators, since it is a process of mediation and intermediation. The process of collaboration can be modeled into a shape or figuration. Objects, that constitute the shape, act in a form of relationship which allows other objects to be transported from one site to another. In communication, "such displacement from the concept of idea to the materialization of the idea is called information" (Latour, 2005, p.223). By providing information, one is putting a concept, an idea into a form represented by a paper slip, a document, a report or any other material providing such information. The objects as well as the humans involved in the collaboration and communication are actors, members of the group in which their activity contributes to the performance of a task. "Collecting statements not only traces new connections but also offers new highly elaborated theories of what is to connect" (Latour, 2005, p.234).

Latour believes that task are shared over a process of management in what could be identified as the social world. "Society is not the whole in which everything is embedded, but what travels through everything, calibrating connections and offering every entity it reaches some possibility of commensurability" (Latour, 2005, pp. 241-242). It is in each element that constitute the social ties groups are associated from one movement to another following a procedure to render in common. In case it fails, participants explicitly engage in reassembling the collective, another way of managing the social ties by means of new actions in the network.

3.3 Collaboration and Communication in Team Work

The purpose of this section is to make a substantial move from the sphere of the social context to the technological environment in which CoP and ANT can be used respectively as tools for sharing knowledge and task. In fact, Allee believes that "technology is the easy part of supporting knowledge creation and sharing. The really hard part is working with people to improve collaboration and knowledge sharing" (Allee, 2000, p.3). On the other side, McBride thinks that ANT can be used as an "analytical tool to identify actions which may speed the social embedding of the technology" (McBride, 2010). Both are looking at several ways of togetherness in a form of cooperative process where CoP aims at understanding the coordination, the collaboration and the cooperation to develop to support a community work over the knowledge sharing. The ANT explores the collective processes by which actors are engaged over the sharing of activities in the network.

3.3.1 Collaborative Process in Control Rooms

CoP is an interaction among people only, with a particular focus on the knowledge. In fact Wenger believes that "it is with this group that you learn the intricacies of your job, explore the meaning of your work, construct an image of the company, and develop a sense of yourself as a worker" (Wenger, 1998, p.1). However, a team work requires an interaction between people and the tools associated to their activities. Therefore, ANT brings elements of the association of people and the required tools that contribute in the accomplishment of an activity.
The following will be on the impact of both theories in control rooms and elements to take into account for an evaluation on the working process.

CoP and Control Rooms

One of the big question in relation to our evaluation of the collaboration and communication will be to identify the control room environment as a CoP. In fact, characteristics of a control room are given at the introduction of this report, which basically is an interaction of many people with an ultimate purpose of managing a traffic system. Unlike organizations, a control room is not bound to an hierarchy structure since the interaction level is a matter of area of control, rather than an institutional organization. An evaluation following the three aspects of CoP prescribed earlier can be presented as following:

- Negotiation of Meaning: By participation and reification into a sustained history of practice, which becomes a resource for continuing this history.

- Preservation and Creation of knowledge: CoPs are sustained by the negotiation of meaning, they can be attuned to emerging needs and opportunities. They can preserve histories of learning as living practices, not just books and databases.
- Spreading of information: The mutual accountability derived from pursuing a joint enterprise and the interpersonal relations built over time together make the sharing of information necessary, relevant and tailored. In communities of practice, information entails communication because it is part of an ongoing process of negotiating meaning. Information travels through a community of practice at a rate, for reasons, and with effects that reflect this process. Communities of Practice are thus nodes for the dissemination, interpretation, and use of information.

The use of technology in such instance should support those aspects of collaboration and communication aiming at sharing the knowledge of the traffic they control, including the use of that technology that is at the disposition of controllers. This will develop the sense of togetherness over their work, and engage them in keeping the level of competence to a certain standard.

ANT and Control Rooms

In the previous section, it has been argued that tasks are managed through a form of groups association and reassembling, in case the association fails, where the collaboration helps understanding the role played by each actor in the network. The communication, in the other part, helps viewing what puts the different actors together, in terms of relationship by providing the information that has structured the connections between the different actors in the network.
Based on the understanding of control rooms given at the introduction, a question could be how does ANT could impact the collaboration and communication in control rooms? In terms of task management in collaboration and communication, it might be obvious following the description provided by Figure 1, that tasks are shared in a control room, since the traffic system requires the use of 14 people and 14 sets of computers, as actors, all connected to a screen panel, as a main interface of communication in a form of network. However, as the purpose of ANT research is to understand group formation, evolution and dismantling, the purpose of an evaluation of BDK's control room is to go through three points:

1. The task distribution over the activities.
2. The different messages that structure the communication between the actors.
3. The actions undertaken in response to an activity.

3.3.2 Participative Communication through a Computer User Interface

In this report the method that will be followed will be in a form of the evaluation of the participative communication via the use of the user interface. In other words, it is the participation that involves all the actors in the control room by means of collaboration and communication regarding the performance of an activity. Such participation is performed over the sharing of knowledge and the sharing of task under an activity. On a user interface configuration, it is characterized by:

1. Knowledge in the environment.

2. Task distribution following the settings of the user interface.

The first characteristic is the organization of the knowledge in the working environment. Basically it is encompassing elements centered around the creation of knowledge, the negotiation around the meaning of such knowledge, and the spreading of that knowledge over the different agents in the control room, by means of the user interface. The task distribution refers to the different tools offered by the user interface, such as interaction styles, colors, graphic designs, messages, that contribute to sharing of knowledge in the control room network.

Chapter 4

The Management of Critical Situations

The purpose of this chapter is to develop a theoretical tool for evaluating the management of critical situations.
This chapter will be going from an overview of critical situations in a general context, with the purpose of describing situations of risky accounts and how such situations could influence the working process. It will be followed by a presentation of Boehm's principles for risk management, and its impact on the user interface characteristics when it comes to manage critical situations on the train traffic system, from the control room. One interesting aspect in this chapter is the approximation being established between the terms crisis, critical situations and risky accounts. In fact according to Thesaurus[1], a situation has reached a crisis when it has reached its critical point. Such critical point could be a disaster, a catastrophe, in order words, it is a point involving risky accounts. Risky accounts, according to the same source, is expressed as uncertainty, unpredictability and eventually danger in a presented situation. The risk of fire is a danger of fire; it can also be viewed as an uncertainty over the fact there is a fire at sight. The words crisis, critical situation and risky account are somehow connected to each other. They are connected in the sense that a critical situation is a situation involving a serious trouble or crisis, a dangerous initiative and even an uncertainty over the course of an action; in which risky accounts could benefit the clearance or management of such situation.

4.1 Critical Situations in a Group Work Context

From a study performed by Herman Charles F., who is looking critical situations as crisis, there are three dimensions that could be associated with critical situations. The first is the threat that could endanger the high priority values, the second is the short response time to a situation, and the third is the unexpected or the unanticipated (Herman, 1963, p. 64). Ulmer et al in a modern approach believe that critical situations should be associated with the terms unexpected, non-routine, product of uncertainty, and threat of high priority (Ulmer et al., 2007, p.8). In other words, Ulmer et al. look a critical situation as a surprising event, or an event that was not expected. For them, a critical situation is a situation that requires a non-routine or an unusual procedure. Moreover, they believe that a critical situation is a product of uncertainty because the situation presents causes and effects that people are not aware of. Looked as threat of high

[1]Thesaurus Online Dictionary: *http://thesaurus.reference.com/*

priority, they point a critical situation as a higher level of threat that can prevent people to reach their goals in an activity. It is an understanding that those four approaches are mostly related to surprise and threat following these dimensions:

- Surprise, as an unprecedented event involving a non-routine management.
- Threat, as a possible precedented event or an event that is known as a problem.

The context in which many people are associated with in terms of critical situations refers to problems those people encounter in their daily activities. Critical situations fail to be sensitive to the predisposition that people bring to the process or the complexity of social information. In fact, when information is exchanged, the result is a complex process, not a simple reduction of risk. "Information gained through interaction has a complex influence on subsequent levels of uncertainty that includes decreases or increases in levels of uncertainty and both positive and negative outcomes" (Ulmer et al, 2007). Ulmer et al. looks at crisis in an organizational context as "a specific, unexpected, and nonroutine event or series of events that create high levels of uncertainty and threaten or are perceived to threaten an organization's high-priority goals" (Ulmer et al., 2007, p. 7). Events are identified here as situations and can be leveled to critical depending on the impact they have in the work of the organization. Moreover, critical situations are situations that are on top of the expected planning and cannot be managed following the normal routine procedures.
Critical situations as events of crises can be identified following Ulmer et al. within two aspects; intentional crises that are crises caused by individuals with questionable motives and unintentional crises resulting from unpredicted, uncontrollable and even natural factors.

4.1.1 Intentional Crises

Intentional crisis could involve a terrorist threat, a situation of sabotage, and even a poor risk management procedure, etc. In fact, since the 9/11 New York and the 7/7 London underground bombings, terrorism starts being one of many issues that evolve lots of attention in terms of critical situation alert. Such situation can disrupt the working process and eventually be a problem on a larger scale. A sabotage is a deliberate destruction or damaging of a product, that could pertain the group work the same way as the terrorist attack. Poor risk management abilities could result as a crisis in a group work process due to the fact that it is connected to the work practices. It stands as the poor ability of reducing risk by a limited set of procedures. There are more intentional crises such as poor connections between employees that could generate frustration over the working process, and influence the collaboration and communication among workers negatively. Moreover questions surrounding the ethics in a working process could lead to a crisis; examples are cases of dishonesty, breakdowns in the collaboration, and also a hostile takeover of a system. Intentional crises can be related to threats since the events are precedented.

4.1.2 Unintentional Crises

Unintentional crises could involve natural disasters, unforeseeable technical interactions and product/system failure. Natural disasters could be tornadoes, floods, wildfires, snowstorms and

even earthquakes that are unpredictable and can have a major impact toward a group working process. Unforeseeable technical interactions refer to technical malfunctions related to system failures or errors in a technical system during the working process. In the case of user interface, it is similar to the error attribute in the usability evaluation. Such failures raise questions regarding the safety equipment or procedure that could be inaccurate. Similarly, system failures are problems related to the inability of the system to contribute in the work process due some risk exposure that the product fails to cover.

The crises listed above are not all major crises that could pertain the work process of a team. It is perhaps important to notice that crises develop the same way as technology develop. A user interface designed to manage critical situations should provide tools to visualize and manage those two types of crises by representing them for instance as threat on the user interface. In case they are surprises, the user interface should be able to identify the crisis, and display it on the screen for a management plan to be established and followed by the crew.

4.2 Boehm's Principles of Risk Management

Risk management according to Boehm is identified as the management of potential losses due to some deficiencies. Through the terms risk exposure (RE) and unsatisfactory outcome (UO), from which emanated the following probability measurement:

$$RE = P(UO) \times L(UO) \tag{4.1}$$

P(UO) is the probability of an unsatisfactory outcome and
L(UO) is the loss to the parties affected by the unsatisfactory outcome.

The risk management is established as a two-step management practice, where each step in itself is divided into three sub-steps in which the following step is a consequence of the previous action.

4.2.1 Risk Assessment

The risk assessment is referred as the quantification or an estimation of the value a risk is posing to a concrete situation. The three sub-steps involved in the assessment are:

1. **Risk Identification**
   It is a checklist of all possible risks that could occur during the working process and the usage of an IT software. The list can be established following problems occurring in the working process. Such problems could either be a threat or a surprise as presented earlier. The risk identification list can also provide some suggestions of a management technique appropriated to the risk identified based on experience.

2. **Risk Analysis**
   It is the evaluation and attribution of the probability rate or probability associated to the risk identified in the previous step associated with each identified risk item. The discussion over the attribution of the rates could be involve decision trees, network analysis and performance models (Boehm, 1989, p.98).

3. **Risk Prioritization**
   It is where the risks rated on the previous step are sorted and ordered as a matter of priority following the risk exposure rate or probability extracted from the previous step. Discussions around the prioritization could be taken over a group consensus technique such as group negotiation to find a common agreement similar to the CoP with a collaboration among all the actants in a way described previously in ANT.

4.2.2 Risk Control

The risk control is the ability to setup elements to control the risks by detecting errors during the working process.

1. **Risk-Management Planning**
   It addresses each risk item listed and prioritized from the previous step by a management plan including a coordination process among risks. The purpose is to bring the risks listed under control.

2. **Risk Resolution**
   It is the phase where resolutions are found through planning from the previous step. It involves an identification list with the risk management technique brought for the risk item, all sorted following the prioritization list obtained on the third step.

3. **Risk Monitoring**
   The monitoring involves tracking the progress of the risk and taking corrective action where appropriate. A way to follow a risk is to make a top ten risk item identified every week or month, so that risks are tracked all along and management techniques can be updated in accordance to the situations.

4.2.3 Boehm's Risk Management Principles on a User Interface

In the scope of a user interface configurations and functions in response to critical situations, the preceding principles can be looked in the following prospect:

1. **Risk Assessment**: On the user interface of a control room, the risk assessment represent the tools for identifications and analysis.

   (a) **Risk Identification**
   The identification could be a change of colors, a blinking sign and even a musical sound telling about a situation of crisis, or an unexpected situation in the course of a routine procedure. Those situations can then be gathered in a list which can be used later for reporting to the central administration.

   (b) **Risk Analysis**
   The analysis of a situation can be viewed on an external window giving a detailed schema of the situation in the area where the problem was signaled. In this step, an evaluation of the risk exposure can be performed following the prescription over the probability measurement of formula 4.1. A discussion over the probabilities can involve people affected by the current critical situation in their area of control.

(c) **Risk Prioritization**
The prioritization ranks the critical situations as a matter of priority in the processing. In fact, it is a way to facilitate the coordinating process that entails the management of the situations, after the assessment of the crises.

2. **Risk Control**: The risk control does not involve the user interface directly. In fact, it paves ways to use the interface to resolve and monitor the different critical situations that were shown on the user interface. It encompasses:

   (a) **Risk-Management Planning**
   The planning is the collaboration and discussion over ways to eliminate a critical situation by introducing a management plan. Such plan could involve the enhancement of the safety and prevention techniques, a review of the system that has failed to respond to the critical situation, and even the dialogue process that preceded such situation. The plan involves the use of the different functions provided by the user interface in ordinary situations.

   (b) **Risk Resolution**
   The resolution refers to strategies that are believed useful to avoid the current problem in the future. It can also help displaying potential exposure in a system represented as threats towards the system.

   (c) **Risk Monitoring**
   It is in the monitoring where critical situations assessed are being followed. The monitoring helps ensuring the safety of the system and its reliability in terms of critical situations management. It is in the monitoring where a possible documentation is provided enlisting the critical situations recorded including their management plans and resolution for future references.

4.3 Managing Critical Accounts on a User Interface Panel

In the management of the critical situations, it is important according to Ulmert et al. that the management follows the primary goal of the organization. In the following, there will be a discussion about the determination of that goal and its impact on the usability design and the collaboration and communication when it comes to manage critical situations.

4.3.1 Determination of a Goal

The determination of a goal is believed by Ulmer et al. to be the primary requirement of organizations. In fact, "goals are often value statements that can help guide decision making for the organization" (Ulmer, 2007, p. 34). Similarly, Wenger using CoP believes that a common practice is naturally defined by an organization perspective (source). In the management of critical situations, defining a goal help setting prioritization over critical situations. The goals help also defining a clear objective of the management of such situations and ensuring integrity by guiding all members all along the process.
In a control room interface panel, signs and symbols on the screen can be element characteristics

in the determination of a goal. The management of critical situations is a constant achievement of that goal reflected by the different positions of those particular signs and symbols. It can occur that those particular signs generate confusion over the user interface during several critical situations. Therefore the choice of goals should not be ultimate, but standard, allowing flexibility in the management planning. The management planning should also be an evaluation of the goal, for the purpose of safety and prevention issues.

4.3.2 Impact on the Usability

The user interface panel provides a visual description of the traffic in control rooms. Therefore a critical situation should be able to be visualized on the interface. In case a user interface is not responding efficiently to a critical situation, issues related to the usability can be raised. Such questions could be whether or not the user interface was well learned and/or used. By following Boehm's techniques, in case the user interface fails to identify a critical situation, then it is not usable, since the user will not notice the problem. Moreover, in case the user interface provides tools for noticing critical situations, it can fail to provide tools for controlling the problem. Such situation will slow down the working process, and thus raising questions about its efficiency. The user satisfaction measurement is based on the response of the user interface to manage critical situation from the screen panel.

4.3.3 Impact in Collaboration and Communication

The collaboration and communication is important for two reasons. By means of CoP, it provides a distribution of the knowledge of the problem, and through negotiation, participation and reification problems are assessed efficiently following the common goal and the shared practice. By means of ANT, resolution over a task is distributed and problems are solved as a single unit, rather than sectoral.

4.3.4 Evaluation of the Management of Critical Situations

An evaluation of the interface for managing critical situations should be following the risk management method provided earlier, aiming at answering some questions such as:

- What happened?
- Who is responsible?
- Why did it happen?
- Who is affected?
- What should we do?
- What should we say?
- How should we say it?

Part II

Methodological Approach and Evaluation

Chapter 5

Methodological Evaluation

As mentioned in earlier chapters, the evaluation of the user interface was conducted following a two-step method. The first step was based on observations based on previous readings on topics related to train traffic management system, airline traffic management system, collaboration and communication in control rooms. The second step was the qualitative method based on the previous observations. The reason for using that method is due to the fact that the three scopes, in the evaluation, share a common element of investigation, the user interface. All three are an analysis of the user interface ability to be easy to use, to enhance collaboration and communication in the control room, and to manage critical situations. This chapter will present the characteristics related to that method in relation to the three scopes of the evaluation.
In the scope of usability, a survey on user satisfaction was implemented to supplement the subjective satisfaction in relation to the interviews. The reason was to level the degree of experience users are having in their interaction with the user interface.

5.1 Observations of the Control Room

The observations are oriented into three aspects. At first it is to get an overview of the applications offered by the user interface in its usability in a control room environment. It is focusing on the ability of the user to handle tasks (Nielsen, 1993, p.227) related to the management of the train traffic. It involves some visits to one or more users during when small questions are posed without interfering with their work. During such phase, it is important to become virtually invisible to the users so that they can perform their work and use the system in the same way as they normally do. Questions asked should be related to explanations of some activities and situations based on what is displayed on the main screen panel of figure 1.1. The second aspect of the observations is to identify factors of collaboration and communication. The collaboration is the social context that enhances collaboration in the working environment, and the role played by the user interface in order to enhance that collaboration. ANT is used in this context as associations in a form of network, where each actor, in the context of the control room, depends on another actor, in a form of mediation and intermediation. The reason is because "ANT is interested in the ways in which networks overcome resistance and strengthen internally, gaining coherence and coexistence." (Ritzer, 2005, p.1) . The communication is the way the message travels over the network through meanings and participation. The third aspect is to identify

to identify the moments of crisis situations, and see how the model is represented during the management of such situations.
An advantage of observing is that it provides elements to figure out the different ways developed by traffic controllers in their relationship to the user interface. For an evaluator not familiar with the user interface and its domain of use, the observations introduces the evaluator in an active way to the configurations and functions the user interface provides, and also users' situations (Nielsen, 1993). The daily routines can be processed and analyzed for another empirical investigation.
The observations were performed following the earlier prescriptions with an observation guide added in the appendixes[1]. The observation guide was made following following the reading of theories related to the three scopes. It randomly choose to make it in a form of questionnaire that could help me make notes in order to identify the necessary elements related to my focus in the evaluation.

On a practical level, before going to the control room, I had to commit myself to the reading of documents related to train traffic controls and activities in control rooms such as *Advanced Tools for Enhancing Control Room Collaborations* (Abla et al., 2006), *Automatic Train Control* (1976), *European Rail Traffic Management System* (Invensys Rail report, 2009) and *Crisis Management and Multimedia Technology in London Underground Line Control Rooms* (Heath & Luff, 1992). It served as an introduction to the environment and also built my imagination of a control room-like atmosphere since I had no experience of control rooms before. On the user interface, I had no idea of how it was, until the first day of the observation where I was introduced to the user interface in terms of traffic scheduling and the functionalities the user interface offers in the overview of the train traffic system.
A very interesting aspect in the observations was the active participation of two companies, DSB and BDK mentioned in the introduction, in the management of the train traffic through the flow of information. However, DSB is not meant to be part of the investigations, but I realized that I have to consider in some instances their participation in the management of the train traffic, since they own the S-trains, or trains running on the S-Lane. The user interface displayed on the main screen panel belongs to BDK, but it is used by both companies and the impact on the train traffic is as if it is one company.
The observations lasted six days, where I also had the chance to experience the switch of teams in the control room and how the flow of information between the two different teams is performed.

The observations were planned to be on two phases; the first on the introduction to the S-Lane control room and the user interface, and the second on the user interface and the interaction with the traffic controllers. I realized after two days, based also on the advices of some traffic controllers, that it will be a good idea to combine both to collect interesting data for the qualitative interviews.

[1]See Appendix A.

5.2 Qualitative Method of Interviewing

Qualitative interviews are useful for studying the users relationship with the interface in terms of usability, by means of description and explanations over the features offered. Within the collaboration and communication, qualitative interviews analyze the users' organization in a form of network, where tasks are shared and knowledge is uniformly distributed based on the data provided by the user interface and the features offered. Questions related to the management of critical situations focuses on how such situations are managed by controllers using the user interface with an identification of the elements that constitute Boem's model of risk management. The evaluation performed at this stage was taking into inputs from the observations and accounts of traffic controllers in their real environment. The qualitative interviews served as an in-depth strategy to explore how traffic controllers interact with the user interface on a single level, and they interact with each other using data from the interface in ordinary situations and critical situations. The in-depth character of the qualitative interviews helps looking for colorful quotes that can be used as statement to stress an important point in the evaluation. The advantage of making interviews is that it gives more insight in the context of use of the user interface and its participation in the train traffic management based on the elements gathered during the observations.

5.2.1 Methodological Issues

The qualitative interview is characterized by open-ended questions between two people following an interview guide[2]. The point is to analyze the theme of investigation by going through the following three elements:

- The experiences of individuals or groups, related to their personal profile and history.
- The interactions and communications in the different practices, by looking at the materials used and the process that lead to a concretization of a task.
- The elements of interaction and communication such as texts, images, signs and symbols, including any similar traces that strengthen the interaction.

(Kvale, 1996, p.x)

The purpose is to understand and be able to describe issues related to the central theme. The central theme by using this method is the evaluation of the user interface characterized by three sub-evaluations, introduced in the previous three chapters. As the evaluation is performed in a form of user participation, the user interface is being used when the qualitative interview is performed. The interaction by means of discussions goes around the day-life of the traffic controllers and their work together with the user interface. During the discussions, there is constant search of meaning, since the controllers take the interviewer in their own world. The interviewer has to bring them back to a common environment by means of interpretations through the use of the interface. The elements recorded are elements of evaluations, such as failure of the user interface

[2]See Appendix B.

in its response to a task, inconsistency in the message flow in the control room or problems identifying a broken track on the user interface. The elements of the evaluation are then carried further in the analysis for interpretations and discussions.
Similar to the Talking-Aloud method[3] and the Cognitive Walkthrough[4], a qualitative research interview seeks to uncover both a factual description and cognitive meaning through body language and oral expression (Kvale, 1996, p.32). The advantage is that it helps obtaining nuanced descriptions from the different qualitative aspects from different controllers and their experience of using the current interface in relation to the train traffic management system on the S-Lane.Moreover, it helps seeking a description of specific situations and action sequences from the controllers' world (Kvale, 1996, p.33) in relation to the user interface. Such specific situations could be the handling of errors made using the interface, the interpretation of signs and symbols or the handling of critical situations, that seems not to be common in terms of user experience. The qualitative interview helps also gathering the different reactions controllers faced in relation to those experiences, their opinions of the user interface that might be relevant in yielding information that is of interest in the evaluation in terms of advantages and disadvantages in the performance of the user interface.

A disadvantage of the qualitative interview is the fact that it keeps the interviewer on issues users want and ignores some other part. It also provides elements related to what features they particularly like or dislike. They are viewed by Nielsen as indirect methods of evaluation, since "they do not study the user interface itself, but only user's opinions about the user interface" (Nielsen, 1993, p.209). In fact, he believes that data about people's behavior, such as system efficiency and effectivity, should have precedence over people's claims or opinions which seems to be related to satisfaction issues. It is the reason why observations were made at the beginning in relation to the behaviors of the controllers and their relationships with the user interface.

5.2.2 Ethical Issues

An interview is a conversation. It is also a careful questioning and listening approach with the purpose of obtaining thoroughly tested knowledge; in fact it is a construction of knowledge through interaction (Kvale, 2007). During the interview session, the social relationship with the controllers influenced the way that knowledge was exchanged based on the fact that I was performing the evaluation on the behalf of the IT department in charge of the signal programs used to manage trains on the user interface. On the topic of investigation, the conversations were opened and access to the different security panels in relation to the use of the interface were wide open, since the BDK staff was also interested on seeing how limited their user interface was.
Before starting the interview, I had to make sure controllers know the topic of investigation, the reasons for the topic and the questions. The reason for that choice was to avoid raising any misunderstanding in the evaluation, by using expressions such as "it is not you I am judging,

[3]The thinking-aloud method is an evaluation method where the user is continuously thinking aloud by verbalizing the thoughts while going through the user interface. (Nielsen, 1993)

[4]The cognitive walkthrough represents the psychological perception of the user interface while going through the different steps that constitute a task or a sequence of actions. The role of an evaluator is to step through the different phases of an action or an ordinary task to check if there are any problem following the attributes of usability prescribed earlier at the introduction. (Dix et al., 2004)

rather it is the system". Users were also informed about the confidentiality and who will have access to the interview. In response to the confidentiality, they did not oppose having their first names being used to refer to them; I choose not to publish their names since they did not know at the time of the evaluation that this report will be publicly available.

5.2.3 The Choice of the Questions

The questions used were brief and simple. Following the different theoretical approaches presented in the three previous chapters. Those questions constitute the interview guide that was used during the qualitative interview. They were divided into five parts, with the first part being in a form of introductory questions related to warm up the interview session. Questions were meant to get to know the controller, through his/her background and the number of years he/she worked as a traffic controller. The second part contained questions related to the question of usability. The questions focused on the 5 attributes of usability in chapter one. The third part encompasses questions related to the sharing of tasks and knowledge in the control room network through the ability of the user interface to display and allow a flow of consistent information in that network. The fourth part contains questions focusing on the management of critical situations following the six steps presented by Boehm in the previous chapter. The fifth part is a concluding question about the different perspectives and expectations of the users in the light of further development on the user interface.

5.3 Survey on Satisfaction

As mentioned in the chapter on usability, the purpose of making a survey, is to supplement the evaluation with numbers related to the user satisfaction in terms of usability. The data collected are used to check the tendencies in the experience of using that interface. "Survey research involves the collection of information from a sample of individuals through their responses to questions" (Schutt, 2006, p.234). In the survey implemented[5] for the usability evaluation, the targeted group was the traffic controllers working in the control room for the Copenhagen S-trains, since they stand as active users of the interface. The choice of the questions were based on the satisfaction related to the efficiency, the effectivity, the messages selection, the interactivity of the user interface and the experience in its use. As mentioned earlier in chapter 2, answers were based on the Likert scale, to draw all possible tendencies in the agreements and disagreements. With the easy access to the Internet and the large use of electronic mail for communication, electronic surveys are becoming widely used. (McCoy et al., 2004). The advantage is that data can be collected from many people at low cost. It is on the basis of that argumentation the survey was made online. The target was to reach a large amount of traffic controllers[6], since they all have electronic mails, to have their attitudes vis-à-vis the user interface.

[5]See Appendix C.
[6]They are estimated by the BDK-staff to be 85.

5.4 Validity, Reliability and Generalization

The evaluation with user participation in their natural environment helps viewing their interaction with the user interface and raising real problems in connection to it. This section looks at the extent to which the elements provided are valid and reliable. The generalizability is due the conduct of a survey on user satisfaction which appeared to have been acceptable in terms of final results.

Validity

The participants in the interviews were 6, 3 males and 3 females, distributed between 7 months and 25 years of experience as traffic controller. Some of them have experienced the different positions of ordinary traffic controller and team leader. Some of the participants have experienced the transfer of technology from the *two-buttons* control to the computer-based control interface. One was on her apprentice period as traffic controller and another was on his apprentice period as team leader. Details about those positions will be given in the coming chapters including data collected during the evaluation.
Similarly, the survey was targeting traffic controllers working in the control room of the Copenhagen S-Lane area. Since it was a survey on satisfaction, the questions are challenging their acceptability of the user interface.

Reliability

Reliability pertains to the consistency and trustworthiness of research findings (Kvale, 2007, p. 122). It is concerned with the different answers provided by the traffic controllers. In fact, answers provided by the traffic controllers were diverse but at some point, they started to be repetitive. I estimated that to be the point of saturation and decide to stop the qualitative interviews. During the interview sessions, all the issues raised were discussed with the support of the interface next to us. We could see on the screen, the problems raised, and also some of the good features provided by the user interface. Explanations regarding the tasks being performed and the behaviors of the interface were similar to the usability method of thinking-aloud.

Generalization

It is hard to talk about generalization when it comes to qualitative interviews since the number was very little compare to the number of traffic controllers working in the control room. However, data from the survey were low compare to the level of expectations. In fact, out of 85 traffic controllers mentioned by the BDK-staff, 40 participated to the online survey. The participation was activated as soon as the traffic controller clicked on the link launching the survey. Only 13 traffic controllers answered all the questions; i.e. 27 may have started answering questions but did not complete. It is thus hard to generalize the data gathered in the online survey. But it helped getting the tendency of the satisfaction that connects with the interviews in relation to the satisfaction.
A critique of the online survey is that it is unpredictable. A paper-survey would have perhaps

been better, taking into account the fact 27 people were curious about it; I could have perhaps got half of them just by being present in-front of them.

Chapter 6

The S-Lane Control Room Environment and The User Interface for Train Traffic Management

This chapter results from the observation period. As presented at the introduction, the control room of the S-Lane in the Copenhagen area is characterized by a main screen panel, a very large screen on the wall, with three rows of people sitting in front of it. The aim of this chapter is to give a general description of the control room environment, and the user interface characteristic of the management of the train traffic system.
During the observation, I have realized that the main function of the controllers is to make sure that all trains are running according to schedules. The main purpose is to keep the regularity of the traffic above 96%[1]; in other words, only a maximum of 4 trains out of 100 trains can be delayed to judge the traffic in a perfect condition. In case there is any problem in relation to the traffic, there is a set of procedures to follow which will be evaluated later in the next chapter.
The user interface provides information about the trains' status including information about the drivers, and the different stations where the trains are required to stop following the schedules established earlier in the day by DSB agents. It also provides information about the tracks used to identify the position of trains in the traffic. Such information is used to operate track switches for trains and many other management mechanisms to keep them in schedule.

6.1 The Role Distribution

In the control room, the management of the traffic is organized following the three-rows set prescribed earlier, in which each row has an impact in the collaboration and communication in the network formed by traffic controllers, DSB agents and the computer user interface. As mentioned earlier, DSB agents are not really involved in the use of the interface, but serves as well as actors in the decision-making when it comes to schedule and reschedule trains by participating in the flow of information that encompasses the traffic management. The same information is

[1]More precisely 95.5%; it based on a common agreement between BDK, DSB and the Danish ministry of transport as part of the payment procedures.

also transmitted to passengers standing at the stations. In the following the two first group of actors in the train traffic management will be DSB agents, and the rest BDK agents.

The train controllers

Train controllers, sitting on the right side of the team leader as shown on figure 1.1 in the introduction, are of two types. The first is in charge of the technical infrastructures required for the trains, i.e. extra wagons during rush hours, adds on the train, train's engines and wheels, etc. The second is in charge of the train drivers being scheduled and the trains they are appointed to. Both are scheduling trains at the start of the day. There are about 1303 trains running everyday, and between 700 and 900 trains in the weekends.

The information agents

The information agents are usually referred in the control room context as DSB-info Center. They are responsible for informing passengers about the different trains' (re)schedules of the day and the train traffic situation. The information is transmitted through the loudspeaker and the screen panels located at the stations. They serve as external voice to the control room for passengers especially when there are changes in the schedules.

The traffic controllers

Traffic controllers are in charge of following the traffic and make the necessary adjustments to keep trains on schedule. In case, the schedule is affected by an unexpected event, they do the necessary rescheduling by reorganizing the traffic, base on the information provided by the user interface in order to keep the regularity on its acceptable value of 96%. Traffic controllers are organized by areas:

- North: Hellerup - Hillerød, Hellerup - Klampenborg
- West: Høje Taastrup - Valby. Frederikssund - Valby
- City: Bavnehøj - København, Valby - København
- East: Vesterport - Farum
- South: Køge - Bavnehøj

An area is a set of train stations, except the City area, that is only represented by the Copenhagen central station and the surrounding circuit. It is due to the fact that the central station of Copenhagen is an unavoidable station for all trains living the other areas, thus traversed by an approximated number of 1303 trains everyday between Monday and Friday. Traffic controllers are often communicating with train drivers whenever the train enters his/her area of control. The communication is not on a regular basis, but in case there is a request, such as a track switch, or the report of a critical situation. The communication ends frequently with a confirmation of the action or set of actions, in the request. The user interface is used to perform the actions requested by train drivers in relation to the management of the train traffic

The team leader

The team leader is also a traffic controller; but compared to an ordinary controller, the team leader is not directly involved in the traffic the same way as the traffic controller. Rather, the team leader serves as guide in the general management of the traffic, as an intermediate person between the DSB's agents and the BDK's agents. As an intermediate collaborator, the team leader manages problems encountered on tracks in term of general overview of the traffic system. For instance, the team leader can tell the DSB agents what to do in case a traffic controller reports a problem that will cause a delay in the traffic and vice versa.
One problem could be a defect on a train signaled by the train driver to the traffic controller. From the user interface, the team leader can see the train that is being reported by the traffic controller in charge of the area the train is currently running. The team leader will tell the DSB agents to find another train to replace the defected train. At the same time, the team leader informs the DSB info center, to leave a message through the loud speaker to the stations the defected train was scheduled to stop. The team leader requests then the traffic controller to find ways to remove the defected train from the traffic, without causing problems to the passengers and the following trains. In case another train is found, the team leader also asks the DSB agent to provide information about the area where that train will come from so it can be followed on the user interface. The traffic controller, in charge of that area is asked to find ways in the traffic to make the new train reach the position where the defected train left passengers for the last time. When the new train has reached that station, the traffic controller informs the team leader, who through the user interface can see the new train, and then inform the DSB-info center about the good news for the benefit of the passengers. The defected train is followed to an isolation area where it vanishing from the user interface. The new train is followed on the user interface after being injected the new schedule, based on the schedule of the defected train.

The Assistant-traffic controllers

There are two assistant-traffic controllers; one is seconding the traffic controllers in case one is absent from the working position, the other one is seconding the team leader. The first assistant is a flexible traffic controller, since he/she can be invited to take over any area. In fact, the area of the central station is expressed by traffic controllers to be the most difficult area since it is a station of transit for all S-trains. From the working position as the first assistant-traffic controller, there is no influence on the traffic, but such assistant is an active force when it comes to replace an absent traffic controller, since he/she participates as an actor in the sharing of knowledge related to the traffic situation.
The assistant-traffic controller for the team leader[2] can eventually help in the traffic control if needed since he/she started as traffic controller. The main task is seconding the team leader in the report of critical situations, since the team leader is busy controlling the traffic system in its entirety including the trains operating in it.

There is a dynamic collaboration and communication among people working in the control room as it was demonstrated in the case of the defected train. The user interface participates in a

[2]The function is also referred as team leader assistant.

form mediator and intermediary in the interaction through the messages exchanged all along the process of the collaboration over a situation. Users are in the exchange of messages, they interpret and discuss the information, similar to CoP, "because members have a shared understanding; they know what is relevant to communicate and to present information in useful ways." (Wenger, 1998, p.6) . The next section gives a description of the different situations controllers are facing on a daily basis.

6.2 Description of the Working Environment

Activities, in the S-Lane control room, are very relaxing since the system that manages the train traffic is controlled by computers. Traffic controllers are only making sure that things are running the way they should according to the schedules. They intervene most of the time to prevent situations that will influence the schedule such as tracks switches, traffic signals, etc. In case there are changes in the traffic, such as the case of critical situations, traffic controllers intervene to get the traffic back on the line, under the influence of a new schedule.

6.2.1 Description of Day-Time Situations

The day-time is the busiest period of the day while working in the control room since all the rush hours are gathered in that period. Rush hours in the train traffic system are the same as rush hours in the road traffic system, estimated to be at hours between 7.00 - 10.00 and 15.00 - 17.00. Similarly, those rush hours are due to the fact that people are going to work in the first range of hours and leaving their work in the second range of hours. The traffic is busy, and a train delayed can affect the traffic, and at the same time influencing the regularity. Trains heading to the City area are often subjected to delays. On one side because all trains are stopping in that area, and on the other side due to major problems such as bomb alert at the central station.

6.2.2 Description of Night-Time Situations

The night shifts start at 10.30 p.m.. During that period, traffic controllers follow the last trains running, park those trains, and also follow the maintenance activities all along the tracks that have been reported to cause problems to drivers in the morning. On the other side, the train controllers are looking after the trains in isolation to find out which train is ready to be scheduled at 4.00 a.m., time when all trains are back again on tracks. Both activities are under the supervision of the team leader with the user interface as their guide.
Nights usually are quiet because after all trains have been parked at 2.00 a.m., there are no commercial trains[3] running, except maintenance trains[4] which can also be followed on the user interface.
During the period of the observations, nights between Friday - Saturday and Saturday - Sunday were very quiet since there were no commercial trains running, including maintenance trains. Later, after my observations, it has been decided that commercial trains on the S-Lane will be

[3]Commercial trains are referred to trains aimed at transporting people to their respective destinations on the basis of a commercial fare.

[4]Maintenance trains are referred to trains aimed at working on tracks or insuring the maintenance of tracks for a safe running of trains.

Figure 6.1: An explosion of a remote control room due to a short-circuit.

running between 1.00 a.m. and 5.00 a.m. during the nights in the week-end period. My guess is that the activities in the control room might not perhaps be just the same as it is in the rush hours, but on an ordinary traffic level situation as described while introducing this section. A problem in the management of the traffic at this time will be the handling of situations where people are falling on the tracks, eventually because of too much alcohol in the blood.

6.2.3 Description of Critical Situations

During the phase of the observations, there have been several situations that were critical following the definition prescribed in chapter 3. The ones faced were in the range of unintentional crises mainly explosion of the remote control room[5] at Allerød station because of a short-circuit. Figure 6.1 shows an image of such explosion. Since the observations were performed in the Spring period, I experienced the situation of leaves falling on the tracks. In fact, it is becomes an unintentional crisis when it causes major problems in the traffic because trains are not stopping normally at the stations after braking. It induces a failure to deserve passengers and in case there is a queue to enter the City area, a train can hit another one in the back. Traffic controllers are not able to see leaves on tracks, unless train drivers report the problem.
As intentional crisis, the only major problem faced during the observation and could be raised as a critical was a suicidal attempt on the railways track. The traffic was blocked for the medical personnel and police to arrive and do their job. I have heard that in such situation, the traffic is reorganized in the area, and start being effective as soon as the medical personnel and police has left the track or station concerned with the incident.

In the description of those three particular situations, the user interface plays a role of

[5]The remote control room is a room which manages the signals at a station. Those signals are controlled directly from the user interface.

Figure 6.2: Screens disposition: The right image shows a traffic controller in front of the set of screens.

geographical mapping of the trains positions and traffic situation. A train is displayed on the user interface if it is running on a track, whether it is scheduled or not. In fact, trains are identified in the traffic by means of track circuits and wayside signals (USC, 1976). The track circuits are electrical circuits that are activated when a wheel of a train is running on the cable that is part of the circuit. The wheel of the train creates an electrical short-circuit by sending signals to the train and an automatic box[6] communicating with the user interface. It is through that short-circuit traffic controllers know the exact position of the train in the traffic network represented on the user interface. In case the train does not receive any signal from the short-circuit created on the track, it will stop. A train being static for sometimes will blink on the user interface to catch the attention of the traffic controller. In a way similar to the defected train example, the collaboration and communication will provides ways to solve the problem, by spreading the information provided by the user interface to other controllers and DSB agents, and by analyzing that information regarding the current status of the train network.

6.3 The User Interface Characteristics and Configurations

As mentioned earlier, the user interface used to manage the train traffic system on the S-Lane is a map of the train routes including the characteristics of the train traffic at each moment of the day. It is very dynamic and designed on a multi-windows interactive platform. The multi-windows system provides to users of the interface the ability to visualize several activities being run on the interface, for instance track switches and trains monitoring. The user interface is used in the control in two aspects. The first is to get information regarding the train traffic. The second is to send information to manage the train traffic. This section discusses the tools and graphics are provided by the user interface to facilitate that interaction; these tools and graphic configurations will constitute the elements of evaluation in the next chapter.

[6]The automatic box is a box exchanging messages between the interface and the track circuit.

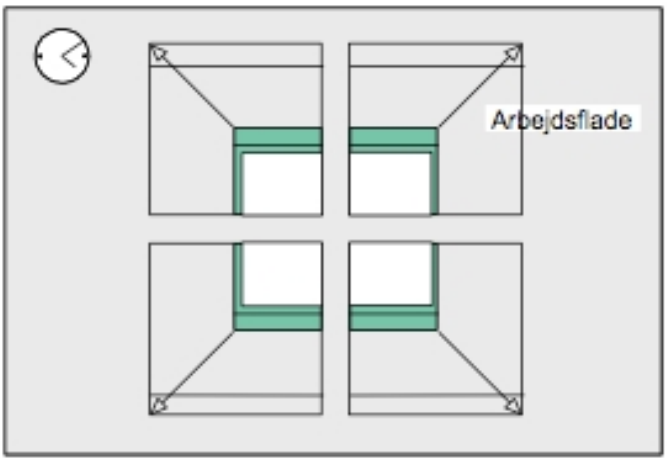


Figure 6.3: Image split over four screens

Screens Disposition

As mentioned earlier at the introduction, the front desk of a traffic controller is covered by a set of six screens as shown on figure 6.2. The set of screens can be divided into three subset of screens. The first subset of screens is made of the four middle screens displaying the area the traffic controller is in charge of. The four screens are supplementing each other by means of superposition similar to the figure 6.3. Images are superposed on several screens for a better visual analysis of an area which can have many stations. The two other subsets of screens are made of one screen each, used for administrative tasks and phone communication with the train drivers. Both screens are not part of user interface and are running independently. The administrative computer is meant to run as a personal computer where the controllers can exchange emails, information emanating from the head administration, and also filling up report forms.

Windows Application

Keeping the focus on the subset of four screens superposing images characteristic of the train traffic, a typical window being displayed is similar to the window on figure 6.4 displaying a subset of an area. The system is not Microsoft Windows based, but Unix based[7] However, some of the features provided by the widely used Microsoft Windows user interface are found on that windows structure. It is thus possible to maximize and minimize the windows, including interposing windows on top of each others. Basically, all the work on that subset of screens is organized on a window structure, where all the information are displayed following an interactive design. The interaction is characterized by the functions used to control the tracks, to supervise the trains running on those tracks including stations where they stop. The control on windows is done using a mouse. The mouse provides three types of clicks:

- Left click: It is the click that opens directly to an application on a window.
- Right click: Opens to a menu box with a list of different windows applications.
- Middle click: It is used for panning images.

[7]In fact, it is following the Unix Centralized Traffic Control Systems configuration, referred as XCTC.

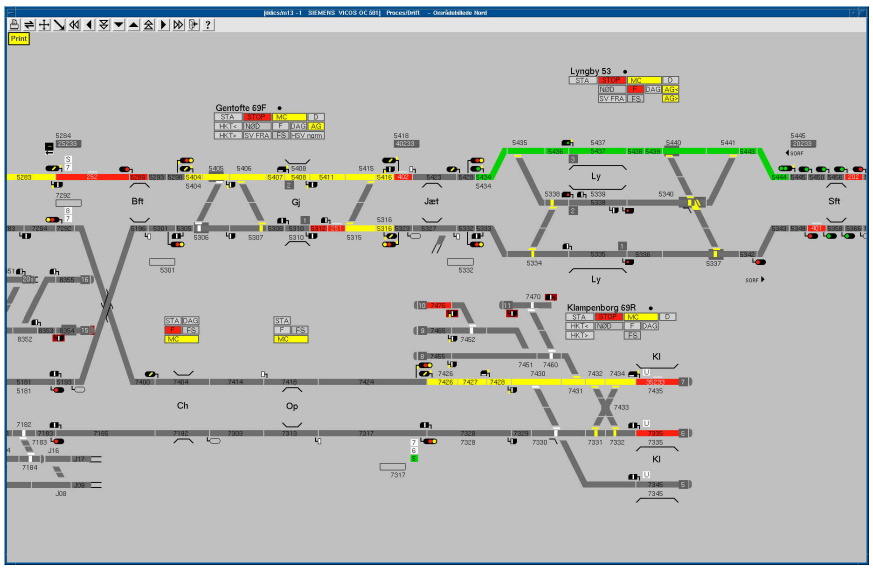


Figure 6.4: A window displaying the current traffic in an area containing Gentofte, Lyngby and Klampenborg train stations

There is a total amount of 8 windows that can be opened during the use of the interface. A control window, that serves as a task bar for all applications running on the interface. Usually referred as the control interface[8], it is always opened and its visual representation is on figure 6.5. Some of the windows' applications it can display are:

- A general overview of the traffic system, through the command **GEO**. It displays the entire traffic network.
- An areal overview of the traffic system through one of the command, characteristic of one of the areas given earlier. More precisely, **Syd** is meant to display the South area and **City** is to display a window with the Central Station area.
- A window for problems related to the communication between the user interface and the tracks/stations by clicking on the command **Fejl**, that blinks red whenever there are.
- A window for technical problems by clicking on the command **Tekn**, that also blinks red whenever there is a state change in the traffic.

The black panel on the control interface window is a log list, displaying information about the state changes and technical problems for technician in relation to the entire traffic. The windows displayed from the control interface also have sub-windows that are referred to as window service menu, because they are used to perform a task or service on the displayed window from control interface. They are automatically closed if not used after one minute.

Menu Bar for Windows

The menu bar is the task bar displayed at the top of every window. It is characterized by many buttons representing all the different actions that can be performed on a window. Similar to Microsoft Windows application, some of the actions are:

[8] *Betjeningsfladen*, in Danish.

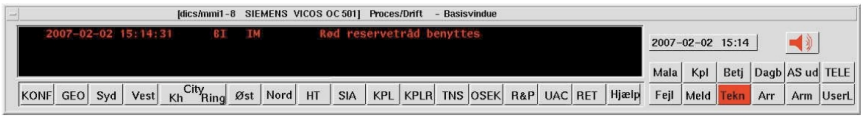


Figure 6.5: The control interface that is used as the task bar for all applications running on the user interface.

(a) (b) (c) (d) (e) (f)

Figure 6.6: Some of the window's menu bar actions: (a) Close window, (b) and (c) Panning Window, (d) Printing, (e) Online Help and (f) Scrolling

- Close Window: To close the current window.
- Panning: To widen and reduce the current window.
- Printing: To print out a page on a hardcopy.
- Picture displacement: Moving picture in the direction of the arrows in order to scroll on the window.
- Help: Giving access to an online documentation, that explains all the features and functions provided by the user interface.

Figure 6.6 shows these menu actions displayed at the top-left of all window applications.

Window Service Menu

Trains and tracks are controlled using the Window Service Menu, usually referred as SIA menu by traffic controllers. The SIA menu is a window obtained after a click on a sign or symbol on the window characteristic of the traffic. It is through the SIA menu signals are sent on tracks and at stations. It is also possible using the SIA menu to perform a rescheduling of trains. Figure 6.7 represents a SIA menu window, where the different acronyms are signals sent to tracks. There are many other SIA menu, depending on where the click was performed. In the figure 6.7, **SP** is used to block a track for a particular train, **-SP** to unblock a track. **KSTRM** is used to prevent a manual train route setting by setting an automatic route for the train contained in the roadmap. The purpose is to get trains running according to schedules. **-KSTRM** is used to remove the automatic route setting on the track.
The click of a SIA menu command activates the two commands that appears to be blurred on figure 6.7 besides **AFBRYD**. All actions are run after clicking **UDFØR**. The **UDFØR** button is located next to **AFBRYD**; the latter is being used to cancel an action. After clicking the button **UDFØR**, the button **AFBRYD** changes to **AFSLUT**, the latter is used to close down the SIA menu window.

Figure 6.7: A SIA menu window after a click on a track.

Information Messages and Dialog Boxes

The interaction between the user interface and the users is most of the time in Danish, since it is the language of communication in the control room. Thus all dialog messages are in Danish, including initials used to identify buttons on windows, such as the SIA menu or the control interface. However, not all error messages are in Danish, since the system was originally built in English, and translated to Danish, to adapt it to Danish users.

Numbers, Symbols and Signs

Numbers, symbols and signs are elements used to simplify the language, and the interaction with the user interface, enhancing a fluidity of the communication in the control room. In fact, a train is identified by a maximum number of 5-digits given at the start of a journey by train controllers. The first digit is characteristic of the traffic line, for instance line A on the S-Lane. The second is the stopping pattern, where 0 means stop at all stations. The third is the direction where 1 stands for train heading to the North/East and 2 for South/West. The two lasts provide the minutes in an hour time the train will pass the central station. On figure 6.8, the encircled number on the right, 35130, is a number characteristic of a train heading East, that will stop at Klampenborg station, represented by the symbol **Kl**. The train number starts with 3, meaning that it is the line C, and the two last digits are 30, meaning that the train stopped at the central station when it was 30 minutes in the hour the image was recorded. The second digit, 5, means that the train will not stop at 5 stations. Another characteristic of that train is the red color which is the symbol for trains, crossing a grey color, representing the track. The red train crossing a grey track is a sign of a track switching the red train is performing.

Colors on the User Interface

Colors play an important role in the distinction of events and activities being displayed on the user interface. The main color in which the user interface lies is grey, perhaps to keep it similar to the colors users were having on the previous system that can be seen on figure 6.11. Some of the improvements in the computer-based user interface is the colored identification of trains and their delays. In fact, trains are running with the red color as mentioned before; in case

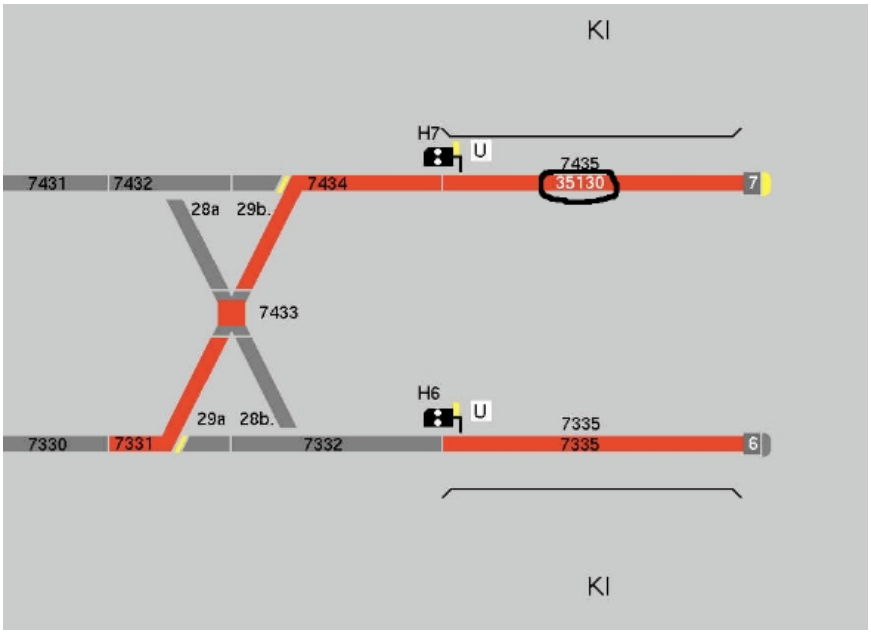


Figure 6.8: Train stopping at Klampenborg(**Kl**) station.

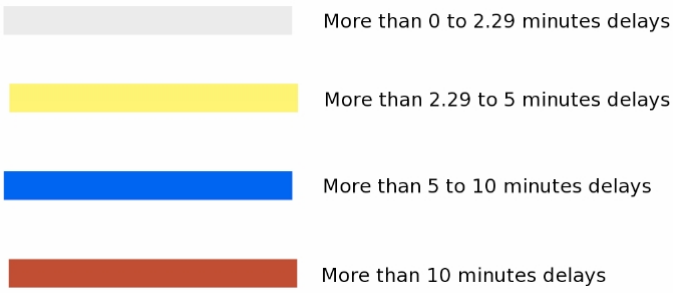


Figure 6.9: The different types of delays and their color representations on top of the train delayed.

Figure 6.10: Left: **SP** representation on a track, Right: **KSTRM** representation on a track. A track is characterized by the dark-grey color

Figure 6.11: Interface display of the new (on the left) and old (on the right) control room

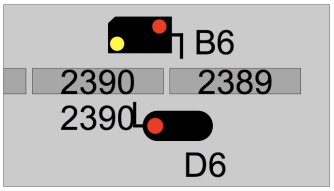


Figure 6.12: Signal representation on the user interface.

they are delayed, there are four colors representing an estimated value in relation to that delay. The figure 6.9 describes the delays and the colors representing those delays. Those delays are represented above the train delayed, helping the controller to identify immediately the delay and find ways to manage it, and maintain the traffic above 96%.
The previous commands **SP** and **KSTRØM** when executed, are represented at the border of the tracks, respectively by the colors, light-blue and bordeaux-red, as shown on figure 6.10, in case they are activated.

Signals

Signals constitute the major part of the activity of traffic controllers while regulating the traffic. In fact it is the only element that has been represented on the user interface, same as it is on the actual traffic. Figure 6.12 shows a representation of the signals on a track, through the two panels with red and yellow colors. Both signals mean stop, to trains running from North/East to South/West and vice-versa. They are controlled using the SIA menu.

It is important to note that this section introduces to the user interface used inside the control room and the information provided that will be the basis of the interaction in the network of traffic controllers together with the user interface.

Chapter 7

Evaluation of the User Interface

The evaluation of the interface was performed during the qualitative interviews, based on the observations. The qualitative interviews lasted three days, due to the fact the information provided by the users in relation to their experience using the interface were repetitive. I have to admit that sometimes I was lost in their statements, not because we were using both Danish and English in the interviews. I was sometimes lost because of their level of experience as users of the interface which was far beyond my competences, despite the reading of many papers on train traffic management system and a week of observations. I ended up reading sometimes the documentation of the user interface, to follow their statements and insure the understanding on both sides. It helped a lot in the follow-up questions I used in other interviews.

As mentioned in the early chapters, the evaluation of the user interface in the control room for the Copenhagen S-Lane, takes into account the evaluation of the usability. By usability, the main problem is to find how easy it is to use the interface in the control environment based on the prescriptions given in the previous chapter, following the characteristics of the user interface also given earlier. The next point to take into account, in that evaluation of the user interface, is the collaboration and communication. It might be certain that there are instances of collaboration and communication in the control room, since there are actions that require the involvement of controllers by the exchange of knowledge following the traffic situation, and with the use of the interface, as a participator in those actions in a form of network. The question this chapter will try to answer in relation to that will be what are the strengths and weaknesses of that collaboration and communication following the concepts related to ANT and CoP?
The management of critical situations will stand as an estimation of the user interface to cope with crises.

7.1 Usability Evaluation of BDK's Control Room User Interface

As described in the first chapter, the evaluation of the usability will stand as an analysis of the ability of the user interface to respond to the controllers requests following the five attributes of usability.

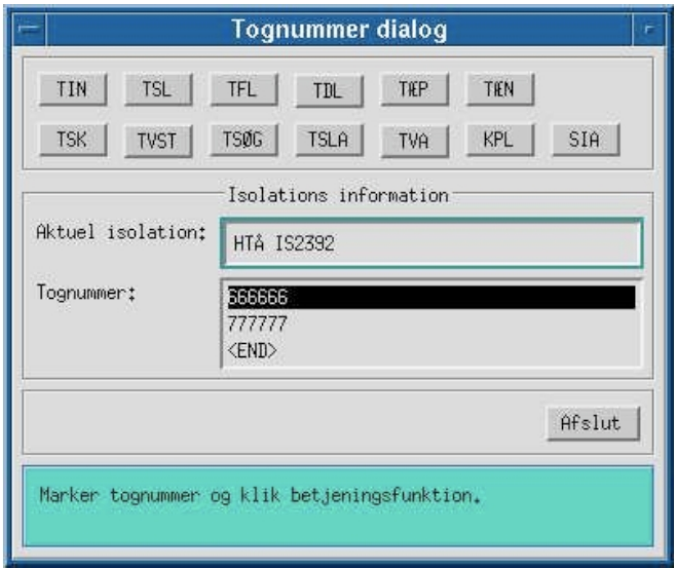


Figure 7.1: Window representing a train dialog box; it is obtained after a click on the train symbol represented on the traffic.

7.1.1 Learnability

As mentioned earlier, learnability refers to the ability of the user interface to be learned easily. In fact, the learning phase of a traffic controller is set to a period of 7 months. During those months, the future user is introduced to the user interface, and its use in relation to the management of the train traffic system. Difficulties in using what one of the old workers refers to as "modern skidt"[1], in an humorous way, depends on how accustomed the user is with new technologies and especially with Windows systems since the user interface is built in the same environment.
For those who had never been used to such systems, they felt it as a "cultural" chock, since they had to switch from the old system as shown on figure 6.11, with *two-buttons* control, replaced by the clicking in the new system. One of the interviewee feels that the menu is not clear enough, and sometimes, if he does not have a clear understanding of the menu, he does use the old way of sending signals. In fact, in the old ways, users were pressing the first button on the track they wanted to operate, and later press on the second button representing the action to undertake. With the new user interface, one simply click on the track, and get the SIA menu where the second click is directed to the action to undertake on the track. However, it can occur that an option on the SIA menu opens another window, which can be annoying if the user only want to send a single signal. This issue will be taken in the efficiency. But it is true that the user interface offers many options when it comes to use a command. For instance, the **KPL** command can be accessed on the control interface of figure 6.5, and also when a user click on the train, the same command is displayed on the window menu for trains, or train dialog box as shown on figure 7.1. On one side, it can be too much to learn, but it can also make the learning flexible so that if the future user does not understand one procedure, he/she can take another procedure.
For those who have already had access to new technologies and are quite used to a MS windows based system, the learning phase is very quick, due to the easy manipulation of the windows and

[1] In English, modern rubbish

traffic controllers believe that it is easy to understand as soon as an action has been performed once. Something interesting, that was mentioned was the first period used, when the system was new and introduced to the users. As a new system, it presented some inaccuracy in what was taught and was being performed, because the system was still under development. At present, a current learner did not notice such accuracy and thinks same as many other new controllers, that the system is easy to learn.
Acronyms seems to be easy to understand since they are Danish abbreviations of the intended function, and all the users are Danes not presenting any mental deficiency. Numbers as well seems to be easy to understand, since they are all are connected to the central station. Besides, the user interface provides automatic tools, such as **AG** or **AS**, for controlling the traffic which also simplify the learning in terms of automatic traffic management.

7.1.2 Efficiency

After the 7 months of training as traffic controller and learning of the user interface, most of the people interviewed believe that the user interface should be simple and easy to use. In fact, they refer to the ability of the user interface to run as a Microsoft Windows platform, because I could see them playing easily with the windows. Traffic controllers were controlling trains by simply clicking on an item, dragging the window, perform an action and close the window; all that performed in less than 10 seconds. One of the issues frequently raised in relation to the efficiency was the feedback response. In fact, as mentioned in the previous chapter, messages are sent back and forth from the interface to tracks and trains, through an automatic box. It can occur that the message-passing is slow and/or even lost in the interferences, making the user interface not displaying the right response from a command. Users can be confused, after clicking several times on, for instance **SNR** on the SIA menu while trying to execute a track switching, and sometimes have to call the train driver to know if the action was executed on the field. The issue of response time is also connected to the amount of clicks performed in a single task. In fact, some of the controllers believe that there are too many clicks. For instance to perform a track blocking, as detailed in section 6.3, the first click is on the track, to obtain the SIA menu. The second click is on the **SP** command and the third is on the **UDFØR**. In case the user interface displays the change on the track, then the fourth click is on **AFSLUT** to close the window. In case there are no changes, users tend to click once again on the **SP** command due the slow feedback response. Thus, an action that was meant to 4 clicks, can possibly end up with more than 5 clicks. Technically, the command was sent, but users do not have any visual element to confirm the action. Users believe that it slows down their work, especially during rush hours.
Besides the feedback response, there was the cancellation of trains. In fact, trains are very much cancelled during critical situations. Taking the earlier situation of leaves falling on the tracks, some of the trains need to be removed from the traffic to avoid accidents, due to the braking problem. The cancellation of trains is performed by the team leader. In order to do so, the team leader clicks on **KPL** from the control interface of figure 6.5, and gets a window displaying the day's roadmap, as shown on figure 7.1. On that window, the team leader enters the train number to cancel, and click **Slet** to delete the roadmap and thus has canceled the train. The issue in

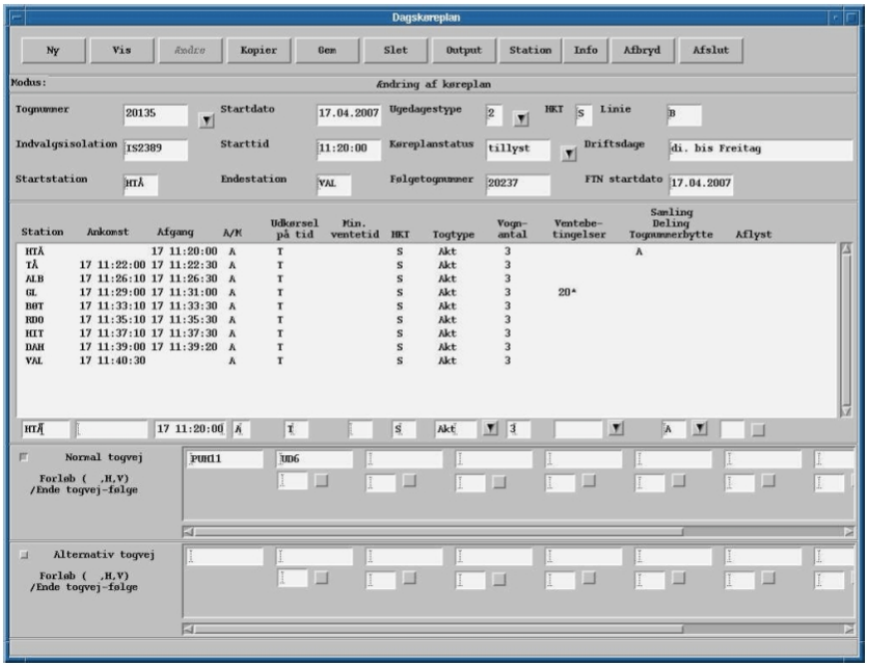


Figure 7.2: Window representation of a train roadmap for the day.

this situation is that the team leader has to do that for each train. So out of 1303 trains, if the team leader has to cancel 100 trains, he/she will have to perform the same operation 100 times. Another issue raised was the clash of colors between the **SP** and the **KSTRM** commands from the SIA menu in section 6.3. In fact, following the figure 6.10, if the two commands are activated, the **SP** color will hide the **KSTRM** color. It makes the user interface unreliable when it comes to give an overview of the general traffic.

As mentioned in the section 6.3, the user interface is built upon a multi-windows function. Users are frequently facing problems with the windows, since they pop-up at any place on one of the four screens. Taking the example of a train dialog window as show on figure 7.3. The command **TIN** is used to insert a train in the traffic. The insertion of a new train is operated through another window emanating from the train dialog window. It can occur that the window is getting displayed at another end on one of the four screens, forcing the controller to drag the window from one screen to another, or to a place where he/she can insert the data required.

All those aspects of the user interface do not necessarily mean that the user interface is bad. There is an interesting features, being named the eyes. It is obtained by clicking on the menu bar of the main window of an area. It is a graphical image representing the eyes that can be moved along the main window of an area. The eyes are always point in the direction of the pointer of the mouse. It makes it easy to find the pointer among many signs and symbols, over the four screens.

7.1.3 Memorability

As said in an early chapter, the memorability refers to the ability to remember the user interface after sometimes away. The people interviewed believed that the system is easy to remember. In fact, the question asked was whether or not after two weeks of holidays, they could remember

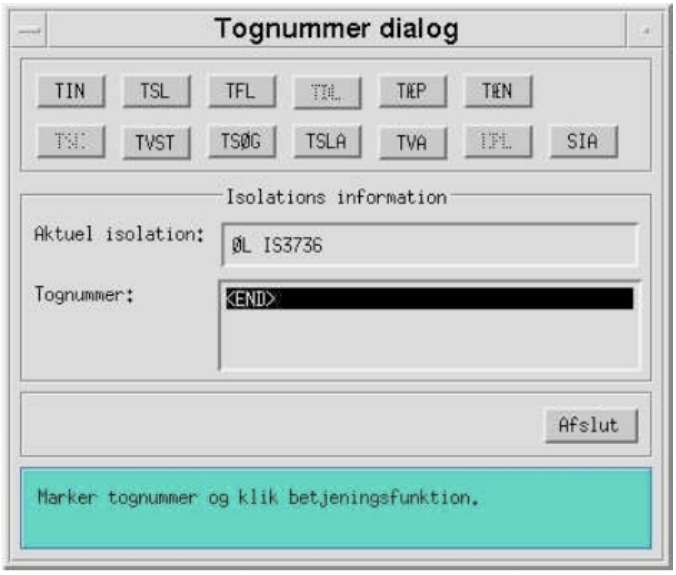


Figure 7.3: Window representing a dialog box of a train in isolation being set to run instantly.

the use of the system. The common answer was yes, and one of the controllers pointed the fact that, it is based on the fact, using the interface is their daily work. For new workers, one of the team leaders believed that, it can take some time after a holiday to remember how to use the user interface. However, the team leader believes that one hour is quite enough to remember the user interface at first sight after two weeks away. One of the new traffic controllers, shared that idea, raising some procedures such as the cancellation of trains. As shown on figure 7.2, the window used to cancel trains presents many features to remember, compared to the SIA menu window of figure 6.7 which only has buttons, with initials representing the action to undertake. In case some of the features and/or commands are not recognizable, there is an access to an online documentation[2] available directly on the user interface. A problem with the online documentation is that it takes more than 2 minutes to start opening the online document, since it is a 8.5 MB PDF-file. It is never used by the traffic controllers who prefer to *google*[3] around to have an understanding of a feature and/or command on the user interface.
During the evaluation, a user identified some of the commands barely used. It was not possible to make a list of those commands, due to the time pressure.

7.1.4 Errors

All the errors are recorded on the control interface, under the command *Fejl*. In general, errors are rare on the user interface. The few ones recorded were in relation to the user interface response time following an action. For instance, when the system is slow, users are afraid the signals was not sent and use other actions as a way to consolidate the behavior intended at first hand. They finally get two signals of the same order being sent, and the error is sent to the *Fejl* window. One of them identify those errors as irregular signals, but believes that they do not endanger the traffic. A controller says that "in case there are errors in the signal, we just

[2]See section 6.3
[3]Ask quickly other controllers

stop the train". It is true that the system is equipped with tools that permit to stop the train. Another controller believes in case there is an error, the user should simply just start all over from the beginning, which is somehow reasonable.

7.1.5 Satisfaction

To the question of the satisfaction, users are quite satisfied with the user interface at the present stage. Apart some of the issues related to the response time which in case it is slow can lead to errors. They believe that the system is appropriate to their daily task. Regarding the design, they all like the design, due to its interactivity, and the aesthetic that surrounds it, such as the choice of colors and the graphic design.
The results of the survey on the satisfaction, confirmed the approach during the qualitative interviews. In fact, as a response to the efficiency, 9 controllers out of 13 thinks the user interface is easy to use. In other terms, users have accepted the configurations of the interface, and have the feeling that it helps them in their daily work. Only 1 controller disagree, but as it was said earlier, it might be a novice user, or a user that still believe the old system was better to use in the management of the traffic. In response to the effectivity, none of the controllers is extremely satisfied with the user interface. However, 8 out 13 are satisfied with the user interface effectivity. It could be a way to certify the fact that even though the system is not quick in response time, all actions being performed are followed by train drivers on tracks. One of the controllers, referred to the train drivers as her eyes on the tracks, since train drivers confirm the actions requested in case they see changes on tracks. Regarding the interactivity, 7 out of 13 enjoy the interactivity provided by the user interface, while 1 believes it excellent. It makes the point of the aesthetic, the graphic design and the information provided to be sufficient in order to understand and share the information provided on the user interface. Regarding the functions provided, 7 out 13 are satisfied with the functions, while 6 are on the margin. It questions the ability of the functions to respond efficiently, and also the trust the users are attributing to the user interface. There are many functions in the user interface and some of them can easily being forgot in case they are not used frequently. The help/documentation does not really help in order to keep the users updated with the use of new and old functions. In relation to the experience, 8 people admits to have a good experience with the user interface, when 2 disagree. It is quite clear that the user interface is not the best interface; and one of the elements on the current interface that makes our users having a bad experience could be the feedback response time.

7.2 Participation of the User Interface in the Collaboration and Communication

As mentioned earlier, the purpose of this section will be to uncover the strengths and weaknesses of the user interface. Before that, I will start by identifying elements of ANT and CoP respectively in relation to the use of the interface in the control room.

Figure 7.4: Error Messages

7.2.1 Sharing of Tasks

It has been earlier said that, following ANT, tasks are being shared within the control room in a form of association of traffic controllers. These controllers are assembled in a form of network together with the interface in a way that the user interface display the characteristic of their actions, in a form of mediation and intermediation.
Looking at the role played by the user interface in terms of mediator and intermediary, one can identify these aspects:

- As a mediator, the user interface is capable of displaying errors messages, as shown on figure 7.4, in response to a failed action by a traffic controller. Those error messages appear to be clear in the sense that it provides information related to the error using simple words in a language that is familiar to the controller. It can however appear that those error messages are in English, since the system was built in English, making it difficult to traffic controllers to understand.

- As an intermediary, the user interface has the ability to represent the traffic controller on the actual field through its visual representation and characterization of the traffic.

The activities in the control room are thus guided by the user interface that helps organizing the train traffic network into areas. The user interface is also organized into rights and roles played by the traffic controllers in their interaction with the graphical content. In other words, a traffic controller in the City area can only have access to the window overview of the traffic system in his/her areas where he/she can perform any action. However, regarding other areas, they are only on a visual mode, meaning that the traffic controller only has an overview of the traffic while clicking on one of the commands representative of an area on the control interface. To perform an action in that area, the controller must be allowed by the one in charge of the area, and in case a controller needs help in an area he/she can remove the subarea where the help is needed and hand it over to another traffic controller. Figure 7.5 is the representation of the window for transferring an area from one controller to another. In order to do so, the controller

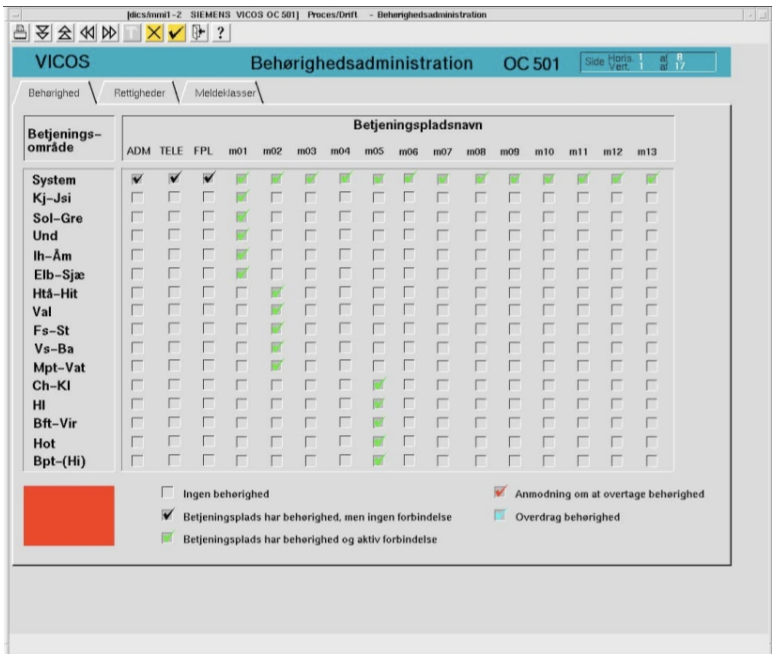


Figure 7.5: Window representing the assignation of rights to other controllers.

has to click on **RET** on the control interface window of figure 6.5 to get the window of figure 7.5. On the window obtained, the controller has three panes; the first is for the competence in the sub-areas[4] described by their abbreviations on the left side of the pane. The second pane is related to the type of rights controllers have in an area, and the last pane is related to the report classes. The different sub-areas and check marks are automatically displayed based on the information the system got from the username and password the user has entered just after clicking **RET**. On the check box next to the sub-areas to assign, the controller select by clicking, the subareas to assign after clicking on the hammer sign on the window menu bar. In case the controller wants to give some special rights, he/she can choose the next pane to assign those rights, such as rescheduling trains in the area. On the following pane the controller can change as well the report classes of the area that is welcome the subarea. After all those action terminated, all users of the interface can see the button **RET** change into red, and the checkbox of the area selected will change with a blue check mark only on the window of the user requesting help. The controller chosen via the**m01**, **m02** and so on, will have to accept the request by clicking on the hammer sign of his/her screen, and click on the blue check mark also displayed on the window, to confirm the take over. The color will then change to red on the check box, and the red color on **RET**, on the control interface, will vanish. To handover the area back to the user in charge, it is the same procedure; it makes the network being flexible and the ability of the network to provide direct collaboration and communication through sign and symbols initiated in the sharing of task.

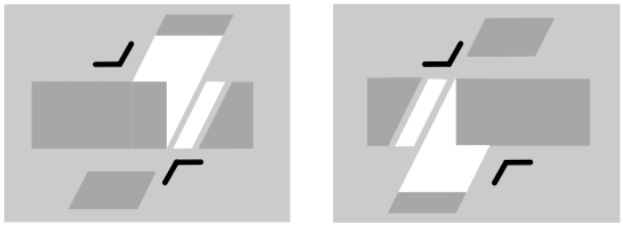
However, in the process of sharing a task, the user interface does not acknowledge any information related to the experience of the user in his/her ability to handle the area. Therefore, the user interface is opened for mismatching that could lead to a break in the network, that could

[4]They are sub-areas in the area of control. There are in total 22 sub-areas distributed over the 5 areas of the Copenhagen S-Lane.

perhaps be handled by some of the mediators and intermediaries.

7.2.2 Sharing of Knowledge

The sections 6.1 and 6.2 from the previous chapter describes events and the different people that interact to organize the train traffic on the S-Lane. The user interface is used as the center of the interaction by providing information about the trains and their situation on the traffic following a traffic schedule. In chapter 2, I presented the CoP as an association of people within a common practice where knowledge is shared.
In the control room, the dialogue over the visual content of the user interface plays an important role in the exchange of meaning. When asked about how controllers shared their knowledge using the interface, they answered uniformly by addressing to each other directly. The reason is that they find it easy to do than writing, or using a telephone interface. However, since they are sharing a common repertoire using signs and symbols from the user interface, they are not lost in the dialogue interaction. In the negotiation of meaning, controllers are all involved in discussions, by means of reification where they are to find ways to handle the traffic situation. It shows how bound controllers are with their practice, sharing the sense of togetherness. Knowledge emanates from the negotiation of meaning on the practice. The knowledge being share has to be uniform and consistent, since it is the same train that leaves the North/West of Copenhagen to its South/East. In case a train is rescheduled in the City area, it will have an impact on the traffic in the North/West and South/East areas. The user interface provides the train dialog box window on figure 7.2, that has included in the characteristics of rescheduling information about the following train. Knowing that the two last digits of a train number represents the time that train is expected to be at the central station, it can also be used as the difference of time to synchronize the access at each station the trains are set to stop.
During the evaluation, there were two weaknesses noticed in the spread of information. The first is during the shift of controllers. In fact, a shift is organized in a way that the new controller only has to sign a service control document, log-in and start using the interface. There is no problem having the paper version, but that could perhaps be included in the user interface, in a management technique that filters resolved problems and only display current problems which the new traffic controller only has to confirm before accessing any window. It is still keeping the knowledge of the traffic situation uniform and gives the opportunity for all traffic controllers to access it, in case one controller could come up with ideas related to some situations. The second weakness is the status of the documentation. In fact, the documentation used at present is the first version, dated back in 2005-2006. The user interface has been used for 3 years now, and is being updated very frequently. In other words, the information in that documentation might not be consistent with the way the user interface is used at present. The information on that documentation is static, and the knowledge of the controllers seems to be far ahead the knowledge prescribed in the documentation.
One good aspect of using the current user interface in terms of CoP is that it opens rooms for learnability. As mentioned in the previous section, the learning phase is set to a period of 7 months, where the future controller is introduced to the work as traffic controller, and the use of the interface as a work tool. After the 7 months, the future controller is introduced to



(a) (b)

Figure 7.6: (a): Representation of the blocking of a track to allow a train coming from the left side of the image to go on its left. (b): Representation of the blocking of a track to allow a train coming from the right side of the image to go on its left.

the practical use of the interface with a monitor or mentor at the introductory process. The future controller learns in the practice in the same way as an active controller following the participation prescribed earlier. In the practice, the future controller learns from the monitor, an experienced traffic controller, the different situations in which information are set on signals, such as the **ASMRK** or the **OPM**. The moment of exchanges between the future controller and the experienced controller is a moment of knowledge transfer, from the experience gathered by the experienced controller in the control room. The future controller is then expected to develop the same routine and melt himself/herself in the association of traffic controllers in the same practice, and be considered as an active traffic controller.

7.3 The User Interface and the Management of Critical Situations

Apart the 3 critical situations personally encountered described in the previous chapter, there are many other critical situations that can be encountered in the train traffic. Following the description provided earlier, in chapter 3, within the two main types of situations the problems mentioned by traffic controllers were:

1. As crises with an intentional purpose, suicide jumping on tracks and bomb threat at stations.

2. As situations with an unintentional purpose, traffic controllers admit that some of them appear to be periodically related. The icy tracks, causing the same problem as for the leaves falling, is frequent during the Winter season, including the covering of tracks by a large amount of snow. The latter does not occur that often, except in the morning when trains are back on the tracks and if it has snowed the night before. The reason is that trains are running frequently during the day on the Copenhagen S-Lane area which is a quite small area. During the Summer time, the main problem is the heating of the tracks, because of the solar ray, causing trains to derailed and tracks to be distorted, as shown on figures 7.7 and 7.8. In case there are heavy storm, cable posts can fall on the tracks, or transmission cable to the trains can be distorted, stopping the provision of electrical current inside the train, and thus stopping the train.

Figure 7.7: A damaged track switcher. The red box on the right side of the picture is the automatic box, that receives all signals from the control room user interface

Figure 7.8: Picture of a train that ran off the railway line because of the heat on the track.

As the user interface is a graphical mapping of the traffic situation, the evaluation of the management of critical situation, will be an evaluation of the ability of the user interface to provide the information in relation to the critical situations enunciated earlier, and its ability to provide the different functions that will enable a risk management of the train traffic system.

7.3.1 Risk Assessment

In terms of identification, the user interface does not provide any tool to identify situations with an intentional purpose. Traffic controllers only rely on what the train drivers say to consider a situation as critical. However, the user interface provides some tools to identify unintentional critical situations. In fact, in case there is a cable being distorted, the user interface will identify the problem by a sound, and a blinking on both **Tekn** or **Fejl** on the control interface window of figure 6.5. A click on the **Fejl** button will open an alarm list window, as shown on figure 7.9, giving a short account of the problem. The red script is representative of the unresolved problems, and the white script are resolved problems. The latter vanishes within a minute following the time the problem was resolved. The letter A is the name of the train line, the number 2 is the category[5] of the alarm, the date and time follows, including the sub-area where it occurred. The alarm line follows with the precise position of the problem and a description. Whenever the alarm log is activated on a category 2, the traffic controllers are checking a DICS configuration window, represented on figure 7.11, reporting an account of the general report of the situation of all automatic boxes, and the different transmissions between the control room and the actual field. It is an internal status of the network. The first network is the network of the communication, from the control room to the different stations, and the second network is the communication to the tracks.
Following the risk management approach for assessing a problem, from the alarm list, there is also a prioritization of the problem following a computer-based analysis of the problem. It is not quite sure the formula of 4.1 is used, but traffic controllers can find ways to manage similar problems.
Other non-intententional problems are not yet included in the alarm list problem identification. Thus, in case the tracks are very hot, only the train driver can report the problem, and management procedures are being initiated by the traffic controllers.

7.3.2 Risk Control

After the identification, the analysis and prioritization, follows the management procedure. In fact, as opposed to the risk assessment, the user interface does not provide any tool for risk control. The management procedures are followed using a reference book, always standing next to the team leader. The reference book is based on the previous problems, and the different solutions related to those problems. A management plan is established following the items listed in the reference book, involving traffic controllers and DSB agents, similar to the procedure described in section 6.1. The collaboration and communication serves as mean to share a common knowledge of the situation, and find ways to cope with the problem.

[5]There are 3 cateogories. 1 stands as an error of lower importance, 2 stands as an error in the management on the remote site and 3 stands as a serious error where a service has to be called.

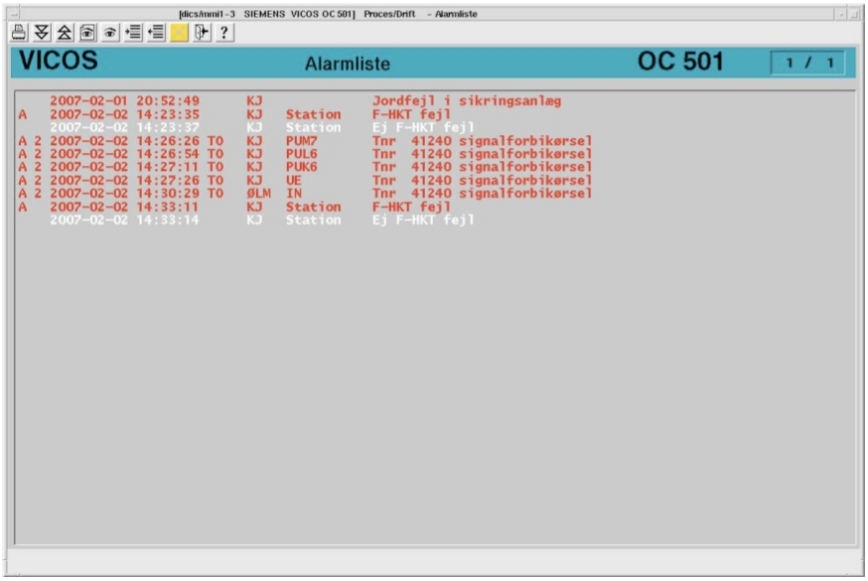


Figure 7.9: Alarm list window.

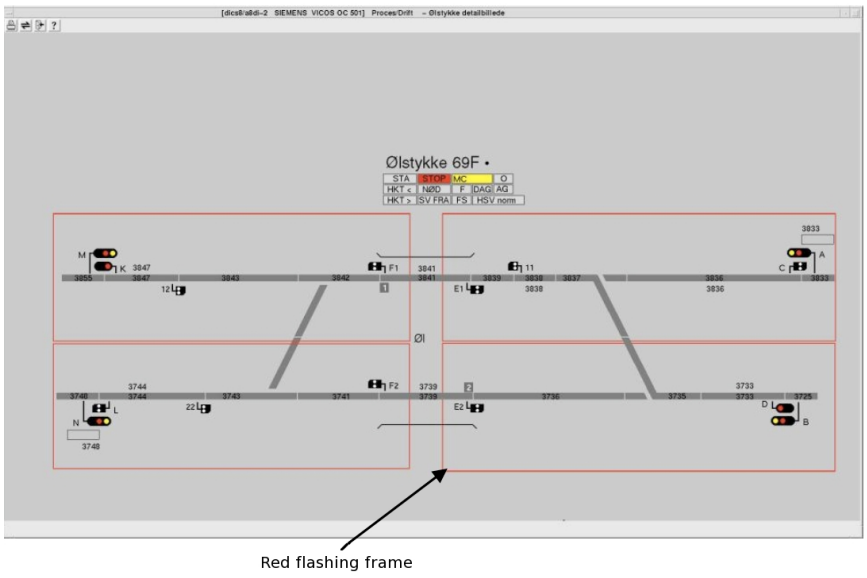


Figure 7.10: Window representing the distress resolution in an area.

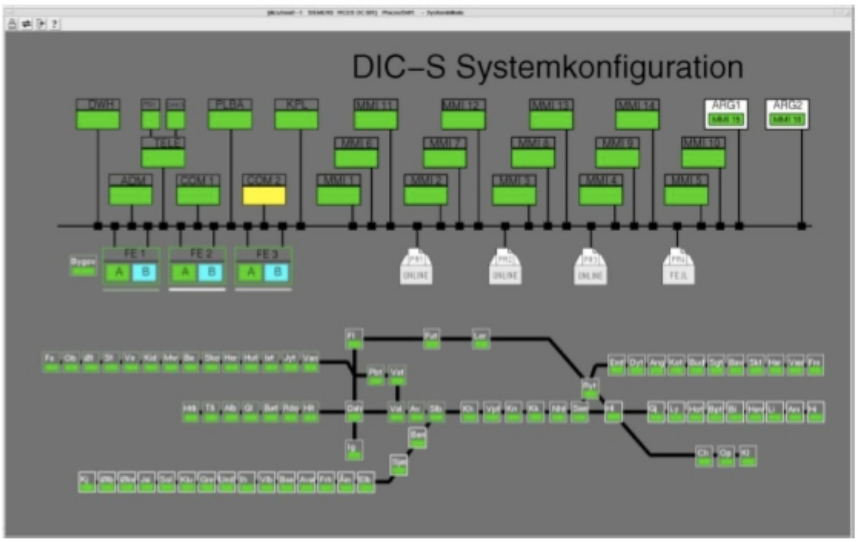


Figure 7.11: DICS System configuration

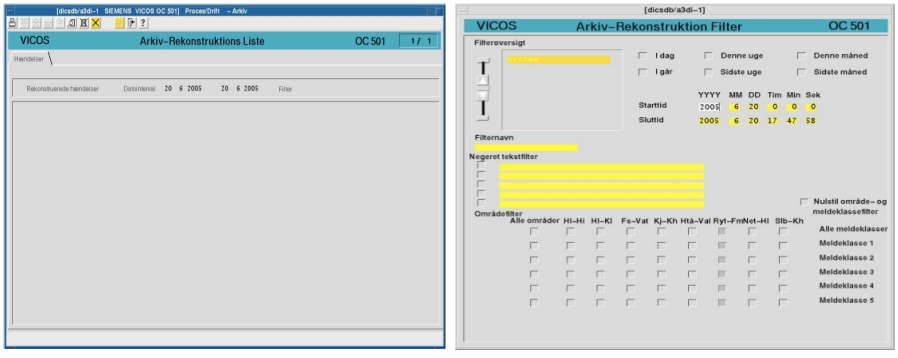


Figure 7.12: Archives reconstruction

In fact, the user interface is equipped with an automatic system recording everything happening on the user interface. Figure 7.12 is a visual representation of the archive window. The left window is the window where the event is reconstructed after input data for the reconstruction have been entered on the second window. The reconstruction is done on a frame of 15 minutes. In other words, one can request a reconstruction starting with years 2005, and month 06, with day number 20. As starting 0 could be the set. The end time can be set to the same day, and the time 1 for hour, 15 for minutes and 0 for seconds. A selection of the area will then give a possibility to click on the yellow check mark to start the reviewing the archive. An advantage of the playback system is that it helps reviewing what went wrong before the incident, and helps as well in the monitoring and control, useful to manage similar incident in the future.
A problem with the archive reconstruction is the reconstruction of specific events, such as the critical situations. In an attempt to review what happened before the fire of Allerød station, we have to wait about an hour, since the traffic controller did not remember the exact time, the incident happened. Team leaders are reporting critical events in a document external to the user interface named **RDS**, which could be useful in giving precise time of when the incident occurred to facilitate the navigation over the archive reconstruction interface.

Part III

Analysis and Conclusion

Chapter 8

Analysis and Interpretations

This chapter analyzes the elements issued in the evaluation within the aspects of efficiency, effectivity and flexibility. The purpose is to define an overview quality of the user interface in response to the traffic management.
The efficiency in prospect in this chapter is similar to the one discussed in the early chapters, with an approach on the collaboration and communication that centers the work of traffic controllers. The effectivity analyzes how the data collected during the evaluation affect the regularity of the train traffic system. The flexibility looks at the possibilities offered by the user interface to interact with the traffic controllers by means of information exchange. The interpretations will take a starting point from the network grouping of actors in ANT, and the participation each actor develops in order to enhance the fluidity of the network through the flow of information. As a reminder, actors include traffic controllers and user interface.

8.1 Efficiency of the User Interface

The multi-windows platform, in which the user interface was made, simplifies the activities of the users who have the possibility to perform several tasks at once. The simplicity in which users can perform several actions using several windows within 10 seconds strengthens the fact that the user interface is easy to learn and use. One of the challenge of such multi-windows system is the consistency in the information diffusion. The user interface is the only tool traffic controllers have, to visualize the traffic and take appropriate actions in order to make sure trains are running on schedule safely. Thus, with a direct access to access a maximum number of 8 windows at the same time, the user interface should be capable of informing about changes on the traffic system. In fact, Strøm looked at those changes within four types:

- States that the user should only be aware of without paying any attention to them;
- Changes of states of an element that is of an importance to the user to be aware of;
- Changes of the state of an element that the user should react to within a very short minute;
- Changes of state that require an immediate reaction, and that the user has ignored.

(Strøm, 2007, pp.104-105)

The first type of changes is a type where changes are only meant as awareness, such as sounds following an action from the user interface or light blinking color. Our current user interface offers such option, with a red blinking of the **Tekn** or **Fejl** button in order to insure the transmission of the message, that can be carried by controllers in case that change, will have a big influence in the traffic system. The second type of changes looks at important types in for instance an area a controller is in charge of. The size of the screens will help having a general overview of the area, and the colors characteristics to such change will help in the visual identification. In the control room for the Copenhagen S-Lane, the 4 screens are of size 19", making an area widely accessible. The user interface is also equipped with a zoom on subareas, to insure a local access of the visual content for details. The constant phones call from the train drivers help the controller locating faster the sector of concern. The third type is similar to the delays in chapter 6, where trains delayed had a colored mark over them; whereas on the last type, it could be a blocked station similar to the case represented on figure 7.10, which is characteristic of a situation where all controllers are aware of an procedures such as rescheduling should be performed in order to avoid the distressed area. The only problem noticed during the evaluation process was the feedback response following an action purposed for a state change. As the information flow between the controller and the machine is slowed down, it influences the efficiency of the user interface. But that is only during rush hours. However, the interaction between controllers and user interface is harmonious since controllers develop some familiarity with the interface by being able to understand the signs, the symbols, the messages and the numbers. The consistency of the information in the diffusion makes the user interface participates in the fluidity of the network, by providing information in case there are changes in the network.

8.2 Effectivity on the Train Traffic System

As mentioned in the previous chapters, controllers are engaged on a networked interaction with computers through the user interface following the train traffic and keeping the regularity above 96%. The effectivity of the performance of the user interface can be viewed as its impact on the train traffic. The networked distribution in areas makes the management more simple for controllers and contributes on making the traffic effective in its entirety. A problem could have been the transfer of trains from one area to another, but it seems to be managed quite well since whenever a train leaves an area with a problem that will be reflected in another area, the controller is directly informed about the situation.

The delays in feedback responses, accused by the user interface, seems not to directly affect the traffic because a signal sent is sent once. The problem is only on the user side who is distracted by the actual state of the system seen from the user interface, apparently not providing a real time representation of the traffic. The collaboration and communication with other controllers can become limited during rush hours through the user interface, due to some accuracy in the control of the train traffic. In such situation, the management of critical situation can also be influenced by the delays in feedback responses, since it can create a break over the correspondence on the network among traffic controllers, and thus affect the train traffic. During rush hours, many messages are being sent through the user interface and it should be able to be configured in a form of WYSIWYG. An advantage with such configuration is that it gives users the ability to

notice all actions being undertaken, and in case there are errors, take rapidly corrective actions. Another issue that could influence the effectivity of the traffic is the access to the help option. In fact, a single click gives access to a document of 367 pages, rather than a quick help. A suggestion will be to simplify the documentation to another window with a search option giving the possibility to the user to access directly the item(s) for which the user turned to the documentation. An advantage of such feature is that it makes the responses to situations on the screen more effective, by providing a system that will do the search on the document, and provide in an effective way the answer corresponding to the entry item of the search. It has an impact on the decision making by making it fast and dynamic with the purpose of keeping the regularity up to its normal rate.

8.3 Flexibility using the User of the Interface

According to Dix et al., "the flexibility refers to the multiplicity of ways in which the end-user and the system exchange information" (Dix et al., 2004, p.266). It is concerned with the dialogue interaction, the tasks migration and manipulations, and the customization to adapt the user interface to circumstances or conditions comfortable to the users.
The dialogue interaction between the user interface and the traffic controllers is done through signs, symbols, colors and numbers displayed over it. The user initiates the dialogue by clicking in the area he/she wants to manage, and the user interface respond by displaying the status in that area. However, even though the system is built on multi-windows platform, another aspect of the flexibility, only 8 windows can be opened at the same time, preventing the flexible navigation over many windows. The user interface is also very flexible in task management. As presented earlier, it allows to pass subareas in the network in a form of task migration, and other users can have access to other controllers areas. The access in another area is limited to views. Thus to perform an action, a user should get the right from the controller in charge of that area. It is efficient, by keeping tasks managed by only one person, and can also help keeping the management of the area in the archives. The general traffic can also be viewed, and the user interface allow the zooming on train stations. On the other hand, the user interface does not allow any customization. A customization for instance could involve the change of the colors or the types of windows, for a custom outlook. It seems to be a nice feature, but since the user interface is new in the control room environment, it is perhaps better to limit the flexibility. The purpose is to simplify the use of the interface by providing a common interface, a common basic understanding of the features in order to avoid confusion, and facilitate the continuity in the learning for the new users.

Chapter 9

Conclusion

This report is set to be an evaluation of the user interface used to control and manage the train traffic on the Copenhagen S-Lane area. The evaluation was performed within three aspects; the usability, the collaboration and communication and the management of critical situations. All three aspects were focusing on the user interface in order to examine its contribution to the management of the train traffic. The usability studied whether the facilities and tools provided by the user interface are easy to use, to understand, and also whether users are satisfied in their interaction with the interface. The collaboration and communication studied the means offered by the user interface to establish a communication between the user interface and the traffic controllers. The interaction between the traffic controllers and the user interface is that start of the collaboration and communication to manage the train traffic system with an active participation of the different actors in that management. The participation was characterized by the sharing of knowledge, related to the information gathered on the screen and sharing of task characterized by the different actions taken by controllers and the contribution of the screen in the network Controllers - User Interface - Train Traffic. The management of critical situations looked at the tools provided by the user interface to assess and control critical situations. Critical situations here were identified as crises and risks; in other words, any situations that could endanger the traffic in the form of threat or surprise, whether it is intentional or unintentional. It was later realized that collaboration and communication play as well an important role in that management, through the ability of traffic controllers to negotiate meaning under an issue presented by a situation, create knowledge regarding an unexpected situation, and spread the knowledge among themselves to establish a common level of management.

From the data collected during the evaluation, it was analyzed that the user interface is effective in the management of the train traffic. In fact, based on the tools used to manage the traffic in the old control room, the present interface used in the computer-based control room presents the same impact in the organization of the traffic, with respect to the events following an action. Such events are evaluated through the regularity of the the traffic that is most of the time above 90%. In order words, trains are running efficiently following the scheduling and rescheduling performed, including other actions that are part of the management with the user interface to keep the traffic running into schedule. The collaboration and communication help in the transmission and exchanges of the information provided by the user interface, that are to consider

in those actions on the user interface. Both, as said earlier, are integral part of the management of critical situations, when it comes to decision-making. On the other hand, despite its ability to provide a large amount of user's tools, the user interface is lacking some efficiency in the feedback response following an action. It is very frequent during rush hours situation, since many actions are being performed and the user interface has to display a consistent amount of information all along the network. Such delay could eventually affect the collaboration and communication, by slowing down the knowledge distribution of the traffic status, and the negotiation of meaning with respect to the situation presented. In the aspect of critical situations, the delay will also affect the identification, the analysis and the management of the situation. However, during other hours, the response time seemed to be sometimes fairly acceptable, perhaps under the 0.1s as mentioned by Nielsen (Nielsen, 1993, p.135). Meanwhile, the access to the documentation does not help in the sharing of knowledge, since it can take more than 2 minutes to open the pdf-file document representative of the help users are set to look in case they have problems in their use of the interface. To get help, users are asking questions to each other, which is an effective aspect of communication, but displays the limitations of the user interface to assist the user in the use of the interface. Moreover, the use of some functions slows down some of the actions performed by controllers, when it comes to send signals, and control application windows. Such problems affect controllers in their speed of use of the system. Most of the functions are understandable by users. Signs, symbols and numbers are actually part of the formation as traffic controllers; so novice controllers are not lost in the common repertoire created in the control room. Besides, the user interface allows some flexibility in terms of task migration, allowing experienced users to take over subareas in which novice or less-experienced users have difficulties. Such flexibility gives more room for participation in the network Controllers - User Interface in response to the management of the train traffic. Moreover, the user interface provides several ways of accessing frequently used commands. For a command such as **KPL** used to set, see and cancel the schedule of trains, there are several ways of accessing and running the command. The first is from the control panel, the second is by clicking on the train, the third is by clicking on a station. Users thus do not need to memorize several procedures leading to frequently used commands. Status about a train schedule can thus be accessed through the flexible means offered by the user interface configuration. The flexibility can be viewed as an element of satisfaction; since it is another way of the user interface to allow interaction in the access to the knowledge of the traffic situation and the management by means of actions following the knowledge of that situation. During the survey, none of the person that answered the questionnaire did claim a bad experience with the user interface; one of the reason might be the capability of the user interface to be opened for the users to access certain information and carry certain actions.

The major contribution of the user interface in the management of the traffic system is that it provides detailed information of a specific status and a specific situation of the trains, the tracks and stations in the Copenhagen S-Lane. The methods to access that information are interactive, and contribute in the efficient, effective and flexible management of the train traffic system. The message displayed in the interaction is consistent, and it is that message which gives rooms for collaboration and communication, through participation and discussions, for a better management of the train traffic system. Taking the example of trains, the user interface provides

an information about a specific train position. A click on that train lead to detailed information about that train such as the schedule of that train for the day, the number of passengers' wagons, and more, through an interactive set of windows. The detailed information are processed in the network of controllers (including the DSB crew) following a visual analysis of the current status of the traffic and the detailed information of other trains, tracks or/and stations. The user interface also contributes directly in management of the train traffic by providing buttons that influences directly the train traffic. From the user interface, one can stop a train (**STOP**), switch tracks (**LA**) to direct trains and also set an automatic station operation (**AS**) to control the trains stopping at the station following a predefined schedule. The actions being performed in the use of those buttons through the interface are influenced by the detailed information provided and by the tools and functions provided by the user interface relative to the organization and management of the train traffic.

Some of those tools and functions can be subjected to improvements in order to enhance the efficiency of the user interface and facilitate the distribution of the detailed information, by adding more interactive tools. The next chapter discusses such improvements and relates them to the future perspectives in the topic of user interface evaluation for control rooms.

Part IV

Perspectives

Chapter 10

Suggestions and Perspectives

At the end of the evaluations, several elements were considered to be developed as an improvement of the current user interface. One of the questions that remains unanswered is how to avoid an information overload for the traffic controllers?
This chapter is built over the concluding remarks of the evaluations taking into account the different elements that will enhance the development of the user interface on the user perspectives. It includes sample interfaces of mockups built in relation to the tools and functions provided by the user interface, taking as a starting point, the different suggestions on the user interface evolved at the interviews. The mockups will be presented and discussed including their impact in the use of the interface. Their contribution in the management in the train traffic, on the user interface is on the efficiency in the speed of execution when it comes to use the windows and buttons. Moreover, they contribute to the spread of knowledge and a dynamic management of that knowledge when it comes to inform about a status, and get the necessary tools to support users in a response to a situation. The elements suggested have been subjected to two meetings, the first with the staff of BDK and the second with some controllers, who, at some point were reluctant at the beginning of the evaluation, but were both satisfied with the suggestions.
This chapter goes over a short discussion about the suggested items and ends with the perspectives in relation to further researches in field of evaluation of user interfaces in control rooms, by presenting two aspects for further investigations as an assumption for this present evaluation.

10.1 Suggestions on the User Interface

During the evaluation I have been suggesting many elements that could be supplemented to the user interface, based on the influence that those new elements will provide in the user interface and their contribution to the management of the traffic. Some of them were the use of CCTV monitors to provide a real-time view on the tacks or/and stations, to break down the limitations over signs and symbols provided by the user interface. The CCTV monitors should not be displayed everywhere, but at certain places, such as stations, so that in case of suicidal events, controllers can have a physical view of the situation and can reorganize the traffic based on that view. Moreover, to make the user interface more flexible, I suggested an online-report of errors directly linked to the user interface. The advantage of such system is that it makes the traffic controller participate actively in the improvement of their main tool of use in the network

(a) (b)

Figure 10.1: A sample display of an improvement to the SIA menu buttons. (a) represents a selection of two buttons and (b) represents the deselection.

Controllers - User Interface - Train traffic. Such feature will help avoiding cases of unreliability due for instance to the choice of colors (section 7.1).
In the following I divided two types of activities, to simplify the understanding, in which the improvements could focus on.

10.1.1 Activities in the Use of the Interface

The activity in the use of the interface represents the different activities that are being undertaken while using the interface. Some of the items suggested are improvements of the existing items.

SIA menu Buttons Control

In chapter 5, I have introduced the user interface configurations with some of the features, such as the SIA menu window. In the latter chapters, I mentioned that the SIA menu is the most used window, since it is holding all the commands that are used to perform actions on the actual field. A problem with the SIA menu is that it does not tell whether or not one has clicked, to select an action, which could cause some inconsistency with the use, in case the system is slow in feedback response. Figure 10.1 displays two pictures, where on (a), there is a picture of buttons when it is clicked. (b) shows the display of buttons when they are un-clicked. An advantage with such window is that it let knows the user about the choice of a command visually.
In order to run the command(s), the user only have to click execute, and the window will close. The point with such process is to reduce the number of clicking raised in the chapter 6. The cancel button is meant for canceling the process of using the SIA menu window.

Windows Manipulations

In the perspective of improvement of the current system, the window popup is posing problems to the users since they are displaying everywhere in the screen. To manage those windows, I made a prototype simulating a follow up of windows next to the previous window opened. Figure 10.2 shows a way 3 windows could be displayed next to each other following the implementation. The solution found to manage the popup windows was to set the next window, following the coordinates of the previous windows, with the originate set to be the center of the screen. With such approach, there are expectations that all windows will be seen, and user will not need to drag windows from one screen to another.

Figure 10.2: A display of windows to manage the popup at any place.

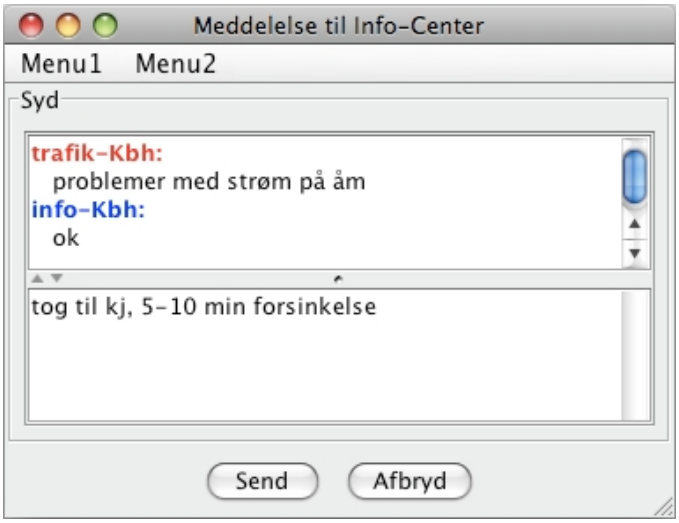


Figure 10.3: A prototype chat messenger to break down the loudly voices and save the communication between controllers

Communication Interface Panel

In chapter 7, it was suggested an interface for managing communications, such as a messenger interface window, that could be part of the control interface with initials **Msg**. The purpose of the messenger interface is to establish a direct communication with all controllers and DSB agents. Since DSB agents are set to use the interface that is subjected in this report and being evaluated, the communication panel could be part of the administrative computer. As one can see, on the prototype figure 10.3, the messages have to be short, and set for directly point to the people in the area concerned by the messages.

10.1.2 Assistance in the Use of the Interface

The assistance in the use is mainly focusing on the documentation, and one way of assisting the user in the use of the interface.

Quick Help

In order to replace the help menu provided by all the window applications, Figure 10.4 shows a prototype of a help menu window that could be accessible at any time. The window is connected to a database that has essential tools required to manage the help menu. The texts entered are directly related to the user interface, and the explanations provided at the bottom should be very precise. An advantage with such system is that it enforces the learnability, and keep the

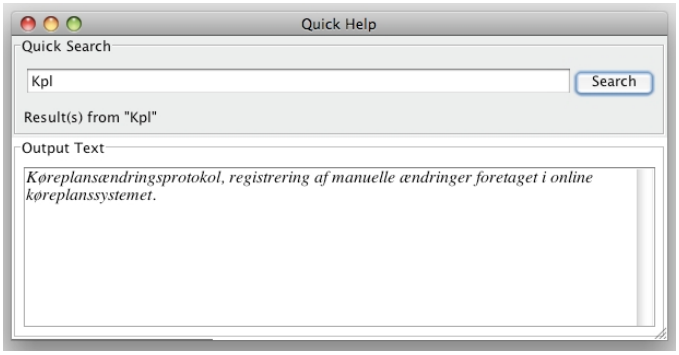


Figure 10.4: A prototype of the quick help window.

information regarding the user interface shared among the users. Moreover, accessing it is fast and easy.

Online Documentation

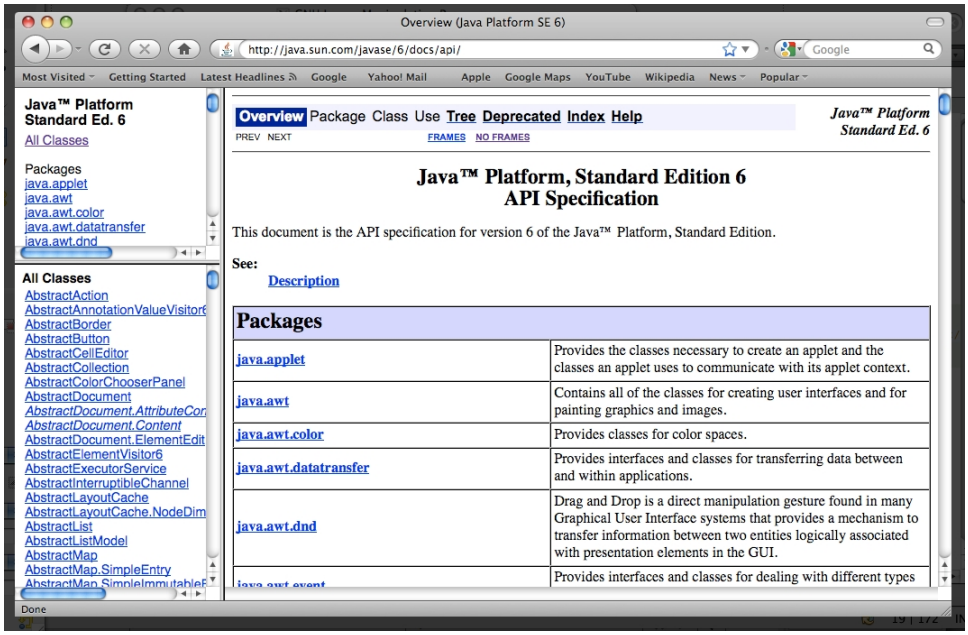
The online documentation is not recommended to be part of the user interface since there is already a quick access to help. In fact my suggestion for the documentation will be to follow the Java online principle as shown on figure 10.5.a. The advantage of such documentation is the fact that it is an online based documentation, that is accessible at any moment. Moreover, it is possible to supplement it with an item for suggestion, as shown on figure 10.5.b. The suggestion text area will be connected to the management team that is in charge of the update of the system. The purpose is to make the documentation flexible, reliable, dynamic and user friendly at the same time. Moreover, further development of the mockup of figure 10.5.b could involve elements for getting the online version of the documentation into a pdf-file version.

10.2 Discussion over the Suggested Items

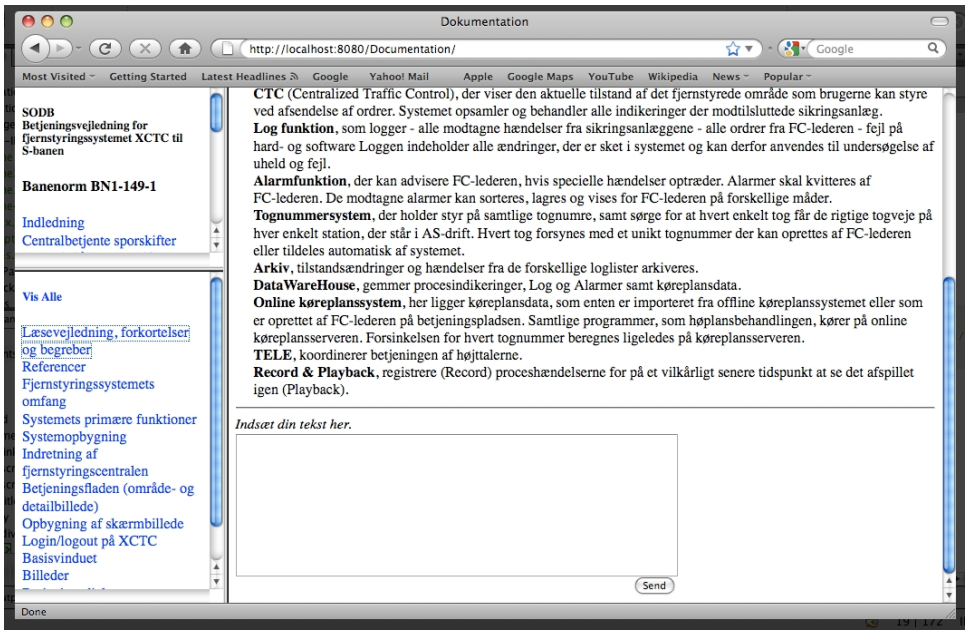
The items presented earlier have been presented to BDK during formal meetings. Unfortunately the meetings were not recorded due to some privacy. But interesting aspects during the presentations evolved and will be discussed within the main scopes of the evaluation.

10.2.1 On the Usability

The programs presented earlier do not have a major impact on the learnability aspect of usability since controllers have a general feeling of the ease to learn when it comes to the user interface. However, some of the programs mocked up support the learnability and the management of errors, during the actual use of the system. In fact, the quick help option represents the documentation in case of need on a quick access, with short and precise sentences. In the management of the traffic, in a situation described in section 6.1, the quick help prevent from calling other controllers, and help in decision making when it comes to efficiency over a task to perform. The flexibility of the documentation is related to the satisfaction over the user interface, since it provides tools for commenting the user interface, and its behaviors regarding the management of the traffic.



(a)



(b)

Figure 10.5: (a): A Java Online Documentation Interface. (b) From a sample mockup, the text area for comments and/or suggestions regarding the documentation in relation to the actual use of the interface.

The windows display and the buttons control improve the efficiency of the interface enhancing a quick use of the items provided.

10.2.2 On the Collaboration and Communication

In the aspects of collaboration and communication, the documentation enhances the sharing of knowledge. The documentation is an online document on which controllers can comment the different uses of the interface in relation to the functions and configurations. It is a document that is opened for the participation of any controller, with a mutual engagement in the practice of traffic management. The signs, codes, symbols and numbers are characteristics of the common repertoire that could be understood by any traffic controller. Another program that is enhancing collaboration and communication is the messenger window. In fact, the messenger window as a communication gives room for the knowledge exchange when it comes to provide information about a specific situation on the traffic. It is also the panel for discussion. The help option only participates in the collaboration and communication by providing the information about the tools needed in order to discuss the management of a specific situation. However the information is defined in a shared repertoire, where the participation of all the actors (including the user interface) through the online report helps in the dynamic evaluation of the tools that contributes to the management of the traffic.

10.2.3 On the Management of Critical Situations

The management of critical situations can be influenced by the messenger interface, from which users are in touch together with other controllers about the situations without having to speak loudly. The documentation as well will contribute since it is flexible, and from it one can access the direct information needed to handle such situations. It will also be an asset to have the reference book in the same way, for an easy access of the account in relation to the situation. In case a situation is handled differently, suggestions regarding the update of the documentation could then follow after wards. The items related to the use will just increase the effectivity in the use of the interface since tools will be manipulated easily, and the direct information will be accessible just in front of the user.

10.3 Perspectives with Accounts on a Potential Transfer of Technology

In this evaluation of the current user interface used by BDK in the control room of the Copenhagen S-trains, there are some aspects that have been left aside. In fact, at the introduction, I mentioned briefly about the previous system that was using a *two-buttons* mode of management, with no graphical resolution to view and analyze the traffic. A comparative analysis of the current user interface and the old system need to be performed. In fact it will benefit old users that are switching to the new system and will provide tools to improve the learnability aspect of the current user interface that has appeared to be frightening for one of the controllers. As mentioned earlier, there are users that are not born in the digital age, and thus may have troubles

using the newly designed interface. Such comparative analysis will include them in the research, and will define rules for the design and development phases in the improvement. Another side of the interface that remains obscure is the management of the changes. The user interface is still under development and some parts of the present suggestions will probably be undertaken in the forthcoming user interface. The problem of the management of those changes in the system and the problem of acceptability, in relation to the information overload, appear to be an interesting area of investigation for potential adjustment with the evolvement of new technologies. A central aspect in both research area is the information provided by the user interface and the way that information is distributed over the network of controllers, because it is such information, that help keeping trains running according to schedule, and also keeping the train traffic safe.

Appendix A

Observation Guide

Observations' guide

This short document serves as a tool for observations. The move made in this document is following the lines of evaluation listed in the synopsis, mainly:

- Evaluation of the usability of the IT system managing the traffic on the S-Lane
- Evaluation of the collaboration and communication in the control room during the management of the S-Lane traffic system
- Evaluation of the safety on the S-Lane traffic system using the current user-interface

The first evaluation of the usability is the evaluation of the system in terms of user ability to learn, understand and use the system satisfactorily. The second line of evaluation evaluates the use of the UI in the atmosphere of a control room where there are frequent interactions between people working in the panels including sometimes train drivers. In the third line, the evaluation will follow three main criteria, I identified as elements for safety:

1. The UI is easy to use
2. The UI is reliable in a control room environment
3. Critical situations can be managed efficiently

The three factors elaborated here are aimed at encompass the three lines of evaluation prescribed earlier.

1. **Usability factors**
   The usability factors identified here are based upon Soren Lauesen works on user-interface design. During the observations, the following items will be analyzed:
   - **Fit for use** (or *functionality*).
     How does the UI support the tasks the user has to perform?
   - **Ease of learning**
     How easy is the UI to be learned by various group of users?

- **Ease of remembering**
  How easy is the UI to be learned by various group of users?
- **Task efficiency**
  How efficient is the UI in response to the user request regarding a task to accomplish?
- **Understandability**
  How easy is it to understand what the UI does?
- **Subjective satisfaction**
  How satisfied is the user with the UI?

2. **Factors for collaboration and communication in a control room**
   The focus here will be on the visual elements that centered the interaction between members of the control room with train drivers included.

   - **Social context and working environment**
     What are the characteristics of the working social environment in a control room?
   - **Functions and activities**
     What are the different functions in a control room and the activities (inter-)related to the functions?
   - **Collaboration in the network**
     How is the collaboration users - UI - train controllers?
   - **Different conflicts**
     What are the conflicts that can erect during the collaboration and communication?
   - **Critical period**
     When and how are the critical periods?

3. **Risk management factors**
   The risk management elements pointed here are stepped in a way that all critical situations (identified as problems), can be monitored in case they occur.

   - **Problems identification**
   - **Problems analysis**
   - **Problems prioritization**
   - **Problems management planning**
   - **Problems resolution**
   - **Problems monitoring**

Appendix B

Interview Guide (English and Danish)

Interview Guide with Traffic Controllers

Interviewer: Jean-Luc Ngassa

The purpose of this interview is to get the impact of the user interface in the work as traffic controller and the function requirements within three prospects. The first is the prospect of usability of the system. In fact working as a traffic controller requires some training; how is it performed and how is the relationship to the user interface in terms of daily use of the system. The second prospect is the use of the interface for collaboration and communication with other members of the crew in the control room. The purpose is to look at that collaboration and communication in terms of share/management of knowledge and share/management of activities by using the user interface. The third prospect is the management of critical situations using the interface. Critical situations are identified as situations related to track problems and different kind of train problems.
As a reminder, the focus is not the people working, rather it is the use of the current interface for distant automatic traffic management for trains and their control. The main perspective is a better user interface to accomplish the work as traffic controller.

1 General considerations

1. Can you tell a little bit about you and BaneDanmark?
    a) Background
    b) Working years as traffic controller

2 User interface configurations

1. Learnability: Was it easy to learn the new user interface?
   For instance, the acronyms after a right click.

2. Efficiency: How efficient do you think the user interface is in response to a task?
   For instance, performing two track switches.

3. Memorability: After two weeks, not using the system, can you remember the user interface configurations and how to use it?

4. Errors:

   a) How much errors have you done with the current system?

   b) How severe were they?

   c) How can you recover from your errors using the interface configuration?

   d) What do you think about the error messages or signs on the current user interface?

5. Design and Aesthetic: What do you think about the design of the current user interface?
   Do you think the texts on the screen is understandable?
   Can you easily manage the navigation among all the screens and all the windows opened on a screen?

6. Satisfaction: How satisfied are you with the current user interface?
   Do you think there are some functions missing?

3 Collaboration and communication with the user interface

1. Share of knowledge: How do you report to other controllers or team manager by using the panel of screens?

2. Share of knowledge: How do you get assistance with the user interface in case of quick help?
   How is the access to the documentation?

3. Share of task: How do you organize the traffic by regions?
   (Can you take over someone else region while controlling your own region?)

4. Share of task: How is the collaboration with DSB (including train drivers) organized from your user interface configuration?

5. Share of task: How is a take-over performed on the user interface perspective?

4 Critical situations management using the user interface

1. Crisis management: What are the critical situations you have experienced?

2. Crisis management: How do you deal with the user interface when a problem occur on a track?
    a) Problem identification
    b) Problem analysis
    c) Problem prioritization
    d) Making a management plan
    e) Problem resolution
    f) Problem monitoring and documentation

5 Perspectives

1. In the perspective of changes in the current system, what would you recommend?

Interview Guide with Traffic Controllers

Interviewer: Jean-Luc Ngassa

Formålet med dette interview er at få virkningen af brugergrænsefladen i arbejdet som trafikkontrollør og funktion krav inden for tre perspektiver. Den første er udsigten til anvendeligheden af systemet. I virkeligheden arbejdede som trafikkontrollør kræver en vis uddannelse, hvordan det udføres, og hvordan er forholdet til brugergrænsefladen i form af daglig brug af systemet. Den anden er brugen af grænsefladen for samarbejde og kommunikation med andre medlemmer af besætningen i kontrolrummet. Formålet er at se på, at samarbejde og kommunikation i form af aktier / forvaltning af viden og udveksle / forvaltning af aktiviteter ved hjælp af brugergrænsefladen. Den tredje perspektiv er håndtering af kritiske situationer ved hjælp af grænsefladen. Kritiske situationer, er identificeret som situationer i forbindelse med spor problemer og forskellige former for toget problemer.
Som en påmindelse, er fokus ikke de mennesker, der arbejder, men det er brugen af den nuværende grænseflade for en automatiske trafikstyring for togene og deres kontrol. Det vigtigste perspektiv er en bedre brugerflade til at udføre det arbejde som trafikkontrollør.

1 Generelle betragtninger

1. Kan du fortælle lidt om dig og BaneDanmark?
    a) Baggrund
    b) Deres erfaring som trafikkontrollør.

2 Brugergrænseflade konfigurationer

1. Learnability: Var det let at lære den nye brugergrænseflade?
   For eksempel akronymer efter et højreklik.

2. Efficiency: Hvor effektiv synes du brugergrænsefladen er som reaktion på en opgave?
   For eksempel, når du udfører to sporskifter.

3. Memorability: Efter to uger, bruger ikke systemet, kan du huske brugergrænsefladen konfigurationer, og hvordan man bruger det?

4. Errors:

   a) Hvor meget fejl, har du gjort med det nuværende system?

   b) Hvor alvorlig var de?

   c) Hvordan kan du komme sig efter dine fejl ved hjælp af interface konfiguration?

   d) Hvad synes du om de fejlmeddelelser eller tegn på den nuværende brugergrænsefladen?

5. Design and Aesthetic: Hvad synes du om udformningen af den nuværende brugergrænseflade?
   Tror du teksten på skærmen er forståeligt?
   Kan du nemt styre navigationen mellem alle de skærme og alle vinduer åbnes på en skærm?

6. Satisfaction: Hvor tilfreds er du med den nuværende brugergrænseflade?
   Tror du der er nogle funktioner, der mangler?

3 Samarbejde og kommunikation med brugergrænsefladen

1. Share of knowledge: Hvordan du rapporterer til andre kontrollører eller togleder ved hjælp af panelet af skærme?

2. Share of knowledge: Hvordan får du hjælp med brugergrænsefladen i tilfælde af hurtig hjælp?
   Hvordan er adgangen til dokumentationen?

3. Share of task: Hvordan man organiserer trafikken på regioner?

4. Share of task: Hvordan er samarbejdet med DSB (herunder lokomotivførere) organiseret fra din brugergrænseflade konfiguration?

5. Share of task: Hvordan er en overtagelse udføres på brugergrænsefladen perspektiv?

4 Kritiske situationer styring ved hjælp af brugergrænsefladen

1. Crisis management: Hvad er de kritiske situationer, du har oplevet?

2. Crisis management: Hvordan kan du behandle med brugergrænsefladen, når et problem opstår på et spor?

5 Perspektiver

1. I lyset af ændringer i det nuværende system, hvad ville du anbefale?

Appendix C

Survey Guide (in Danish)

Tak fordi du vil tage din tid til at udfylde dette spørgeskema. Det handler om din oplevelse med brugergrænsefladen (inkl. det nuværende IT system) i forhold til dit arbejde som trafikkontrollør.

Undersøgelsen er anonym og tager kun 5 minutter.

Jeg er tilfreds med, hvor let det er at bruge brugergrænsefladen

(4) ❑ meget enig
(3) ❑ enig
(5) ❑ hverken enig eller uenig
(2) ❑ uenig
(1) ❑ meget uenig

Jeg er tilfreds med den tid, det tager at færdiggøre en opgaven

(5) ❑ meget enig
(4) ❑ enig
(3) ❑ hverken enig eller uenig
(2) ❑ uenig
(1) ❑ meget uenig

Jeg er tilfreds med de oplysninger, der vises på de forskellige vinduer

(1) ❑ meget enig
(2) ❑ enig
(3) ❑ hverken enig eller uenig
(4) ❑ uenig
(5) ❑ meget uenig

Jeg er tilfreds med de funktioner og muligheder brugergrænsefladen giver

(1) ❑ meget enig
(2) ❑ enig

(3) ❑ hverken enig eller uenig

(4) ❑ uenig

(5) ❑ meget uenig

Jeg er tilfreds med oplevelse med brug af brugergrænsefladen i forhold til mit arbejde

(1) ❑ meget enig

(2) ❑ enig

(3) ❑ hverken enig eller uenig

(4) ❑ uenig

(5) ❑ meget uenig

Tak fordi du tog din tid til at besvare spørgsmålene.

Venlig hilsen

Jean Luc

Kandidatstuderende på Datalogi på RUC

1. Jeg er tilfreds med, hvor let det er at bruge brugergrænsefladen

	Respondenter	Procent
meget enig	1	7,70%
enig	9	69,20%
hverken enig eller uenig	2	15,40%
uenig	1	7,70%
meget uenig	0	0,00%
I alt	13	100,00%

2. Jeg er tilfreds med den tid, det tager at færdiggøre en opgaven

	Respondenter	Procent
meget enig	0	0,00%
enig	8	61,50%
hverken enig eller uenig	4	30,80%
uenig	1	7,70%
meget uenig	0	0,00%
I alt	13	100,00%

3. Jeg er tilfreds med de oplysninger, der vises på de forskellige vinduer

	Respondenter	Procent
meget enig	1	7,69%
enig	7	53,85%
hverken enig eller uenig	4	30,77%
uenig	1	7,69%
meget uenig	0	0,00%
I alt	13	100,00%

4. Jeg er tilfreds med de funktioner og muligheder brugergrænsefladen giver

	Respondenter	Procent
meget enig	0	0,00%
enig	7	53,85%
hverken enig eller uenig	6	46,15%
uenig	0	0,00%
meget uenig	0	0,00%
I alt	13	100,00%

5. Jeg er tilfreds med oplevelse med brug af brugergrænsefladen i forhold til mit arbejde

	Respondenter	Procent
meget enig	0	0,00%
enig	8	61,54%
hverken enig eller uenig	3	23,07%
uenig	2	15,39%
meget uenig	0	0,00%
I alt	13	100,00%

Appendix D

On CD/DVD

1. Interviews
2. Mockups
   (a) Help function
   (b) Documentation
   (c) Communication Interface Panel
   (d) Windows manipulations
   (e) Signal buttons

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