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Usability of Operational systems in Train Traffic Control

Development of Indicators and Metrics for Measuring Satisfaction

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Abstract

Usability of Operational systems in Train Traffic Control

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This study focuses on how to define and measure usability in systems used for operational train traffic control. The study is conducted as a project for the Swedish Transport Administration (Trafikverket); the authority that is in charge of the train traffic in Sweden. The train dispatchers are the ones that control the train traffic. Their job includes much decision-making and problem solving and they need to have complete control in each situation. The systems used for train dispatching therefore need to be designed to comply with human cognitive capabilities and skills, to support the users in their work and also to be well adapted to the work tasks of the dispatchers. It was therefore decided to evaluate the usability of the systems by looking at how well they support the train dispatchers when they carry out their work tasks.

The analysis of the evaluation focused on finding indicators of bad usability in the interaction between the user and his/her systems. Such problems can affect the user's cognitive capabilities and result in unnecessary cognitive demands. Such issues can affect their abilities to control the systems and their work situation. An analysis of the social support in their work environment and their use of the systems was also conducted.

The analysis showed that the systems used today had indicators of both good and bad usability. The usability issues that were found caused cognitive work environment problems for the users. Problems like tunnel vision, short-term memory load, orientation issues and unnecessary cognitive workload was the most distinct ones. To investigate further the specific systems used for traffic control, an evaluation instrument was developed. The purpose of the instrument is to be used by the authority to evaluate the usability in their operational traffic control systems. The evaluation of the systems' usability will give greater insight and knowledge about how it actually affects the user's work situation and cognitive capabilities.

Key words: Human-computer interaction, usability, train traffic control, train dispatcher, cognitive work environment problems, psychosocial work environment, techno stress, evaluation instrument USOT.

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Populärvetenskaplig sammanfattning

Hög kognitiv belastning och behovet av ständig kontroll är faktorer som kan orsaka stress eller andra hälsoproblem i olika arbetssituationer. Dessa faktorer uppkommer mycket ofta i arbetssituationer där beslutsfattande och problemlösning är vanligt. De orsakas ofta av en brist på stöd i den psykosociala arbetsmiljön och i synnerhet i datorbaserat arbete om stödet från de tekniska systemen är undermåligt. Forskning har visat att om system inte är utformade på ett användbart sätt så kommer det att ge resultat i form av sämre prestationer, säkerhetsrisker, höga felprocent, låg tillfredsställelse och stress.

Tågklarerare är de som arbetar med att styra och planera tågtrafiken i Sverige. Deras arbetsuppgifter innefattar mycket beslutsfattande och problemlösning och de måste ständigt ha kontroll och kunskap över varje situation. De system som används vid styrning och planering av tågtrafiken måste därför vara utformade enligt principer som är anpassade efter människans kognitiva förmågor och färdigheter, för att stödja användaren i sitt arbete och också vara väl anpassad till de arbetsuppgifter som tågklareraren har. Att utvärdera användbarheten i dessa system gjordes därför med avsikten att utvärdera genom ett psykosocialt perspektiv för att se hur användbarheten påverkar användarnas kognitiva förmågor. Användbarheten av de system som används för att styra och planera tågtrafiken har utvärderats i denna studie som ett projekt för den svenska myndigheten Trafikverket. Användbarheten observerades och analyserades genom en arbetsplatsstudie med observations-intervjuer med tågklarerare. I analysen fokuserades det på att hitta indikatorer i samspelet mellan användaren och hens system som skulle kunna påverka användarens kognitiva förmågor och genom det ställa krav på hens kognition och som skulle kunna påverka deras förmåga för kontroll i systemen och i sin arbetssituation. Analysen fokuserade också på vilka möjligheter till stöd som de kunde få från sin arbetsmiljö och i deras användning av systemen. Analysen visade att de system som används i dag hade indikatorer för både bra och dålig användbarhet. De användbarhetsproblem som hittades visade att de orsakade kognitiva arbetsmiljöproblem för användarna. Problem som tunnelseende, belastning på korttidsminnet, orienteringsproblem och onödig kognitiv belastning var de som stod ut mest. För att vidare undersöka de specifika system som används för trafikstyrning, har ett utvärderingsinstrument utvecklats. Syftet med instrumentet är att det skall användas av utvärderare med tidigare kunskap inom människa-datorinteraktion, arbetsmiljöforskning eller människa-teknik-organisation. Instrumentet ska då användas för att utvärdera användbarheten i de operativa trafikstyrningssystemen som används av Trafikverket. Utvärderingen av användbarhet i de operativa systemen kommer att ge större insikt och kunskap om hur användbarhet faktiskt påverkar användarens arbetssituation och kognitiva förmågor vilket bidrar till nytta för myndigheten då användarcentrerad utveckling vidare kan ske.

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Chapter 1

Introduction

The Swedish Transport Administration (Trafikverket) has since 2010 been responsible for long-term planning of the transportation systems for railway, road, air and sea traffic. The authority has today eight regional traffic control centrals around Sweden. This study only focuses on investigating those traffic control centers that are in charge of the train traffic control. The train dispatchers are the people who work in the operational centers to optimize and control the train traffic. They control all actions needed for the trains to move in an optimized way, from controlling signals, gears and railway. The train dispatcher needs to take the time-schedule and safety into account when making decisions about the train traffic. However, factors like technical problems; cancelled trains, weather issues or contractors working on the tracks are constantly changing factors that the train dispatcher also needs to take into account.

The structure of the work environment is important so that it supports the train dispatchers' work situation. The conducted work can many times be intense because they need to make many fast decisions to be able to control the traffic. The actions to control are conducted within an interaction between the train dispatcher and the computer- and paper based systems they have in front of them. The increasing demands on the train dispatchers to have optimal control and knowledge of their whole work situation, makes it crucial that the systems fulfill the requirements of usability (Salvendy, 2012) and are usable and supportive. It is because of this important to investigate and focus on the usability of the interaction between the systems and the train dispatcher. The systems need to be designed to comply with human capabilities and skills and to be well adapted to the work tasks of the dispatchers. It is also important that the systems support the human's cognitive conditions, work processes and decision-making in different situations. If the systems are not designed in a usable way, according to the requirements of the user, it will give results of low user performance, safety risks, high error rates, bad user satisfaction/acceptance and stress. Because usability in systems, within computer-based work, has over the years become more noticed, it has also become more important for organizations and companies to investigate the usability in systems in their work area. Trafikverket has with this project seen the need to investigate the usability of their systems for train traffic control because of all the factors that can affect the train dispatchers' work situation. By using an instrument for evaluating the usability that is based on, and developed by, the train dispatchers' work can help the authority to make better decisions about what requirements the used systems should have to be able to support the users in the most optimal way.

1.1 Purpose of the Study

This thesis is written and conducted within a project for the Swedish Transport Administration (Trafikverket). The purpose of the study is to investigate how the train dispatchers' systems support their work situation and their work environment. The usability evaluation is based on the perspective of a cognitive work environment investigation. This will give insight into the overall fundamentals of the systems usability like efficiency, effectiveness and satisfaction, from the human perspective of cognition and how the systems actually support the user.

The aim is to develop an instrument for evaluating how the usability of the systems affects the human cognition in regard to the user's workplace. The instrument will be used to establish a baseline of the perceived satisfaction of how well the systems work in relation to the train dispatchers' cognitive capabilities and their support from the workplace. It can then be used to plan for continuity within this area based on the results. The instrument will be based on the studies of the human cognition and system usability in the train dispatcher's workplace. The study is based on the following research question:

- *"How can usability be defined and measured in systems used for operational train traffic control?"*

1.2 Delimitations

One limitation within the project is which operating area I decided to investigate. Trafikverket deals with railway, road, and air and sea traffic control. I decided to limit this project and only evaluate one of the four areas, the train traffic control, which was a decision made between me and my supervisor at Trafikverket. The target group is also limited down to the train dispatchers. This will give me a better chance of going deeply into that specific area of work.

The location for collection of data is also limited to two traffic control centers in Sweden. This was decided together with my supervisor at Trafikverket and it is because there is no need to make the first study on more than two. The result of the instrument will then be tested on more control centers in Sweden. This will give a greater insight into how the instrument can be used on a more general level, in more centers.

When working with system usability and human-computer interaction, it is important to limit what approach to take and what to look at. This project is limited to the Level 2 of usability levels (see 3.2.1), where I only investigate the interaction between the person and his/hers systems. I will therefore investigate how the systems support one individual's work situation and their cognitive workload. The purpose of this approach is to identify depth structures in the use of the systems and how these affect the train dispatcher's work environment. This approach will give a great insight into the interaction between the train dispatcher and his/hers systems and also into how the systems usability affects the whole work situation, the user's cognitive capabilities and their psychosocial work environment.

Chapter 2

Background

In this chapter, I present the background of the investigated environment at the authority Trafikverket. An explanation of the train control centers and a specification of the different support systems the operators' use are also presented. The chapter ends with an explanation of how the specific work environment looks for the target users of this study, the train dispatchers.

2.1 Train traffic control

The Swedish authority Trafikverket is responsible for planning and controlling the road, air, sea and railway traffic around Sweden. Information about the traffic is also being transferred out from the centers. The traffic management in Sweden is divided into different traffic management areas. There are today five distinctive areas; Stockholm/East, West, South, North and National. The operators who work inside these areas are responsible of controlling the traffic within their area. They are responsible for monitoring and controlling different factors that can affect the whole traffic and the traffic information. The area National is responsible of handling the national perspective of traffic control (von Geijer, 2014).

Divided on the different management areas are today eight traffic control centers. The eight traffic control centers around Sweden are the hubs of the authority's operations. It is within these centers traffic operators work with controlling and managing the traffic around Sweden. Each control center is regional and deals only with the traffic in their area. There are different functions within the each control center; train traffic control, road traffic control, electrical operation, monitoring facilities, train- and road traffic information. Four of the control centers (Hallsberg, Ånge, Boden and Norrköping) are today purely train traffic control centers while the centers in Stockholm and Göteborg deals with both train- and road traffic control.

There are many different functions and roles within the traffic-control centers. There are three main areas within the traffic management centers; National operative management, Regional operational management and Production places (von Geijer, 2014). This study is limited to investigating the Production places which involve the roles; production leader, railway traffic informant, road traffic operator, train dispatcher, electrical operator, electrical engineers, facility monitoring, operating technicians and especially to investigate the work of the train dispatcher.

The traffic management operational staff works in shifts, which has been shown that it can affect the operators both physically and mentally. Working in shifts affects how the information flow between operators works. It can, for example, be hard to transfer information about how the traffic has been during the day to someone who works in the evening. This can be seen as heavy workload for many operators (von Geijer, 2014).

2.1.1 System support for traffic operators

Every traffic operator has support from distinct systems within their work of traffic control. These systems have different purposes, and they are not all used together or at the same time. Below is a description of the systems used in different areas in the traffic-control centers. The descriptions below is found and defined in von Geijer (2014):

Traffic Information

- **Planno**

This system is an information system that is used for displaying advertisement information about trains, information that will be shown on signs, which will be called out on stations etc. This information is put into the system of the operator every time a new train plan is set. Changes about the train plan are also put into this system.

- **Anno**

The operators work inside Anno with the operative work of the advertisement information. What is planned in Planno is a ground for this operative work. The traffic informants can work inside Anno with the advertisement information within the operational period.

- **Basun**

Basun is a system that supports the handling of events, like delays of trains etc. An operator working in Basun can also get the information about the events out to others. This system makes it easy to communicate both internal and external via so called Basun-messages.

- **TRISS**

TRISS stands for Traffic Information Support System and is the national system that is used for handling of national, dynamic traffic information at Trafikverket. Different stakeholders can via TRISS automatically get information about the situation on the road. All the information within TRISS comes from SOS Alarm, the police, individual traffic users, the road and weather information system VViS and other entrepreneurs. TRISS is also a grounding system for NTS.

Road traffic management

- **NTS**

NTS (national traffic management support system) is a support system for decision-making. The system comes with plans for action for incidents and or events. NTS gives an insight into complex connections, which will give the user a change to solve more tasks at the same time in the same system.

Electrical operation

- **GELD**

GELD is the system Trafikverket use for electric operational management and for monitoring facilities and tunnels. GELS is the electric operation engineers support system for controlling the power supply for the railway.

Train traffic control

The different train control centers in Sweden has today three different systems for train traffic control, EBICOS TMS, EBICOS 900 and Argus. These systems are the main train traffic control systems. Nevertheless the users have some support systems with different purposes described below.

- **Opera**

This is the system that receives and presents train means to the railway companies and to other systems. The train means are the composition of the trains, the weight and the length.

- **MATS**

MATS is a computer supported telephone solution that is used within the traffic centers. The system has an integrated telephone switchboard and an application for conversational support with functionality of a global system for mobile communication for railway communication. MATS is a secure system that among other things supports communication with other control systems.

- **STEG**

STEG as a system is a prototype that is used to try a new way for traffic operators to control trains in a real environment. The traffic operator uses a computer-based graph with the timeline where the time schedules for the trains can be preplanned. Necessary railway commandos are sent out to conduct the current plan based on the time schedules that exists within STEG. STEG is used today in both Norrköping and Boden.

- **TAM 2014**

TAM 2014 is a system for documentation used by the train dispatchers to document the agreed status of the monitored distance. The agreement is between two train dispatchers, often one at the train control centers and one that control a regional station.

- **Ofelia**

The cause of errors within the infrastructure is coded into Ofelia. Ofelia is used as a support system to support handling of errors. The registration of errors, error cause and error recovery is done by the train dispatcher. This is then connected to one individual from the facility for analysis and monitoring.

- **Trainplan**

Trainplan is a support system that is used to organize and cancel trains during the operational hours. It also supports and helps out with capacity distribution in the railway tracks.

- **The paper graph**

The train traffic operators use a paper graph with information about all the trains that will go through their geographical area that they control during the whole day. The graph is a supporting tool for especially reducing errors at train meetings. The operator can read at which times the trains will leave and come into one area and then plan through that when two trains meet. This paper graph is a big support because it gives some information that the systems are not giving by themselves. For example, information about train meetings, departure and arrival times for the trains and if there is newly entered trains that need to be taken into account for when planning.

2.1.2 The train dispatcher

The train dispatchers at Trafikverket have a high level of expertise and a system for dispatching trains. For the train dispatchers to achieve the desired level of expertise, they need to go through some extensive training. This training combines both practical and theoretical elements. During the training period, they do their practical training in front of simulators where they can practice on real-life events that can occur in their future work. The theoretical elements are based a lot on learning the different elements of the work tasks but especially to learn all the rules and security regulations that exist within the work. All interactions between users and between the user-system interactions are in Swedish.

2.1.2.1 The role’s purpose, responsibilities and work tasks

The train dispatchers shall contribute to a safe and optimal implementation of the production plan within their specific geographical area, they are responsible of. This means that the train dispatchers are responsible of:

- Allocate capacity according to the production plan
- Prepare a plan for deviations in case of deviations
- Handling and making traffic deviations within their known area.

The train dispatchers has several work tasks that all relate to train traffic control in different ways. The foremost work tasks for the dispatchers are to dispatch trains through a specific geographical area as efficiently and safely as possible according to a time schedule. Their leading role is to supervise the train traffic and how it flows according to the established schedule. The work tasks can be summarized in a general way as:

- Allocate capacity according to the production plan and the plan of actions
- To document the delivered capacity
- Prepare a plan of actions according to the operational management's priorities
- Give traffic information to the train leader, traffic informant and the traffic leader
- Give the train leader information about consequences, prognosis and decision proposals about risks and deviations in regard to delivery of capacity
- Identify and report needs of corrective actions to the train leader
- Document deviations from the production plan
- Conduct tasks according to regulations and safety routines
- Participate in the process of continual improvements

The work tasks include control of the traffic but also at the same time take care of a number of deviations from the time schedule. The train dispatcher needs to handle deviations that can result in a few minutes or up to hours of delays, which then can lead to major disturbances in the train traffic. This is why one of the work goals that the authority has set on the train dispatchers is that they should control through planning. To be able to work in an efficient way, the train dispatchers need support from the systems they work in and also from their workplace.

As other operators in the traffic-control centers, the train dispatcher's work in shifts as dispatching trains is a 24-hour business. This puts high demands on the workplace because it then has to support the dispatchers' work, so they do not experience any form of workload.

The systems the train dispatchers work with needs to work as supporting systems for their everyday tasks. It is important that the systems support their work so that the workload will minimize. The systems therefore, need to be as easy and usable as possible for the user to be able to use them in an optimized way. The support systems the train dispatchers uses at the investigated traffic control centers are:

- **EBICOS**, used as the main traffic control system.
- **MATS**, used as their telephone system.
- **ANNO**, used to keep track on what information the informant needs.
- **Basun**, used as a documentation and report system to report delays of trains etc.
- **OPERA**, used to find information about trains and railway. Like train length or weight.
- **TAM 2014**, used to report agreements between the dispatchers between the control center and the regional center
- **The Paper graph**, used as their time schedule and plan for the day. They can see all trains that will go during the day, newly inserted trains; they can draw and write delays etc.

The train dispatchers work closely with each other inside the traffic-control centers. They also work closely with the traffic information informant so that communication between them can flow easily. A lot of communication flow is done between human interactions and not in the systems. The information any train dispatcher inserts in any system is available for any other dispatcher or informant to see. Despite this, much of the necessary information is being transferred through human interaction and speech in the workplace.

Chapter 3

Theory

In this chapter, I present the theoretical background for the study. The theory is divided into different parts. A technology part is presented with theory of the complexity of dynamic systems and system usability. A description of different factors of the human cognition is also presented with parts about the psychosocial work environment, cognitive work environment problems, and demands on the human cognition, control and techno stress. The chapter ends with a part about previous work in the same area as this study and a conclusion.

3.1 The Complexity of dynamic systems

Train dispatching is a dynamic process that requires work within complex systems. A dynamic process means the processes that are to be controlled are dynamic and that the systems conditions changes spontaneously, and by any internal or external influences. The system therefore, chances its behavior because of the influences (Andersson et al., 1997). This then also means that the actions made for control not only affect the present situation but future situations (Sandblad, 2006). The word complexity furthermore relates to that variables of the current state, with varying time constants, must be controlled simultaneously. It also relates to that the goals are multidimensional with different parts that can conflict with each other, and that several decisions and actions made by the controller are needed to fulfill the goals (Andersson et al., 1997).

Different factors need to be fulfilled to be able to control a dynamic process, like train dispatching within a dynamic system (Sandblad, 2006). The factors that need to be fulfilled are:

- That a clear **goal** of what that is going to be achieved exists,
- That the one who has control has a **model** over (understands how it works, have knowledge about etc.) the process or situation,
- That there are enough possibilities to affect the process or situation (the so called the **controllable condition**)
- That the one who has control have enough information about the process or situations current condition (the so called the **observable condition**)

If the factors are not fulfilled, the control of the dynamic process cannot be conducted as planned or even worse, not conducted at all. The organization subsequently gets uncontrolled and ineffective, which leads to that safety- and quality requirements cannot be fulfilled. This leads to different kinds of obstacles for the person conducting the work, obstacles as irritation, stress and helplessness, etc. The obstacles that arise from this kind of situation are therefore, closely connected to cognitive work environment (Sandblad, 2006).

If the goals are not correctly or fully described the controller will have a hard time conducting his/hers work tasks. This is not unusual in different work situations and does many times lead to stress and uncertainty for the user. The four factors, therefore, affect the interaction between the controller and the systems. And even if the factors are fulfilled the systems can still be too complex or not user-friendly to support the controllers work situation. It is important that the systems are usable so the train dispatchers can work in the most efficient and effective way possible.

Research within train dispatching has been done to find structures in the system usability of the systems used in their workplace. Andersson et al. (1997) have previously made research with a system analysis approach to modeling train traffic control. The main goal of the research was to define a framework for analysis of the present control system and activities, and for specifications of tomorrows. Andersson et al. (1997) mean that future research needs to be made to be able to model the train dispatcher's decisions, actions, their use of information and strategies. Because these factors are so important in the train dispatcher's work, it is factors that all can be affected by the computer-based work the train dispatcher's work with during his/her work shifts.

3.1.1 Usability

What to put into the word usefulness depends on what you are studying, and perhaps especially how you define the user's interaction with the system. What makes something usable can be described as the absence of frustration when using it. One can define usability as a product that is truly usable when *"the user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions"* (Rubin & Chisnell, 2008, p.4).

Another definition is the one by the International Organization for Standardization (ISO, 1998, p.2) that defines usability as the *"extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"*. It is a fast-growing property that is based on the interaction between the users, products, tasks and environment (Salvendy, 2012). The different attributes of usability: effectiveness, efficiency and satisfaction need to be fulfilled in an optimized way for a system to be usable. When investigating usability, it is these three attributes that are mainly being analyzed. Rubin and Chisness (2008) define the attributes as;

- **Effectiveness** is usually measured with error rate quantitatively. The attribute refers to the ease with which the users can use the product to do what they intended to do, and also that the product behaves in the way the user expects it to behave. This attribute can, for example, be measured as how the systems support a train dispatcher in their work by looking at the error rate within the system when the dispatcher conducts an action. The error rate can be measured by how the systems functions are good or bad for the specific actions the dispatcher's conduct.

- **Efficiency** is usually a measure of time. It is the rapidity with which the user's goal can be accomplished completely and accurately. This attribute can be measured by timing how long time it takes for a train dispatcher to start an action until it's finished. This will give indicators to how useful the system is according to how long time it takes.

- **Satisfaction** is usually measured and captured by both oral and written questioning. The attribute refers to the user's feelings, perceptions and opinions of the used product. This attribute can be measured by observational interviews with the train dispatchers. This gives then an insight into their perceptions and opinions about the functionality of the systems.

The most fundamental goal when testing usability is to find usable and fewer usable elements of a product and with that then produce it to be more usable. Usability testing gives the chance to find and eliminate design problems, and to minimize frustration for users when using the systems. To find indicators of good and bad usability in a product, an investigation can be conducted in different ways. Some example of how it can be done is; by ethnographic research, participatory design research, research in focus groups, with surveys, walk-troughs with users when using the product, follow-up studies and heuristic evaluations (Rubin & Chisness, 2008).

This study will use heuristic evaluations to find usability indicators in the relevant systems. A heuristic evaluation involves a review of the product or system. The review is done according to usability heuristics (principles), and the need of user involvement is not required. The goal with the heuristic evaluation is to use the principles to make an opinion about what is good and bad about the interface of a system. This type of usability review is seen as an "expert review" because it takes background knowledge about usability or human factors to be able to fulfill a good review (Tucker, 2004). The heuristic evaluation in this study will be done by observations with Nielsens Heuristics (Nielsen, 1994) for usability as a ground for the review. Nielsens heuristics are a set of 10 heuristics that is used to help find indicators of good and bad design in the observed system. The 10 heuristics are defined as (Tucker, 2004):

1. **Visibility of system status**

"The system should always keep users informed about what is going on, through appropriate feedback within a reasonable time."

2. **Match between system and the real world**

"The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order."

3. **User control and freedom**

"Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo."

4. **Consistency and standards**

"Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions."

5. **Error prevention**

"Even better than good error message is a careful design which prevents a problem from occurring in the first place."

6. **Recognition rather than recall**

“Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.”

7. **Flexibility and efficiency of use**

“Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.”

8. **Aesthetic and minimalist design**

“Dialogues should not contain information, which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.“

9. **Help users recognize, diagnose, and recover from errors**

“Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.”

10. **Help and documentation**

“Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large. “

With increasing demands on the train dispatchers to have optimal control and knowledge of their whole work situation, makes it crucial that the systems fulfill these 10 heuristics of usability and therefore, are usable and supportive.

3.1.1.1 The different usability levels

With regards to train traffic control, I have identified four different levels of interactions where usability can be investigated and measured. It is significant to identify and define in what way the usability can be measured in the most relevant way. Even though this project is limited to one level of interaction (see 1.2) it is important to get an insight into which other directions that are possible to take. This can be a way for future researchers to understand what can be done within this specific area.

The levels are as follows:

- Level 1: Interaction- & Interface Design - *“Me and my system”*

This approach extends to the first level of visual design. When evaluating the usability of system/systems within this level the evaluation is mostly about the graphic design of the system. How are symbols used, which symbols are used and why? Why are those specific colors used, how do they affect the user and can they be used in a better way. These are typical questions about usability in this level of evaluation. This is more focused on what info that is visual and how it is visual. This is evaluated from how the system design looks like in Figure 1. This approach investigates this by looking at the interaction between one user and his/hers system, one system at the time. This approach is good if the researcher wants to get a deeper insight into the usability and functions of one system towards one user.

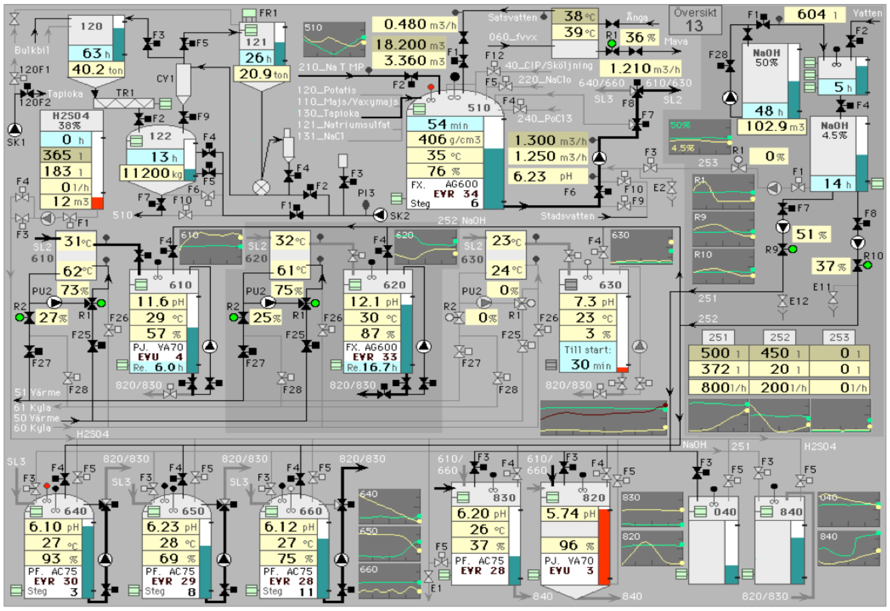

Figure 1. An example of what the researcher can look at in level 1.

- Level 2: Cognitive work environment - *"Me and my systems"*

Level 2 is used when the researcher wants to investigate the interactions between the user and more than one system (Figure 2). This approach is about measuring how usable the systems and interactions between the systems are to in the most beneficial way support the users' psychosocial and cognitive work environment. The researcher in this approach can investigate how the systems support the user's decision-making, working memory, cognitive workload and other psychosocial and cognitive work environment factors.

Figure 2. The interaction between one user and multiple systems.

- Level 3: Collaboration within the organization - *"Me and my colleagues joint working system"*

This approach extends to a working environment where the user jointly with his/hers colleagues are taken into account. The researcher at this level can evaluate what is usable for more users together (Figure 3). This level has a broad HTO (Human-Techniques-Organization) perspective and is therefore, a broader level for investigating usability. It is important, in this level, to take into account the bigger perspective of the whole information flow between co-workers and major parts of the organization in a joint working system.

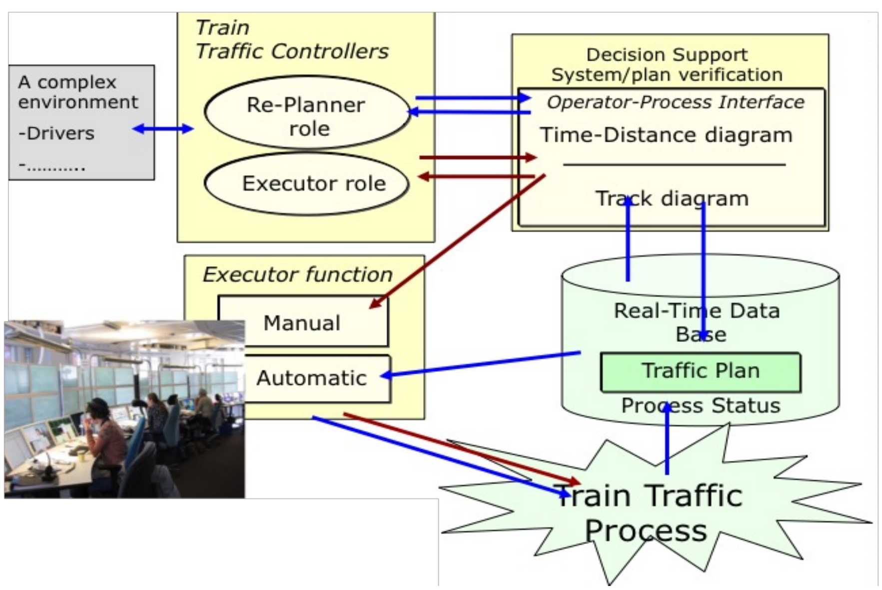

Figure 3. A schedule of how the interaction between different parts of train traffic controlling.

- Level 4: Collaboration throughout the organization - *“Me as a part of a socio technical system”*

The last level of usability evaluation has the broadest perspective of them all. This approach is still within the HTO perspective but has extended to more users with a bigger variety of tasks among them. Within this level, the researcher can investigate how one user is a part of a socio technical system that involves more users (Figure 4). The users are some within the train control centers like; traffic operators and traffic controllers but also outside the centers like; locomotive drivers and trackside workers. This level can give the researcher a broader perspective of how the systems support a wider range of users with sometimes different needs.

Figure 4. Displays how one user is a part of a whole socio technical system with multiple affecting factors.

By limiting a study towards a certain direction, where the usability is to be investigated, is crucial to make it optimized. By choosing one of the levels above will help the researcher to understand how to investigate one area within train traffic control. This can therefore be important to have in mind for future work within this area.

3.2 The psychosocial work environment

The psychosocial work environment is a wide concept that has a big range of factors within its definition. It is defined by Eisele (2008) as the physical environment of the workspace, and how people are handling this together. This also includes the social conditions the employees are involved in and the importance these have for the mental well being. Another definition of the psychosocial work environment, made by Theorell (2003), says that “psychosocial” is the interaction between the mental and social surrounding factors. To summarize the definition we can describe it as a work environment that includes social, physical, mental and organizational factors that affects how the employee conducts their work tasks and how their experience of the work is. The factors of the psychosocial work environment, therefore, affect the human cognition and the demands set on human beings. To find a way to have an optimal work environment requires knowledge about how the different factors cooperate with methods for improvements built on the general perspective of the work situation (Lind et al., 1991).

The Swedish authority Arbetsmiljöverket are responsible for work environment- and working hours issues in Sweden. In their report *“Psykosociala frågor i det systematiska arbetsmiljöarbetet”* (Arbetsmiljöverket, 2010) they provide examples of psychosocial factors in the work environment that can cause health disorders for the employees. These factors are: high workload, high work tempo, monotonous or repetitive work, vague expectations of work effort, risks of threats, shift work, social conflicts, deficiencies in the physical environment, conflicts or violations when interacting with other people, etc. These factors affects how the employee's work will be conducted, and if they are satisfied with their work situation. It is important to acknowledge that issues concerning the psychosocial work environment have a big impact on the workers’ daily situation.

It has been shown that stress for the employees is a big factor that is caused by flaws in the psychosocial work environment (Agervold, 2001). Stress that is caused in relation to how the computers and systems support looks like is as well something that has been shown to be important to acknowledge (Lind et al., 1991). If the systems are poorly developed with a lack of usability, it can cause high cognitive workload, which will lead to both stress and health disorders. The system usability and how the usability actually affects the employee's cognitive work environment are not usually focused on in investigations of the psychosocial and cognitive work environment and are therefore, usually forgotten. Problems with more physical characteristics are more common in focus when it comes to technology-use and work environment investigations. This is why it is important to acknowledge the fact that the usability of the systems also has a big impact on the human cognition.

3.2.1 Problems within the cognitive work environment

It is crucial that every employee who will conduct work within a work situation understands the course of events and their power to control and affect the working process to be able to reach the goals of the work tasks and the authority. Distinctive factors in the work environment can hinder this. The factors that can lead to a number of problems are the cognitive work environment problems.

The cognitive work environment problems occur when different factors in the work environment hinder the person working from using his/hers cognitive capabilities to perform the work tasks in a satisfying and effective way. These problems then affect the work situation for the employee in different ways. It means that it affects their ability to understand, to collect information, to control, to get an overview and to affect or control parts of the situation they are working in (Lind et al., 1991). The cognitive work environment problems were founded by Lind et al. (1991) within the field of human-computer interaction to give a greater understanding for work environment problems such as control, stress and constraints. They mean that cognitive work environment problems are more common in the use of computer-based systems in the work process. They have therefore identified nine different classes of cognitive work environment problems that relate to that interaction. The class division makes it possible to relate the different problems to design methods to be able to find indicators of how interfaces are designed, and if they support the human cognition so the cognitive work environment problems won't occur (Lind et al., 1991). The classes defined by Lind et al. (1991) are:

1. **Interruption of thought**

The interaction does not allow the user to focus on the actual work task; instead, it forces the user to use cognitive power on a higher level to be able to control the computer/system. When doing manual work, we can often automate these functions that are around us that are needed for conducting the work tasks. When doing computer-based work, we are often forced to do the same thing but with more a cognitive workload.

2. Orientation problems

The user ends up in doubt or with lack of knowledge about where in the system they are. Likewise, it can be hard to formulate where you are going. This problem can also be formulated as that the user "gets lost in the information space." It is common that most interfaces do not allow the user to at all time see where they are in the system, and how the current position is related to the whole picture. Another important aspect of the orientation problem is how quickly the user can be in the situation, the context that is displayed on the screen when the user returns to the work tasks after he/she has been away doing other things or has been disturbed. It is therefore, significant that the user quickly, with a glance can see where in the process they are.

3. Cognitive "tunnel vision"

When someone makes assessments and decisions it is hard to take information that is not attainable into account. Even if the user knows that important information does exist and is attainable in other places, it is hard to integrate it with the decision-making. This makes the user tend to put more weight on the visible information more than another information. If the user can see the information at the same time, for example, documents that are spread out on the desk, the user can include very large amounts of information for the decision-making.

4. Short-term memory load

Research within cognitive psychology has shown that the short-term memory has limitations. The memory works such as; it can store 5-6 information units at the same time; it has a short decay time and high sensitivity to disturbances. An information unit can be a number, a word, a picture or any fact. If the user, for example, will read parts of information on a screen, other parts on other screens and then integrate these in the mind it will affect the short-term memory. If the user cannot hold information in their short-term memory, they have to skip from one screen to the other. This takes time and is exhausting. If the user also needs to perform actions like; control the situation, give commandos, etc. that requires cognitive efforts, the user will disturb the short-term memory very strongly.

5. Unnecessary cognitive load

Human beings get a lot of necessary information in a work situation through interpretation of the information patterns and not through reading of the actual information content. We take advantage of this property by a fast glance at the document to find what is important for the current situation to be able to zoom in towards the interesting parts. If the interface doesn't support these kinds of search possibilities, the user has to read all information in the document. This means that if the information isn't organized in an easy and understandable way, it affects how the user processes the information. This then affects the mental workload, the mental power the user needs to use to be able to find information and perform the work tasks. Pattern recognition is easily automated and is a fast method. Reading is not fast and cannot be automated, which makes it a worse method to use.

6. Spatial "headedness"

Human beings tend to relate aspects of information with the spatial properties of the information. We remember information in terms of color, position, shape, movement, etc. We use this spatial information to in a quick way search and identify relevant information, without having to specify the exact issue. We know what we want to see in a specific work situation without having to say it. If the spatial information is unclear, doesn't exist or changes it will remove the possibility of spatial coding of the information.

7. **Inconsistent information coding**

This cognitive work environment problem means that the information that to be conveyed to a user is being coded in a way that the user cannot obtain it without using unnecessary cognitive workload. Different ways of coding information can be used to send a message about the information. For example, using colors, shapes, positions and functions can be ways of coding information. If the coding isn't the same over time and in different systems, it will be hard for the user to automate the usage. The coding of information must be done in a thoughtful way. The interface elements must be connected to the concepts used in the work situation. This will make the identification and decoding of information easier and more natural for the user.

8. **Problems with time coordination of values**

It is common in a work situation that it's important for a user to associate an information value to a specific time or different information values to each other related to a specific time. An example of this is for the user to know then a certain information value was measured or in what order of time some information came, etc. If the user cannot obtain this information in a quick and easy way and has to read and think a lot to be able to time-relate information it will lead to time loss and unnecessary cognitive workload.

9. **Problems to identify the status of a process**

It is often important to quickly be able to identify a work process status in a work situation. This means that the user, for example, identifies which cases that are being processed or are coming up in the work process. If this identification is impossible for a user, it will complicate or disable the possibilities for the user to plan their work, to in a quick way be in the correct working context or to switch between work tasks in an effective and easy way. The user is thereby controlled by what the system conveys and won't be able to conduct what is really highest prioritized.

Research of computer support has shown that the actual handling of the computer takes up to 80% of the working hours, where the main workflow is being disrupted by decisions about what commandos to take in the systems. This can lead to a low level of work effectiveness and a very high stress-level for the user (Lind et al., 1991). When there is a lack of usability, it affects the whole work situation for the user because it sets high demands on the user's cognition and their situational control. This will lead to work-related stress; bad work performances, inefficiency, workload and other bad health issues.

3.2.2 Cognitive demands, human control and support

The different cognitive work environment problems arise from insufficient computer support from lack of system usability, and that it is not adapted to humans cognitive capabilities. This means that the computer support sets excessive demands on the users' cognition and their capacities to process information. These demands and lack of support or control in the environment can lead to stress for the user. Karasek and Theorell (1990) have developed a Demand-control model (Figure 5) that is commonly used for evaluating the psychosocial work environment, by trying to predict situations where stress can arise by looking at the cognitive demands, the human control and the support in the work environment.

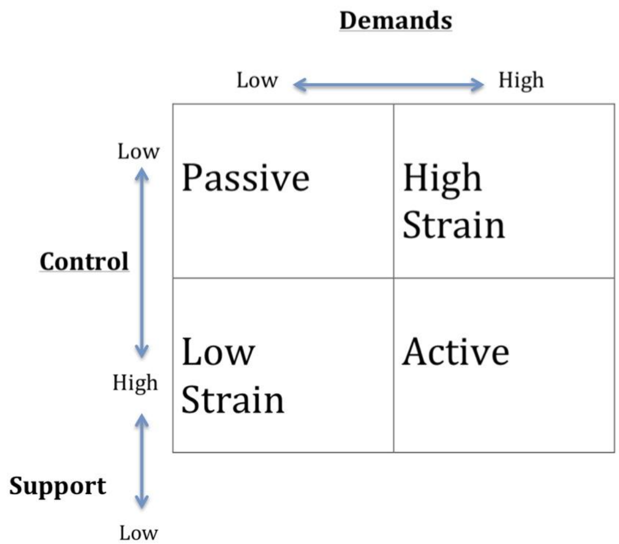

Figure 5. The Demand-Control model from Karasek and Theorell (1990).

The Demand-control model is about the relationship between the possibilities for decision-making (control), the support in the environment and the external demands. Karasek and Theorell (1990) focus on both psychological and physical demands in the definition of external demands in the model. They mostly focus on psychological demands. They mention a couple of examples of psychological demands in a typical work situation; deadlines, productivity demands, mental arousal (needed to perform a task), handling of their role, demands on coordination and the most central form of psychological demands: the mental workload. These can affect how the employee performs their work tasks. The mental workload is the most central demand according to Karasek and Theorell (1990) because it refers to how much mental power needed to perform a task and can increase from example time pressure. This demand is one of the most central ones because it can also be related to information processing and interface usability issues as the amount of disorganizations or disorder in a work task that the employee needs to sort out to be organized again. This can be related to the cognitive work environment problem “Unnecessary cognitive load” (Lind et al., 1991, see 3.2.1) that says that if the information in the interface isn't ordered in an understandable and easy way it will be harder and more ineffective for the user to find and process information. The user then needs to work with more mental power, which demands a higher cognitive workload, which then can lead to stress and other health issues. The definition of cognitive demands is factors in the psychosocial work environment that sets demands on the user's cognitive capabilities. This means that if the cognitive demands get higher, the user's work situation will have a higher cognitive load (Karasek & Theorell, 1990). The mental workload can therefore, also be called as cognitive demands because it affects the user's cognitive load within their work situation.

The part of the model about decision-making, or control, is referred to two aspects by Karasek and Theorell (1990). These are; how big social authority the user has over the decision-making, and how big range of experience and competence the user has available in their work. These two aspects form together the user’s ability to control or take decisions over a certain situation and the demands that are set for their work. When it comes to computer-based work, this translates to what competence and knowledge the user has about the systems and what possibilities he/she has to be involved in changes when it comes to the systems functions and interface. Control has also been defined and exemplified by Hultberg et al. (2006)

as the users' control over how their work should be conducted, their possibility to develop a relevant competence and their possibilities to participate in change-related decisions. Hultberg et al (2006) means that it's important to define control as if it is the user that has control over the systems he/she uses or it its the systems that control how the user can work.

The last dimension of the Demand-control model to be able to evaluate the psychosocial work environment and predict stress is support. Support by Karasek and Theorell (1990) means social support in the workplace by helpful interaction from colleges and managers. It is important that every employee finds support in their workplace from different social actors. If there is a lack of social support it can affect the user's comfort and satisfaction about their work situation. The dimension of support within Karaseks and Theorells (1990) Demand-control model is also focused towards the computer-support. If the user lacks of support in different ways from the used systems, their work situation will be affected in negative ways, and their work performance can decrease together with an increase in their stress level.

The demands-control model together with the dimension of support is a good tool for evaluation of situations that causes stress. If the user has high cognitive demands set on him/her or is under stress, it is important that he/she has good possibilities for control and support. The combination of the three dimensions: cognitive demands, control and support create four possible conditions: the active, the low strain, the passive and the high strain (Figure 5). These conditions are possible conditions for the individual worker in their work situation (Karasek & Theorell, 1990). The *low strain* condition is characterized by a high degree of control and few psychological demands, and the risk for stress is small. Individuals in this condition have both the time and authority to conduct their work and live up to the demands set on them. The *active* condition is characterized, as the relaxed condition, by a high degree of control, but the demands set on each individual is also high. Within this condition, challenging situations are formed for the individual and their possibility to control prevents stress or workload to occur. This condition is therefore; good because it can lead to development, work satisfaction and high productivity. The *passive* condition is characterized by situations with a low degree of control and demands. The work situation lacks challenges, which makes the users' work situation unsatisfying in the matter of trying their own ideas and in their development. This kind of work condition can affect the individual's competence if they work in it over a longer period of time. It then affects their skills and their motivation to continue working. This condition therefore represents a big psychosocial work environment problem. The last condition, the *high strain* condition has the most negative health aspects of all the conditions. The condition is characterized by very high demands and a very low degree of control. The risk for long lasting stress is very high if someone works with this condition at his/her workplace (Karasek & Theorell, 1990).

3.2.3 Techno stress

There are many aspects that can affect an individual's work satisfaction and performance in different work situations. Cognitive work environment problems, lack of usability in systems and the different conditions mentioned above in the demands-control model (see 3.1.1, 3.2.1, 3.2.2) are some examples of these factors. It has been shown that high cognitive demands, low degrees of control and support can affect the stress level for individual workers. Levi (2001) describes different factors that can affect the stress level for an individual. He means that there is especially a strong connection between information and stress. Both if there is too much information, which can make it hard to process all information and see what is relevant for a specific situation, or too little information available, which can lead to uncertainty for the individual, which can lead to stress. This can direct be related to the use of computers and information technology in a work situation. The system and computer-based work need to be usable and need to give the user the right amount of information and support needed for them to in an easy and effective way conduct their work tasks. The systems can have too little information or too much information (information overload), which both affect the work experience and efficiency and can lead to stress (Case, 2008).

Stress levels for individuals have been shown that it has increased through the years as computer-based work has emerged more. Employees who work with computers, and system-based work have high demands set on them to learn all the new technical functions in the used systems to be able to conduct their work tasks. They also need to learn how to handle more complex systems and to handle the higher demands for productivity that often comes with the prejudgment that the user should be capable to handle when using more complex systems. These factors lead in many cases to techno stress for the employees (Wang et al., 2008). There is no clear definition of techno stress but the earliest definition came from Brod (1984) and says that techno stress is: *"modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner."* This definition means that the use of technology can lead to an unhealthy process for the user if the technology does not support their work in a proper way. Weil and Rosen (1997) define techno stress as stress that includes all negative effect on thoughts, behavior and attitudes for someone using technology. Furthermore, Arnetz and Wiholm (1997) define the expression as that information technology is a potential stress factor that challenges humans' cognitive processing, which occurs in work situations where the employee cannot control the necessary skills needed to use the technology, even if the work situation feels stimulating.

The user is forced into a situation where they need to follow the demands set out by the systems they use. These demands lack of support and can therefore affect the user's possibilities of control, which can lead to stress, poor effectiveness and bad satisfaction for the user. Research made on techno stress has shown that a couple of techno stress creators (factors that create techno stress) have been defined. One creator is *information overflow*. If the system the user is working in has a large amount of information available for the user, the user may experience difficulties in understanding and processing all information. It can also be hard for the user to be able to sort out what information that is of actual interest. Many times, users have developed a mental model of the information they know they need for a certain task. If this information isn't available or easy to find quickly because of another information surrounding it, it can cause stress and bad performance of conducting the work task. Another creator: *multitasking* or *continuous partial attention* means the ability to perform several tasks simultaneously, which also refers to the motivation that drives people to that kind of performance. The computer-based work situations today often require a high demand of multitasking on the employees. Relevant information to perform tasks can be missed out or forgotten due to the high demands of keeping deadlines, productivity and multitasking. This is of course a major problem that can lead to stress. The ability to keep work and leisure time apart from each other has become harder as the progress of technology-based work has developed. Many employees are today available at any time of the day, even after work hours due to the help of technological products. This can cause much stress because it makes it hard for the employee to ever really drop their work tasks when they end their workday. This makes technology an electrical "leash," which makes *availability* another factor that can create techno stress. As the technology and computer-based work situations develop among us, the requirements for fast learning and understanding of the technology increases. Users are required to understand and use more complex systems, which can contribute to stress, especially if the time they have to learn the new systems or functions are within their work hours when they also need to do their usual work tasks. The requirement of continuously *learning new technology and application* are therefore, also a creator of techno stress. The different creators of techno stress all goes hand in hand with the last creator: *usability*. This creator refers to whether the technology is well designed and is easy to use so that the user can experience good efficiency, effectiveness and satisfaction with their performance at their workplace. Many employees at various workplaces have at some point experienced the frustration that can arise when the used technology does not meet the demands placed on the system. For example, if the response time in the system is too long before something happens when a user is performing an action it can lead to stress. It can also lead to high cognitive effort and cognitive workload if the systems have poor design and a lack of usability (Sellberg & Susi, 2013). These factors are commonly referred to as cognitive work environment problems (see 3.2.1).

These creators can lead to different negative effects for the user. Research has shown that these creators occur in computer-based work situations, and in most cases leads to increased levels of stress for the employees, after only a day's work. With the increasing amount of computer-based work, the techno stress issues cause more and more negative effects on the users. For example, research has shows that techno stress is related to health disorders and psychological stress symptoms such as; sleep problems, memory disorders, mood swings, high blood pressure, heart diseases, clinical depression and burnout. All of these health issues caused by the creators of techno stress then affect the employees' productivity and satisfaction of their work situation. It affects them in a way that can decrease their ability to perform their goal with their work tasks, their involvement in work, their behavior and positivity, etc. All of these issues are examples that show how the computer-based work actually can affect the employee's work (Sellberg & Susi, 2013). The high level of stress and health disorders that can occur if the computers and systems do not support the user cannot be accepted. This is yet another reason why it is important to see what needs to be usable in the systems the employees use and how this will support them to work in an efficient and satisfactory way.

3.3 Existing instruments

Research about cognitive capabilities, cognitive work environment, psychosocial work environments and computer-based work has previously been done with different perspectives, and at times connected to each other. The most common way to evaluate the psychosocial work environment has formerly been by using Karaseks and Theorells (1990) Demand-control model. Thorner (2011) describes that high cognitive demands and stress for the users related to computer-based work often gets neglected in research and evaluation of the workplace and psychosocial work environment. This is because the cognitive demands set on human beings usually is related to only decision-making and not to any of the other problems that can occur related to cognitive demands (see 3.2.1). This is why the Demand-control model needs to have more elements than only the ones existing today. Evaluations with the model need to have a clearer connection to how computer-based work can influence an increase of cognitive demands on the users, and how this can lead to health disorders such as stress. Checklists are another common method for evaluating the work environment but have also a lack of reference to the effects of computer-based work on the psychosocial work environment. Because computer-based work is so common in today's society, the cognitive strains from computer-based work should have a central role in the evaluation checklists (Thorner, 2011).

Åborg et al. (2003) has developed the ADA-method that aims to diagnose an employee's work situation including there work environment. The goal of this method is for partly the occupational health to in a quick and easy way identify cognitive work environment problems and usability problems, to work as a ground for the developers for more analyses and improvements to the systems. The ADA-method is developed for specific analyses of skilled employees work, this is because Åborg et al. (2003) means that the skilled users experience other cognitive work environment problems than beginners do. The method has a combination of interviews, questionnaires and observations. Thorner (2011) criticises the fact that the ADA-method only has focus on the skilled users. Thorner (2011) means that the cognitive work environment problems such as orientation problems and unnecessary cognitive workload (Lind et al., 1991) can affect both beginners and skilled users, which means that the method therefore, should involve a more general approach to involve more users. It should specifically involve all users who spend their work hours in front of a computer, even if they are beginners in their work field.

Another instrument for analyzing consequences in work environments and the effects of IT support were developed by Cajander et al. (2008) in a project at the Central student aid for the purpose to improve their work environment related to technology. This work was based on Karaseks and Theorells (1990) Demand-control model and is said to be a good ground for future work because it could be improved, according to Cajander et al. (2008).

Thorner (2011) has kept researching the area of psychosocial work environment evaluations and has developed the instrument UDIPA. UDIPA is an instrument used to help organizations to acknowledge the psychosocial and cognitive work environment problems based on computer support. The instrument is supposed to be used by people with background knowledge about work environment problems, technology stress and human-computer interaction. The instrument has its ground in the theory behind other methods and instruments and especially Karasek and Theorells (1990) Demand-control model. This instrument has been taking the evaluation methods one step further towards a mash-up between analysis of psychosocial work environments and computer support in the workplace. The instrument has four different parts; first is a presentation of the purpose and use of the instrument to give background knowledge to the user, a motivation to why the instrument should be used and also how it should be used. After this, a short presentation of the theory behind it is given. The aim of the development of the instrument was to contribute with increased knowledge about the effects the computer support has on the psychosocial and cognitive work environment. The instrument had some flaws and one of them was, according to Thorner (2011), that it was developed to be an evaluation instrument for users who sits at the computer every hour of their workday. This restrains the instrument and some users, who also have, for example, paper-based work, cannot be evaluated. The instrument is also based on only one field of work, which also makes the instrument hard to use on other work environments. Further development and improvement of the instrument need to be done. Improvement can be to divide the different parts of the instrument, or to develop it in a more general way that would fit more organizations and also towards other usability approaches than only with focus on the Demand-control model by Karasek and Theorell (1990). The focus of the instrument is to find how computer-based work can affect the workers work situation and cognition. The usability is then evaluated from a psychosocial work environment perspective. Despite this, the instrument does not have a theory based on system usability. It is a fact that usability can be measured in the perspective of how the computer supports the user, but it should also be within the theory-based usability measurements that exist. By integrating the UDIPA instrument with existing usability evaluation methods could give a greater insight into the systems usability and how it affects the human beings.

3.4 Conclusion

There is plenty of existing literature about usability, psychosocial work environments, cognitive problems, and techno stress and about the train dispatcher's work environment. Despite this, there is no good existing instrument for measuring the usability of the train dispatchers' systems with a ground in their cognitive capabilities and psychosocial work environment. The fundamental theoretical ground of the new instrument developed in this study, will be with Karasek and Theorells (1990) Demand-control model together with the implementation of computer-support in UDIPA (Thorner, 2011). However the cognitive work environment problems together with the theoretical ground of usability heuristics will also be a part of it. The different aspects of the instrument like surveys, checklists, etc. will be developed so they are relevant for evaluating the systems used for operational traffic control. The aim of the new instrument is that Trafikverket will use for evaluating the usability of their systems in regard to the cognitive work environment. People should use the instrument if they have previous knowledge within HCI or work environment issues, because a knowledge base about human cognition and usability is required to be able to analyze and interpret the results. The instrument will be easy to use and understandable for a big range of users.

Chapter 4

Overall Method

Within this chapter, an explanation will be given of the target group of participants, the working procedure as a ground for the thesis and also an explanation about the tools for analysis. A review of the reliability of the study and the ethical considerations taking into account will also be explained.

4.1 Participants and selection

The decision to have the chosen target group was primarily done by the authority in the beginning of the project specification. The selection was based on the participants working tasks for traffic control and by their roles in the train control center. Based on the purpose and delimitation in this study the selection was made that the target group was going to be the train dispatchers that work with train traffic control within the train control centers. This selection was suited with the selection of limitation of the study. Because the study was limited to investigating an operator and his/hers systems the most suitable example of this interaction, where one person is working inside different systems at the same time, was the train dispatcher.

A number of 11 people participated in the study, two for the first direct observations, nine participants in the workplace study and two for testing the questions in the new instrument. The participants were picked through random sampling. By doing random sampling, every train dispatcher working at the train control centers has an equal chance of being selected. The selections are independent and do not affect each other. Characteristics as gender, age, background, knowledge base of novice or expert users, or ethnicity have no value in this study to be picked in a structural way, which is why this also is random. Random sampling, therefore, takes away the chance of systematic biases that can lead to that one of the participants would have a greater chance of being selected (Graziano & Raulin, 2010).

4.2 The Iterative procedure

I have been working with an iterative work process from the very beginning of the study. The different parts below have made me evolve my thinking about the project. Every part has been a step towards the development of the structure and the purpose of the project. This is the benefit of working in an iterative way with different steps towards one goal.

To get an insight into the projects different factors, received from the project specification, I started to read up on literature about human-computer interaction within complex systems, the human cognition, psychosocial work environments, cognitive work environment issues, usability methods and socio technical systems. I decided to have a wide perspective in the choice of relevant theory for the study. I chose literature both about the individual and the systems to get an insight into both those areas.

After reading relevant literature, I took the first step towards an insight into the systems and humans involved in the study. I visited one of the train control centers to start with direct observations of the train dispatchers, the systems and how they work with them. Under two days I got to follow two train dispatchers. In my direct observations under these two days, I got to sit down with the train dispatchers who explained and showed me their work. I observed their work tasks, the tools they used, which systems they used to be able to conduct their tasks and also their thoughts about this. The observations were made without video recording and just by taking notes with paper and pen. This way of observing made it possible for me to focus 100% of my attention at most to the train dispatchers and their work situation. The main purpose for these direct observations in such an early stage of the investigation was to educate me as a researcher to understand the project's purpose in a better way. This is why these observations only lie as a ground for my understanding to be able to work towards the following step of the work process.

The following step after the direct observations was to have a workshop with people from Uppsala University and the authority Trafikverket. The participators at the workshop were my supervisor from the university, four professors and two PhD students who all were involved in other projects for Trafikverket. A group of people from Trafikverkets Human-Technique-Organization council who are involved with projects with the university was also there.

I began the workshop with a brief explanation of the project, the problem specification, the purpose and my thoughts around it. After that I opened up for discussion and reflection by presenting three more open questions to the group. The questions were as follows:

- “What expectations do you have for this project?”
- “What is your opinion about looking at the usability of the relevant systems? Is it important or not? Why?”
- “Do you have any tips or own thoughts that can be helpful for me when conducting this study?”

This workshop gave me an insight into how this specific group of participants reflected and thought about the project. Their reflections and ideas have made me widen my perspective to come even further towards the right method to use for the project.

After doing the first steps of research, direct observations and the workshop, I had gained new information and perspectives for my collection of data to begin. To be able to develop a brand new instrument for evaluating the system's usability with the perspective of the cognitive work environment a couple of different phases of investigation will be done.

The first phase was to conduct a workplace study to collect empirical data about how computer-based work can affect the users and their work environment. This phase also included a usability study with system observations of how the systems support the user's cognitive work environment. The results from phase one in conjunction with the theoretical background is the ground for the new instrument, described in phase two. By connecting the elements of good and bad indicators for the cognitive work environment in conjunction with elements of usability in the systems, a good base for the instrument can be formed. Phase two also include a test of the new instrument to see if the different questions are well developed and ready to use.

4.3 Methodological Considerations

The evaluation of the transparency of the study is based on the method. Since the study has a qualitative research approach an evaluation of the reliability, the validity and the generalizability can be made on the interview technique and the selection of participants (Kvale & Brinkmann, 2011).

In this study, the measurement is an interview-technique. In interview studies, the transparency is evaluated in relation to whether the method and results can be replicated at repeated measurements (test-retest reliability), by other researchers (inter-rater reliability) (Kvale & Brinkmann, 2011). Transparency is a demand for another researcher to be able to replicate the method and then test the reliability. I have been very precise with the descriptions of the method, the purpose and the procedure of the study to achieve transparency. I did this so that future researchers easily can replicate my method as exact as possible. Only one person held the interviews so all the questions were asked in a similar way. Since the interviewer followed an interview-guide, the questions were the same for all participants, which, therefore makes it easy to replicate. Even if the interviewer sometimes asked small follow-up questions on some of the participant's answers, they were all in line with the questions in the interview-guide. This might have impacted the participant's answers even though the interviewer was alone and mainly followed the interview-guide. The fact that seven people participated in the observation-interviews made the interviews deeper and comprehensive. If there had been more participants the interviews would have been shorter and not as thorough as they became in this study. The participants were chosen randomly but from a specific target group. This made the selection unbiased by gender, age or experience and relevant because it still was chosen from a specific group of people.

Reliability is a necessary condition for validity in a study. Validity means that what is meant to be measured really got measured in a test (Wikipedia, 2015a). The purpose of the procedure was to get an insight into the train dispatcher's work, their interactions with the used systems for train dispatching and their thoughts about the use of the systems. By using observation-interviews, I got an insight into how their work is, what they do and how they interact with the systems. The participant's answers can, to some, extent be used to generalize the train dispatcher's thoughts about the use of the systems for train dispatching. This is because the selection of participants is a random selection, and the number of participants is representative of the purpose of the study. Despite this, it is very hard to say exactly if the participants have the "true" answers, and if it truly can be generalized over all train dispatchers. The answers within this study will be used as the representative answers because of the purpose of this study, to form a generalized instrument for measuring usability in the used systems for train dispatching.

4.4 Ethical considerations

It is important to take ethical considerations into account in all research. There are certain requirements when it comes to ethical considerations. There are four requirements to take into account according to Vetenskapsrådet (2007), these are; the *information requirement, the consent requirement, the confidentiality requirement* and the *usage requirement*. The requirements have been taken into account in the study as follows:

The information requirement is about how the information about the study has been transferred to the participants. Vetenskapsrådet (2007) defines this requirement as: *"The researcher must inform the people concerned by the research about the purpose of the research tasks"*. The participants were informed about their rights about their participation in an early stage of the study. An information letter was sent out to the participants with information about the purpose and data collection procedure of the study. They were also informed what they would do in their participation, that it was voluntary, and that they could withdraw their participation whenever they wanted to.

Vetenskapsrådet (2007) defines the consent requirement as: *"The participants in an investigation has the rights to by themselves decide over their participation"*. The participants were from the beginning informed about the purpose of the study. I, as a researcher had much contact with the person at the train control centers who transferred the information to the participants. They were informed by us that they got to choose for themselves if they wanted to participate or not, and how much they wanted to be a part of the study. The connection between me and the contact person at the centers made it possible to find participants who were interested in the study and who then wanted to participate.

Confidentiality is a crucial part in the ethical considerations of research. Vetenskapsrådet (2007) has defined the requirement for this as: *"Details of all participating persons within the investigation should be given the utmost confidentiality and personal data shall be stored in such a way that unauthorized persons cannot take advantage of it"*. The participant's identity was kept confidential throughout the whole investigation and also afterwards. The names of the participants were never stored, and no identity was therefore revealed under any stage of the study. The personal data is stored confidential.

The last ethical requirement is the usage requirement. It is defined as: *"Data collected about individuals may be used only for research purposes"* (Vetenskapsrådet, 2007). All data that was collected throughout the investigation was only used for research purposes. None of the data have been used for non-research or commercial purposes.

Chapter 5

Phase 1: A workplace study

The purpose of this workplace study is to collect empirical data, through observation-interviews, about how computer-based work can affect the target users in their work and work environment. A workplace study is an appropriate approach to use in this thesis because the investigation will show how the train dispatchers' work situation actually looks like in a normal day of work. Heath et al. (2000) say that workplace studies are based on the assumption that the only way to understand technology is to see how they are used in practical real-life activities, with regards to different surrounding circumstances that can affect the daily activities. However, Heath et al (2000) also say that the users themselves form a meaning of the technology, its use and their interaction to each other. This can be accomplished by using observation-interviews as the method for the data collection.

Observation-interviews are interviews where the observer sits next to the user who is performing his/hers normal work tasks. Within this situation, the observer has the possibility to observe aspects of the work situation that the user may not be aware of that he/she is doing (Gulliksen & Göransson, 2002). Patton (2002) means that the combination of observations and interviews is beneficial because they enhance each other. This is because it gives the observer the possibility to compare what is being observed with the user's opinions and thoughts about what is being done. The interview is a semi-structured interview that will be conducted parallel with the observation. The fact that the interviews are semi-structured will give the observer a change to make follow-up questions about interesting observations that occurs along the way. The semi-structured interview will be combined with an interview guide (Appendix 1). This is appropriate for this study because it gives the observer the chance to make a more decision beforehand about what the questions in the interview should be about, so that it fits more to the limitation made for this study. The interview-guide is related to the one used in Thorner (2011) for developing the measurement UDIPA. Because of the fact that this study has its ground in UDIPA and can be seen as a follow-up study from Thorner (2011) made it clear that the interview-guide for the workplace study should be quite similar. The interview-guide used in Thorner (2011) is also developed after interviews with psychosocial workplace professionals, which makes it a good measurement to use. Some of the questions differ in how they are presented to better fit into the investigated environment of this study.

Workplace studies usually include descriptions of human activity that are based on field studies conducted over a longer time. This study is conducted over 20 weeks so a long-term field study cannot be made. This is why this workplace study is more of a "quick and dirty" version of such a study. In a "quick and dirty" workplace study, human-computer interaction researchers often do short but focused studies to in a quick way form an understanding about the work domain they investigate (Millen, 2000), which is how this study also will be conducted. Despite the "quick and dirty" approach, the new instrument developed in this study has the purpose to be used for organizations to get a better understanding of the interactions between the cognitive work environment and the computer-based work.

This phase also includes a usability study integrated into the workplace study to investigate how the systems support the user's cognitive work environment. The usability study will be conducted as observations with Nielsens usability heuristics (see 3.1.1) as a ground for what to observe. The usability of the systems will be evaluated from the focus of what cognitive demands that are set on the users, what possibilities they have of control and what support they have from their work environment. This will be connected with the cognitive work environment problems that may exist.

The results from the workplace study with an analysis based on Karaseks and Theorells (1990) Demand-control model by using demand, control and support in the analysis (see 3.2.2), and Nielsens usability heuristics (see 3.1.1) will lie as an empirical ground for the new instrument.

Both the observation-interviews and the system observations in the workplace study are used to investigate the systems that the train dispatcher's use in their everyday work situation. These systems that, therefore, are being investigated are: EBICOS, MATS, ANNO, Basun, OPERA, TAM 2014 and The paper graph (see 2.1.2.1).

5.1 Method in Detail - Procedure

The workplace study was conducted in two control centers for train traffic control in Sweden. Nine randomly picked train dispatchers participated in the study. Seven participated in the observation-interviews and two in the system observations where usability heuristics was taken into account. Age, gender and work experience as a novice or expert user wasn't taken into account within the selection. This is because the instrument that is being developed has the purpose to work on different systems with no regard to the employee's age or work experience.

Every observation started with a brief information-session about the project and the participant's rights and ethical considerations when participating (see 4.4). During the observation-interviews, the observer collected the data by manually taking notes in a prepared observation protocol. The answers from the interview were noted within the interview-guide so that all data was collected in a simple way. Video- and voice recording were not used because it could affect the user's behavior and how they will answer the interview questions. This is because a set up environment with video- or voice recording is not a natural work environment. By not video- or voice record the participants, gave the observer the chance to catch the user's thoughts about the systems and the interactions with the systems.

The system-observations were conducted by simply observing how the system works in relation to the user's work tasks and with a ground in Nilesens usability heuristics (see 3.1.1). The data was collected in the same way as the observation-interviews by manually taking notes and without video- or voice recordings.

The focus of the observation-interviews in combination with the system-observations is to note different factors with regards to Karasek and Theorells (1990) Demand-control model in the user's work environment (see 3.2.2). Focus will lie on their cognitive demands the computer support puts on the user, which control they have over the computer-based work and their interaction with the systems, and what support they have in general from the work environment but especially within their computer-based work.

5.2 Analysis and Results

The collected data of the observation-interviews was analyzed through a content analysis. A content analysis is an empirical method used to find conclusions about the content in different kinds of communication, in for example interviews or observations (Wikipedia, 2014b). Statements from the interviews were brought out to find connections that could fit into different themes. The separation of themes was made before the analysis began and is based on the different dimensions in Karasek and Theorells (1990) Demand-control model (see 3.2.2). The themes are therefore, *Cognitive Demands, Control* and *Support.* The observation-interviews were conducted in Swedish and the statements in this analysis are thereby translated to English. The statements from the interviews were color-coded to see which ones who would fit into which theme. To get a deeper insight into the usability of the systems, the usability heuristics (see 3.1.1) was part of the analysis as a ground for how the system usability was. These heuristics was therefore taking into account in the analysis of each theme and its statements. The results of the analysis are presented below by the following themes: *Cognitive Demands, Control and Support.* Results about the pure system- usability are presented in *System observations,* presented in the end of this part.

5.2.1 Cognitive Demands

Several cognitive work environment problems were found during the analysis of the workplace study. The most salient ones were *Orientation problems, Cognitive "tunnel vision"* and *Short-term memory load.* However, indicators of cognitive work environment problems within *Interruption of thought, Unnecessary cognitive load* and *Inconsistent information coding* was also found (see 3.2.1).

The train dispatchers use multiple systems in their work of dispatching trains. To be able to perform the work tasks, the dispatcher needs to find information and navigate through all the different systems, sometimes by navigating in one system while observing information in another system. This way of working can be hard if the dispatcher has many things to do or if he/she is in a tough situation with a tough task to solve. A couple of statements from the participants in the observation-interviews are examples of when this type of work in multiple systems can be a bad thing. One participant said:

> *"Its tough to have so much information that I need but in so many different systems.*
> *Just because I have to then go into several systems, I have to make more steps to solve a problem, which sometimes can be tough and time demanding. If we don't have all information in a quick way makes it harder and takes more time to solve a problem and also to plan forward."*

Another participant said:

> *"There is a lot of information to retrieve from the systems but I think that there is too*
> *much information spread out on different systems. I have to remember to open every system to remember that different information are in different places, this is not always easy."*

These two statements above indicate the abundance of information spread over multiple systems, and that it's hard to remember where the information came from. This indicates that the way of working with the systems today creates *Orientation problems* and *Cognitive "tunnel vision"* (see 3.2.1). This is because the user has a hard time finding information in a quick way and if an emergency comes along, he might get tunnel vision and miss important information. Each participant in the workplace study had insights that show these types of cognitive work environment problems.

Another problem connected to these two above is the *Short-term memory load, which* is a problem that occurs if there is orientation problems or tunnel vision. One participant said:

> *"It becomes a workload when you have to find information from different places, from different systems. Because I then have to cut and paste information to be able to remember it all from one place to another."*

This indicates an issue that leads to *Short-term memory load* (see 3.2.1). Because the user needs to put so much effort into remembering information, and cut and paste it between different systems, will affect their work performance and make it more ineffective. This issue was also noted during the observations and was especially visible in emergency situations. The user could then get stressed when he/she don't find the information quickly. This cognitive work environment problem can also be connected with *Unnecessary cognitive load* because it is joint with how the user reads the information on the screens. If the information's isn't visible in an effective way and is spread out over multiple systems makes it hard for the user to use pattern recognition to see the information in a quick way. Instead, the user needs to put more effort into reading the information and remembering it from different systems. This puts high cognitive demands and an increase of mental workload on the user. This is also a sign of *information overflow*, which is one factor that can cause techno stress for a user in a computer-based work environment (see 3.2.3).

During the observation-interviews, signs of *Inconsistent information coding* within the systems were also found. One participant said:

> *"The fact that they changed the background in EBICOS was a mistake, thinks many in the control centers. Its hard to learn to read in the system even though it's the same system. But the contrasts are not as easy anymore to see when the background is grey and the tracks of the trains are grey."*

Another participant said:

> *"Its hard to read the information and understand it quickly when looking into different systems. Because even though two systems show the same kind of information like information about a train or something, the systems look different with different colors and buttons. This makes it hard to in a quick way see that it's the same information. You have to learn everything on your own."*

These two statements above indicate that the systems information coding and the different visual functions like colors, etc. are too inconsistent through the different systems. It also indicates that the user can feel spatial "headedness" because he/she has a hard time finding relevant information in a quick way. If the information coding is inconsistent, it can be hard for the user to read and understand the information in a quick way. This is very important in the train dispatcher's work because they need to make fast decisions. If, the system does not support them with an easy way to read and understand the information given to them, it will affect their work and again make it more ineffective.

Because the train dispatcher works in a computer-based environment makes it important that the systems are designed to match the user's capabilities and work tasks. The analysis makes it clear that the train dispatchers' everyday work environment is characterized by system-driven work with high cognitive demands. This creates many cognitive work environment problems, and it causes a high mental workload. It causes high mental workload because the user needs to use lots of mental power to perform a task. This is related to information processing and interface usability issues (see 3.2.2), which also becomes clear in the analysis. The Demand-control model by Karasek & Theorell (1990) combines the three dimensions together by saying that if the user has high cognitive demands or a high level of stress set on them, it is important that they have good possibilities to control and support in their everyday work situation (see 3.2.2).

5.2.2 Control

Karasek and Theorell (1990) refer control in the Demand-control model to the user's decision making. The user's ability to control or take decisions over a certain situation is formed by the two aspects of the control dimension; how big social authority the user has over the decision-making, and how big range of experience and competence the user has available in their work. The user needs to have control in their everyday work situation. Control over how to perform tasks, over their decision-making and control over their own development of competence and their possibilities to participate in change-related decisions about the systems functions and interface. It is also important to see if the user has control over the systems he/she works with, or if it is the systems that control how the user can work (see 3.2.2).

The train dispatchers go through 10 weeks of training and learning to get the knowledge base they need to be able to conduct the work in an efficient way. After the 10 ten weeks they get a chance to sit with an experienced dispatcher for a minimum of a half year to learn the job in the right context. All the participants said that they felt that the ground training they had prepared them for the work. Some said that even though they had almost a year of training it all came down to the experiences they have had over the years that are why they can conduct their work efficient today. One participant said:

> *"I feel that I can work a day and then be pleased with that, so my experience and knowledge is absolutely enough. But then new situations comes along all the time and you have to learn how to handle them."*

For the user to have control is very important in every work related-situation. Even though many of the users feel that they have a good knowledge base from learning and experience to be able to work efficiently, having control can also be both stressful and high demanding. One participant said:

> *"Sometimes I wish that the systems could support me more in my work just because we have to make so many decisions. Sometimes it feels like you have to trust your own abilities more than the systems because the systems sometimes fail. That can be very stressful because it demands so much control from our side."*

This statement indicates that the user cannot always trust how the systems work even though they have long experience working with them. It also gives signs about lack of support from the systems because the user says that he/she sometimes wishes that the systems would support them more. This is a sign that there should be changes of the interface in the systems.

One participant said when a question came up about if he/she felt more workload because the systems they use sometimes are complicated and fail on them:

> *"Its probably if the systems does not work it makes you feel that you don't have control. That's why it sometimes feels that to be able to have control you have to learn everything about how the systems work and then the human, I have to take over to keep the control."*

During a normal workday the train dispatchers needs to make different decisions and at the same time understand the consequences of every decision and to plan for an outcome. If the systems do not work in an optimal way and often fail when the user conducts different actions in them, it will cause inefficient work. The fact that the participant above says that their way of having control is to learn everything about how the systems work in case it would fail them is not a good way for the user to work. It both creates cognitive work environment problems such as; *Short-term memory load* and *Unnecessary cognitive load* (see 3.2.1) because the user then has to remember how every system works. It also creates stress because if an emergency situation occurs, it can be hard for the user to both take their work role and their role as knowing everything about the systems into account. Another participant also made the connection between heavy workload or feeling stress and having control over a situation due to a lack of trust if they work or not. The question was about whether the user at any time had felt stress or irritation when using the systems and why:

> *"Yes I think we feel that very often in this job. But it's more when you feel that you don't have 100% control on the current situation and about what's happening. Since EBICOS lives "its own life" with the trains coming in, changes happens and so on makes it stressful to have control over it. Especially if the telephones rings all the time as well."*

This can be a sign that the systems control how the user can work in them and not the other way around. This can affect the users' trust to how the systems work, and it can also cause stress if the systems "live their own lives" and don't give feedback why some actions happen. Even though the train dispatchers' work is almost fully computer-based they don't have a lot to say about how they think the systems should work. This is also an indication of continuous partial attention, which means that because of the lack of usability in the systems, the user needs to be aware and have his/hers attention on many different things at the same time. This is a factor that easily can create techno stress (see 3.2.1). They have the possibility to talk to their colleagues or the production leader if they have any pinpoints about anything in the systems but usually it's not much they may affect in the development of new interfaces. One participant said:

> *"We get to say things about the current systems we use or when we get a finished system. But we never get to say much in the development of a system and frankly, I don't know how much they use of what we say."*

The other participants said more or less the same thing and some of them also added that they, mostly just had to learn all the new functions and features that can come with new systems during work hours. This puts high demands on the users because they get more things they need to be in control over, they need to have control over their learning abilities and the train traffic as well. This can after a while cause stress to those who have a hard time handling too many things at the same time. High workload and high work tempo are factors that affect how the employee's work will be conducted, and if they are satisfied with their work situation (see 3.2). To be able to have control and at the same time minimize the cognitive workload, support from the surrounding environment and the systems is crucial for the user.

5.2.3 Support

It is important that every employee finds support in their workplace from different social actors. If there is a lack of social support it can affect the users' comfort and satisfaction about their work situation (see 3.3.2). Support can come in different forms in a workplace. This study focused on looking at the support from the social environment and the computer-based work. All participants had the same thoughts about the support they can get from their social environment. They said that they always had the possibilities to talk to a colleague or their production leader if they need any help solving a problem or just planning for future train traffic control. One participant said:

> *"There is a lot of support from my colleagues and we discuss a lot when problems occur. All the computers and systems are connected so we know what happens all the time and what the other ones are doing in the systems, which is good because then we can help each other and take over each others telephone calls and paths someone controls."*

Since all the train dispatchers see the same systems on their computer screens makes it easy to understand where your colleagues are in the train control system EBICOS, where the train traffic control is mainly conducted. This makes it possible for the dispatchers to easily change paths with each other and take over each other's phone calls if someone has a lot to do in, for example, an emergency situation. This type of connection between all screens is a good support for the users. It forms a security because it gives the user the possibility to get help from a colleague through speech and also within the systems in a quick way.

Much of the work that is made inside the traffic-control centers involves planning. To plan and to make fast decisions also involve a security that the dispatchers must have about what they know, what to do and when to do it. If the systems do not support the user, the security and self-esteem can minimize. One observation that made this clear was: when the train dispatcher sees in EBICOS that there is a non-moving train on the tracks he/she has to find out what has happened and what is wrong. The train dispatcher then needs to call the train driver, talk to colleagues, check if there is anyone who may be working on the tracks, if there has been an accident, if there is a track error or a signal error, etc. With other words, EBICOS doesn't have a security function that will tell either the train driver or the dispatcher why the train isn't moving. This incident happened during one of the observation-interviews and when I asked the participant what happened and if this affected his/hers workload, the answer was:

> *"The workload definitely just got higher. EBICOS doesn't give me any feedback at all that something is wrong so I have to have supervision over the system to even find out that a train had stopped. Here must therefore the man take over and take action and no wrong decisions can be made. This puts a lot of pressure on us."*

This is a sign of a system that doesn't fully support the user's every need. Even though the train dispatchers are used to work inside the systems they use and despite their long training, flaws within the systems that affect the user's work situation negatively exist. If the user lacks of support in different ways from the used systems, their work situation will be affected in negative ways. Their work performance can decrease together with an increase in their stress level (see 3.2.2). This is a sign of techno stress that can occur if the usability of the systems isn't as good as it could be (see 3.2.3). When a user has techno stress it can cause a long period of stress in work. This is of course not good because it will affect the users' productivity and satisfaction in their job.

5.2.4 System observations

In addition to the observation-interviews, two extra system observations were conducted. During the whole workplace study, observations about the interaction between the user and the systems were made. Many interesting results came from observing the user-system interaction, many of them that can be seen as indicators of good and bad usability.

To analyze the usability, I used Nielsen's usability heuristics (see 3.1.1). The observations are therefore connected with the heuristics. The systems used for train dispatching are both complex and dynamic systems. This can make the technology difficult to understand when it comes to different factors such as functions, features, and actions in the system, etc. The most interesting observations about the usability of the system were:

- When planning the train traffic, it is important that the dispatchers know when the trains are coming and where they are. This information is not as visual in the controlling system EBICOS as it could be. They can read it from the paper graph, but a train meeting is not something they can see in any system. This can be a sign of that the visibility of the system status (see 3.1.1) is not enough. The system should always keep the users informed about the system status. If the feedback is not visible in an optimal way, it can affect the user's work situation.

- The user doesn't get feedback from EBICOS if there is something wrong with the tracks or if there is a signal error. The only thing that is shown in EBICOS is that the part of the track where it is something wrong becomes a static red line. When the train is moving, the track line is a dynamic red line. Many of the participants said that this was learned by experience. That it takes a long to time to be able to, in a quick way, see the little static line, especially when they have much work to do. This is again a sign of the system not having the system status as visible as it could. It is also an indicator that the system doesn't help the user to recognize a problem that has occurred. This will then make it hard for the user to diagnose what type of problem it is, which will lead to a hard time for the user to recover from the problem as well (see 3.1.1). This is a sign of bad usability because the user needs to use much mental workload and memory because they have to learn this function by themselves instead of having the support of the system.

- One good observation made was that there is a good match between the systems and the real world (see 3.1.1). The systems use words and phrases familiar to the user and that many of them understood well. This is especially for the systems MATS, ANNO, BASUN and TAM, the supporting systems. EBICOS is such a complex system for controlling the train traffic so it took a long time to learn all the functions and features. This makes EBICOS less usable in the matter of its match of words, phrases to the real world. Because the system uses technical terms, which are terms the train dispatchers needs to learn from training.

- All the systems supported the feedback of user control and freedom (see 3.1.1). If the user clicks on a button when they, for example, want to make an action of putting in a new train way for the trains or adding a line of documentation in a system, the system gives the user the chance to close the pop-up window with the actions or continue. This is a common way for systems to work. The possibility that the user has to change and close and not do the action they first started with is good. However, the system EBICOS doesn't always give the user a chance too quickly undo and redo actions. If the user has planned for a new way for a train to go, it can take up to minutes before they can undo their action in the system. This can be both beneficial and inhibiting because it is not always effective to have a quick fix because accidents can happen if the dispatcher quickly takes away the trains' ability to go further on a track. Despite this, the user never gets another feedback if they want to accept the new train way, or if they want to take it away. This feedback could be given at the same time they choose to perform the action. Because they, now, have to see for themselves if the decision was optimal and if something else happens in another part of the system, which can make it hard to remember what they just did. When I spoke about this with the participants, they all said that they have learned this with the years, and that they always have to be in full control not to miss anything. This increases the mental workload for the user, and it can cause stress in the long run if they do not get more support.

- To plan for the future and to take decisions about future planning are a big part of the job for a train dispatcher. Despite this, the systems they use don't always make it easy for them to plan through controlling, which is desirable according to the production plan. Sometimes the train dispatcher's work is about planning the traffic 20% of the work time and 80% controlling the traffic, and sometimes it's the other way around. This depends on situations and, which train traffic control it is in Sweden. The systems don't support with helpful feedback when it comes to this. EBICOS as one system doesn't show any help for future planning, instead they depend only on the paper graph they have in front of them. To just be able to use the paper graph is not an optimal way to work. The user has to look down from the systems to use the graph, which takes their attention away from the system, which can lead to that they easily can miss if a deviation in the system occurs. The paper graph is a very useful tool, which all the participants spoke highly of. The graph makes it possible for the train dispatchers to control through planning, which is important, so they always can be one step ahead.

- EBICOS needs to have better error prevention (see 3.1.1) by using better error messages. Today there is no usable error message that pops up if a problem occurred. The users need to learn by themselves how to keep track of any problems that can occur and then how to read this in the system. If the system had better error messages, it could help to prevent a problem from occurring in the first place.

- The flexibility and efficiency of use within the systems is shows not to be optimal in regard to the results from the observations (see 3.1.1). This is because the design of the systems does not at first support the novice users because of their complexity. Interactions between the systems that the user can use make their work more efficient and may speed up their work a bit, but this is not good for the novice users. This is also mentioned from many of the participants. They often say that much of the work, they do today is efficient because of many years of experience, and that they did not work efficient when they first started. That an expert knows more and may work more efficient is common in any job but the fact that there is such a big difference is not so good in the work of a train dispatcher. Even if they have many years of expertise, or if they are novice, they still have to make fast decisions and plan for the train traffic to work. This then puts high cognitive demands on the user because they need to use their memory in order to recognize problems and what they have learned about them to be able to solve them.

- One major usability issue that in the interaction between the systems is that the information today is displayed for the user in a way so they have to use recall rather than recognition to retrieve information. This can be connected to the cognitive demands set on the users when they need to find information and remember it through different systems (see 5.2.1). The biggest example of this, that every participant said, was that the information they use exists in many systems but it is hard to find. This was especially all the information that exists in the system OPERA. Information about track length, train weight, if the trains transport toxic waste, etc. is information that only exists in OPERA and is hard to in a quick way reach to. Because of this, many of the users skip to use the system and therefore, miss much relevant information. This can definitely be seen as a usability issue that affects the user's work situation. Two of the participants said that they rather wanted all information that they could find in OPERA by clicking or hovering on a train or track in EBICOS. The information could also be visual in the system in a sidebar or something similar, but the pop-up could be better because the users said that the information they retrieved from OPERA is information they only need to see sometimes, which is why is may not always have to be visible but should be easy to find. That could be a quick and easy way to see information relevant for each train and situation.

- The telephone system MATS worked well but had some flaws. For example, the user cannot put the calls in order from which ones that are more important to answer first. This became a frustration for many of the users because they had to call back to some people if they didn't have the answer they wanted to give to them because they first had to speak to someone else who's incoming call came later in the list. This becomes a workload for the user because it can distract them from having control in the systems for train dispatching, and the work can become inefficient.

- It is useful that EBICOS has the security function so that no trains can go towards each other or be put to tracks that go towards each other. This is a security function for the users to feel comfort in the fact that it cannot happen, and that they cannot by mistake put in two trains to go towards each other. This is not always the way it works though. EBICOS has two frames for rules inside of it; H and M. H is the system they see all the time while M is not visible for them. M is a rule frame that is used for only some parts the train dispatcher controls. To be able to send a train on this path they need to call a regional personnel which says if it's okay or not. M doesn't then have the same safety regulations as H does. If the user is stressed or doesn't have full control, they could by accident send one train away on the paths connected to M, and a train collision could occur. The participants said that this never happens because they have the rules for M in the back of their head, but it can still be hard for a novice user to remember all of it and at the same time work efficient in H.

5.3 Conclusions

The results of the analysis made it clear that the train dispatchers' work is about controlling and planning the train traffic. Because the train dispatcher's work is about planning the traffic 20% of the work time and 80% controlling the traffic, and sometimes it's the other way around could make it significant to evaluate the usability by separating the planning and controlling parts. Despite this, it is important to try to measure the usability where the planning and controlling are connected to each other. This is because one of Trafikverkets goals is for the train dispatchers to control the train traffic through planning (see 2.1.2.1).

The analysis showed that the train dispatchers have high cognitive demands set on them caused by the computer-based work. The systems they use have usability issues and due to a lack of support, it causes high mental workload, control issues and stress for the users. The users experiences that they don't get enough support from the systems through feedback and visible information. This is something that each participant made clear by talking about how it's hard to find information because there is so many information spreads over multiple systems. And also because many of them have a hard time trusting the systems to work as they should, and they, therefore, get stressed because they know that they have to learn everything the systems should know and do if the systems failed in a situation. The cognitive work environment problems that stood out the most were *Orientation problems, Cognitive "tunnel vision"* and *Short-term memory load.* However, indicators of cognitive work environment problems within *Interruption of thought, Unnecessary cognitive load* and *Inconsistent information coding* was also found (see 3.2.1). The five problems that were observed are indicators of how the environment is and how the systems actually support the users. Even if there only had been one cognitive work environment problem it would have been a problem that should be evaluated and fixed. To have indicators of five cognitive work environment problems is therefore, a high number of problems in the train dispatchers' work environment. This is therefore, a clear sign that the systems have issues with usability. Because of the lack of usability in the systems, creators of techno stress were also found. *Information overflow* and *continuous partial attention* were two creators that exist in the train dispatchers' interaction with the systems.

By analyzing the statements in the observation-interviews a conclusion can be drawn that the train dispatchers' work both are within the active and the high strain condition in the Demand-control model (see 3.2.2). The train dispatchers work in an environment where they have a high degree of control because they always have to have control to be able to make fast decisions about what to do and how to plan ahead for the train traffic. This also sets high demands on the user to manage to have this control and at the same time perform successfully. This is a sign of an active condition of the work environment. It is good when the user has control because it can prevent stress even though the users have high demands on them. Many times the work situation reaches a high strain condition as well, which is mostly negative as a health aspect. In this condition, the user has high demands on them and a very low degree of control. This is seen in the analysis when the user speaks of lack of control in trust for the systems to work, that they don't find information easily and when they have to interact with multiple systems and at the same time keep track of the current traffic situation. Working in the high strain condition can cause a high risk for long lasting stress. A conclusion can be drawn from this that it is very important that the usability of the systems is good so that the high demands can decrease so that the train dispatchers can work without a risk for techno stress.

Because the systems used for train dispatching are dynamic (that they change their behavior depending on the influences of different situations and that the actions made for control not only affect the present situation but also future situations (see 3.1)) makes it hard to measure usability in these dynamic systems. For example, to see usability as effectiveness in terms of time to conduct a specific task etc. can be difficult because of the changes of conditions in the systems.

One last conclusion can be drawn from the analysis, that the user needs systems that:

- Has understandable and easy solutions
- Has relevant information visible in a good way
- Don't have information spread over many systems
- Gives feedback to the user about what happens in the system and also feedback on how to do undo/redo in an easy way
- Not too many functions and drop-down menus. This can be distracting when dispatching trains

Chapter 6

Phase 2: USOT - The new instrument

A new instrument has been developed with its theoretical ground in Karasek and Theorells (1990) Demand-control model (see 3.2.2). The instrument has been developed through analysis of results from the workplace study and system observations (see Phase 5). The purpose of the instrument is to be used to evaluate which cognitive and psychosocial work environment problems that can occur in the work of a train dispatcher at the authority Trafikverket. This is done by investigating the usability of the used systems from a psychosocial and human cognition perspective. The usability of the used systems is then evaluated in regard to how the train dispatchers' cognitive capabilities are being supported in their work situation. The instrument got the name USOT that stands for *Utvärderingsverktyg* för *System-användbarhet* i *Operativ Trafikstyrning* (english translation: *Evaluation instrument* for *System-usability* in *Operative Traffic control*) (see Appendix 2).

The instrument will be used to evaluate the usability of the system-support. Since one of the major goals for the train dispatchers is to control the train traffic through planning, the instrument will combine these two parts together and evaluate the general usability for the interaction between the user and the systems. The first part in the instrument is an introduction part that describes the problem domain and the purpose of the study with a motivation to why it has been developed. It will also have a chapter describing how and where it should be used. The next part of the instrument has a theoretical chapter that will introduce the instrument for the user and the background. This part will have a short description of cognitive work environment problems and the Demand-control model. The Demand-control model was chosen as a reliable model for the evaluation instrument because it is a well-known model that is used for existing evaluation methods of the psychosocial work environment. The model is used to evaluate how the systems support the cognitive demands set on the user, if the user has control and how the social and computer-based work affects the user's work satisfaction. How the computer-based work affects' human beings in their everyday work situation are not commonly evaluated. The only developed instrument that is close to doing this is UDIPA (see 3.2). The developed instrument and the survey questions are therefore inspired by the evaluation methods in UDIPA, but developed to fit the current investigation area of traffic control. By using the theoretical background from the instrument UDIPA with existing usability evaluation methods could give a greater insight into the systems usability and how it affects the human beings. This is done in the current instrument by the integration between the Demand-control model, and the usability heuristics of Nielsen (see 3.1.1). The description of the Demand-control model and the factors listed for demand, control and support has its ground in the theoretical background together with the empirical data produced through the workplace study so that it's designed specifically for evaluating operational traffic control systems.

The theoretical background is the ground for the developed survey that is the method used in the evaluation instrument. By choosing a survey as the method for evaluating the usability makes it possible to engage more users because it takes less time to conduct such a study. One benefit with this is that the users will stay anonymous, which can make the results more truthful because they don't need to answer to a specific person. Due to the short period of time it takes to conduct a survey study also makes it a cheap method to use. This is beneficial for the authority because making evaluations and investigating current systems may not always be a priority when there is another work that needs to be conducted.

The survey consists of 16 estimation questions that are all related to the usability of the systems and the cognitive demands, the user's control and the support that is affected by the computer-based work. The questions have their base in the Demand-control model, the cognitive work environment problems and Nielsens usability heuristics that is presented in the second part of the instrument. The questions are formed by the results that were found in the workplace study (see Phase 5) about how the train dispatchers' work situations looked like, how they used the systems, what they thought of the systems and how the systems supported them in their work. The questions are not presented in order after cognitive demands, control and support because that could bias the participants, and their answers could be affected and not as reliable as they could be. The questions are instead ordered randomly so that the participants do not become affected by any theme or pattern. Even though the questions are not ordered after the three dimensions they are still in a logical order that the participant easily can understand. This is recommended according to Trost (2007) who also says that by using similar questions, even if they have different meaning, represents good reliability in survey studies. The questions are formulated in an easy and logical way so that they are easy to understand. The answers of the questions are answered on a Likert-scale, which is a common method for measuring attitudes of the respondent in workplace studies (Wikipedia, 2015c). The measurement has different scales of numbers to get an index of the answers. The respondent gets to answer by selecting which degree he/she agrees with in the scale. The measurement consists of an ordinal scale, which means that there is the same size between the different numbers in the scale (Wikipedia, 2015c). It is a six-point scale, 0-5, which gives the respondent a chance to take a more negative or positive stand in the questions. This also makes it easier to interpret and analyze the results. If the scale had five points, the respondent could have chosen the middle one and with that don't take a specific stand in the question. The response options consist of one side that goes towards a positive attitude and one that goes towards a negative attitude. The options are either "Ja, alltid" ("Yes, always") and "Nej, inte alls" ("No, not at all") or "Ja, fullt ut" ("Yes, fully") and "Nej, inte alls" ("No, not at all"). These types of response options are optimal for this evaluation instrument since the evaluation is not about the technical functions within the systems but instead the subjective opinions of the users, which will give indicators to how usable the systems, are. The survey ends with an open qualitative question (questions 17) to capture the user's full opinion about their use of the systems. By combining quantitative data with qualitative will give a bigger insight into the user's thoughts. This is because the open question in the end can be seen as a closure for the whole survey which combines all the answers and is sort of a statement that can explain why the users answered the way he/she answered in the survey.

After the survey has been presented in the instrument, a description of how the results should be interpreted and analyzed is presented. The structure of how the questions are formulated is vital for how easy it will be to analyze the results. The response scale is ordered so that if the respondent answers with a low value (0-2) it indicates that usability issues and cognitive work environment problems exists. If the respondent answers with a high value (3-5) it means that they have a positive attitude towards their work environment, which indicates good usability. Usability issues are indicated by conditions such as high cognitive demands, low degree of support and control. Good usability is indicated by the opposite conditions. This way of analyzing the results is a good way because it is easy and simple for different evaluators to understand. After the description of how to analyze the results, a last description will be made about how the authority can take the results and information forward and why is it important to note and fix usability issues.

People should use the instrument if they have previous knowledge within HCI or work environment issues because a knowledgebase within human cognition and usability is required to be able to conduct a well-interpreted analysis. It is important that the evaluator who uses the instrument has a relevant knowledgebase, because it otherwise is hard to fully understand how to interpret the results. The instrument is used as a manual for the evaluator for the analysis of the users survey-answers. The users will therefore, only take part of the survey and not the other parts of the instrument. The survey will be easy to use and understandable for a big range of users. The instrument is not so big so it will not take so much time to use it in an evaluation. This is good because the authority then doesn't have to put too much time into the evaluation because time doesn't always exist. Since the evaluation will take a short amount of time when using the instrument, it will be more efficient and less expensive for the authority. The instrument should be used regularly with either evaluations ones a year, when new functions or systems are being used or when the organization considers it necessary to have an evaluation of the usability. The instrument can be used to evaluate different conditions. Either, it can be used to see differences between users, between novice and expert users or between control centers. The instrument can be found in Appendix 2.

6.1 Method in Detail - Procedure

After formulating the questions they were tested on train dispatchers to see if they were relevant and easy to understand. The test was made as a pilot test to get a first glimpse of how the questions actually worked in the survey and if their design could remain. The test was conducted like a "real" test would have been conducted, in the pertinent setting (traffic control center) and with relevant participants (train dispatchers). When testing the instrument the evaluator went through all the different steps needed to conduct the test. The test session was around 25-30 minutes long per participant. They got to answer each question and after the whole test they got to give feedback if there was anything they didn't understand or got confused by. This could be about formulations of the questions or about the order they came in. The data from the pilot study was not recorded but only written down manually on a piece of paper. It was done in that way to avoid nervousness or fear from the participants, which can come from being recorded. The participants were kept anonymous because it is not important for the study or for the results to know exactly who participated.

6.2 Analysis and Results

The result of the pilot test showed that the questions in the survey was well formulated and could be used as questions for the real tests. There were only one or two of the questions that had to be explained to the participants. Changes were therefore made in these two questions. Despite this, most of the questions were easily understood.

One participant said after he/she had answered the survey:

"I understood all the questions because I could relate to them. It felt like it was connected to my work"

This indicates that the questions were well formulated and that the purpose of developing them based on the train dispatchers' work was successful. This also indicates that the questions may be too developed towards the train dispatchers. This might therefore be a field for future development to make the survey more general so it can be used on more user groups.

One participant said during the survey:

> *"The questions are easy. This will go quickly."*

This is also an indication that the questions in the survey were well formulated and easy to understand. It was also interesting that the participant said that answering the survey was going to go quickly. This was one of the requests that I set for the survey when developing it. To have a survey that is easy and can be answered quickly is cost-effective for the authority.

Another participant said:

> *"I did not spot any big differences between the questions that stood out.*
> *Like if it would have had a specific theme or something. They all felt connected."*

The questions were developed to fit the themes cognitive demands, control and support, but they were randomly ordered in the survey. The statement above indicates that the randomly selected order of the questions were successful. It also shows the importance of the formulation of the questions so that the participant doesn't get biased by how they are formulated.

6.3 Conclusions

By doing the pilot test of the survey gave more insight into how the questions actually would work in a real test setting. The pilot test showed that the questions were formulated in a good way, and that they were easy to understand. The random order of the questions was also successful because the participants did not understand the themes behind the questions.
Despite the good results of the pilot test, the survey still needs further development, and it needs to be tested in a real work environment.

Chapter 7

Discussion

Since the results of the workplace study showed that the usability of the systems used for train dispatching is not as usable as they could makes it clear that this is a question that needs further investigated within the authority. Furthermore, the fact that many users thinks the systems work as efficient as they could, but they still don't trust the systems fully to work in stressed situations makes it clear that the support of the systems may not be as good as it could in those situations. By investigating the usability of the systems used for operational train traffic control can both contribute with knowledge to the authority, but it's also a chance for the train dispatchers to get their thoughts heard but also more support in their work. This is crucial for train dispatchers since their work is all about decision-making and problem solving. The systems have to support them in their work so that the complexity of the systems does not become another work task for them to control. This is clear in the analysis and is therefore, important to understand and further investigate. The level of usability that this study investigated is only one of many ways to investigate the usability. It is important to investigate more levels of usability, like for example, to look more into functions, and interaction design of the systems, or a socio-technical perspective (see 3.1.1.1). By doing this, greater knowledge could be given to the authority about more usability levels in their systems.

The developed instrument USOT has both its strengths and weaknesses. One of the biggest strengths of the instruments is that it both have a solid theoretical ground based on the well-known Demand-control model developed by Karasek and Theorell (1990) (see 3.2.2), and it has the empirical investigations of usability with observations-interviews and Nielsen's heuristics (see 3.1.1) that confirms the theoretical assumptions. Another aspect that is a strength of the instrument is its definition of how it can be used to evaluate usability. The fact that the usability evaluation is about the support that the system and the environment gives the user, and how it affects their cognitive capabilities makes it easy to generalize over more than one system and user. The strength, therefore, is that the instrument can be used on different types of systems, which could give the authority a broader insight into how the system environment works for the users. Together with the system independent evaluation, it is also a strength that the survey used to evaluate is developed so that it collects both quantitative and qualitative data. By combining quantitative and qualitative data gives the researcher and evaluator a chance to understand more about how the user thinks. This is because they can connect statistics and highly structured data with statements of the users' attitudes and ideas to see how these cause their actions and their decision-making.

Despite the fact that the definition of evaluating usability through USOT is a strength because it is easy to use the method to generalize over more users, it is also a methodological weakness that is significant to discuss. Because, given that the purpose was to investigate how the current systems support the train dispatchers in their work, and through that develop a measurement to measure the usability of the systems, the definition of measuring usability through USOT may not be optimal. This is because USOT is based on the users' thoughts, experiences and satisfaction more than efficiency and effectiveness of the systems. The investigation of this study, that is the ground of the development of USOT, was made only with qualitative research methods and not with a "regular" usability evaluation method where the systems is taken away from its context to be evaluated from some tasks participants would conduct. This type of usability evaluation would have been interesting to conduct to see efficiency measurements like, for example, how much time, or how many clicks it takes for the user to fulfill a task in the system. These types of measurements, therefore, were never measured in this study. This type of usability evaluation could not be conducted because the systems cannot be taken away from its context, which is needed to be able to hold the variable of time and clicks, constant. The train dispatchers work all day and night with the systems and there is no way to "borrow" the system on another computer in a lab. Despite this, it would also have been hard to measure the usability of the technical functions in the system because the systems are dynamic. It is very hard to measure, for example, time in dynamic systems since the time will always differ due to each new situation. This is why it also was hard to define how to measure and investigate usability in the operational traffic control systems.

To find out how a user's work situation looks like and what cognitive demands that exists, a connection between the users' experiences and how he/she conducts the computer-based work, is needed. If the systems don't support the users' cognitive capabilities and their abilities to conduct their work tasks in an optimal way, there can be a lack of usability within them that can affect the users work performances and satisfaction. This indicates that to evaluate the systems with regard to how they support the users cognitive work environment is something that needs to be done. Despite this, it is not easy to draw any conclusions of how to re-design the systems to fit the users better, with only the results from an evaluation using USOT. This is because it does not give any distinct answers of the efficiency, effectiveness or design of the systems. This is an issue that requires its own empirical study. USOT can therefore be seen as start of a usability evaluation and as a pointer towards the right direction of a comprehensive evaluation and measurement.

The fact that the instrument only has one part of evaluation that combines how the systems support the user's work of planning and controlling may be both strength and a weakness. It can be a weakness because it may not fully give optimal results of either how the systems support the user's need for planning or controlling. However, I have not seen any results in this study that shows that a separation of these two is necessary. Trafikverkets goal is for the train dispatchers to control the traffic through planning, which indicates that the design of the instrument could be strength. To evaluate controlling through planning and how the systems support this are therefore, something to strive for with the evaluation instrument. At the same time, it may also be necessary to see first if it is even possible to control only through planning or if these two parts actually are mostly separated. Even though the instrument USOT is developed through a long study of empirical research with a ground in a solid theoretical background, it needs further research and development. The fact that no first baseline testing was done is therefore, a weakness of the instrument, and it is something that needs to be done. This is a weakness, but it is also a strength because of all the time that has been spent on the development of the instrument instead of preparing it for a first evaluation. The time spent on developing the instrument could therefore be a benefit for future research and development.

7.1 Conclusion

The purpose of this study was to investigate how the train dispatchers' systems support their work situation and their cognitive work environment. The aim was also to develop an instrument to use for evaluating how the usability of the systems affect the human cognition in regard to the user's workplace. The research question for the study was:

> *"How can usability be defined and measured in systems used for operational train traffic control?"*

Within this study, the literature review, the theoretical argumentations and the empirical collection of data have shown that the usability of systems used for train dispatching is an important factor in the psychosocial work environment and that a lack of usability can cause cognitive work environment problems. The way of evaluating usability in the operational train traffic control systems was defined through observations of the systems, and the theoretical background of usability and workplace studies. A clear definition of how to evaluate and measure usability in the system used for operational train traffic control was made (see 3.1.1.1). The chosen definition for this study was Level 2 because it fitted best with the investigated setting. Through the literature review, it has also been discovered that an instrument to measure usability within the context of a train dispatcher's work, in regard to their psychosocial work environment does not exist. The whole study is an investigation of how to measure usability within the perspective of human beings cognitive capabilities. The developed USOT is the result of one way of defining and evaluating the usability in operational systems for train traffic control. Because the instrument only investigates the systems support by investigating the users' thoughts and experiences, other measurements of efficiency and effectiveness needs to be done to conduct a more comprehensive usability evaluation. The instrument can, therefore, be seen as a pointer in the right direction towards a complete usability measurement of the systems used for train traffic control.

The evaluation instrument UDIPA (see 3.3) was defined as a reliable base for the evaluations instrument but for the purpose of this study used as a ground for further development, with more system-usability and developed to fit the train dispatcher's workplace. The authority Trafikverket can use the new instrument, USOT, to highlight the importance of the usability in their systems, and how it affects the users. It is also used to contribute with knowledge to the authority about usability, cognitive work environment problems and how the systems support the traffic-control operators. Because of this, the purpose and the research question of the study is therefore, considered to be answered.

Chapter 8

Future work

The work that was conducted throughout this study has formed a solid base for future work within this area. This study will hopefully create more knowledge about the importance of usable systems within computer-based work in train dispatching. Not only for the management of the authority but also the operators working in the traffic-control centers, so they can understand how important their voice is in this matter.

One desire is that more researchers can continue the development of the instrument USOT so it can be tested to see if there are other ways to make it more optimal and relevant for evaluation of different types of systems. One example of how to make it more optimal is to investigate if the questions in the survey really can be generalized over all train dispatchers by, for example, making new but similar questions to see if they reach the same kinds of answers on different users. The design of the instrument could also look different. The fact that the train dispatchers usually work either 80% of their time with controlling and 20% with planning or the other way around can be a factor that should be taking into account when designing the instrument. It could therefore be good to investigate this to see if it is relevant to redesign the instrument to fit an evaluation where these two ways of working are separate. The design could then have two parts, one to evaluate the usability of the systems when the train dispatcher is controlling and one part to evaluate when the train dispatcher is planning.

There are different types of methods for evaluating usability, and it would be interesting to develop the instrument so it can be used to evaluate usability with a broader perspective (see 3.1.1.1). One example could be to develop it so it can be used to evaluate a broader human-organization-technology perspective to see the whole interaction between the information flow from the authority to the train dispatcher and at the end to the train driver. By making the perspective broader could give more insight into how regulations and work approaches in the authority actually work. This is because even though the usability of the systems is evaluated the authority's regulations that set demands on the user's work in the systems is also a big factor that may affect their work performance and satisfaction. Research could therefore be conducted to see how the authority uses their regulations to in the best way control the railways, and by that see if it affects the user's work in a negative or positive way. The evaluation instrument USOT can thereby be seen as a start of more development towards evaluating usability within train traffic control.

To get a deeper insight into how the system-usability is, the interaction design perspective can be investigated. In this perspective, the researcher can look at functions, colors and other elements that are pure technical within the systems to evaluate the usability. This research is also something that is important to conduct to get a greater insight into the usability. This information can be a first stage, and it can be connected with further evaluations were the instrument USOT can be used. If these two parts were connected the authority could get results of system-usability that truly connects technical functions with the user's capabilities. However, to measure the technical usability of the systems used for train traffic control is tough because the systems are dynamic. The systems cannot be taken out of context, and it is therefore, hard to measure efficiency (for example, time to perform a task) within them. To be able to measure this, the systems need to be taken out of context and into a controlled environment. This can be done if, for example, simulators were developed where usability tests could be done on different tasks in different situations in the systems. This is something that future researchers could do. It is also something that can be connected with the evaluation instrument USOT to gain insight into how the users' cognitive capabilities, and the demands set on them can be connected with different situations and usability factors in the systems.

It is important to keep validating and developing the evaluation instrument USOT. Future work that needs to be done is that it needs to be tested on more traffic-control centers in Sweden to see if it fits on different systems and in different situations. A first measurement needs to be done to have a baseline for how the usability is in the used systems and to see how the users work situations affect their cognitive capabilities. To get a greater insight into how the work situation and the usability are, further measurements and evaluations need to be done because it can be used to create a greater insight into how the system-usability can shift depending on situations, users and if new functions were implemented into them.

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Appendix 1 - Interview guide for the Workplace study

1. Hur fick du lära dig de systemen du arbetar i idag när du började arbeta med de?

2. Hur upplever du att det förberedde dig för arbetet med systemen?

3. I vilken mån upplever du att du har tillräckliga kunskaper och förståelse om systemen för att kunna utföra dina arbetsuppgifter på ett tillfredsställande sätt?

4. Hur upplever du användningen av systemen?

5. I vilken mån upplever du att systemen innehåller tillräcklig information för att du ska kunna utföra dina arbetsuppgifter?

6. I vilken mån upplever du att systemen innehåller för mycket information vid användning?

7. Har du någon gång upplevt irritation eller stress på grund av användning av systemen?

8. I vilken mån upplever du att du får en större arbetsbörda på grund av att tekniken är komplicerad eller om den felar ofta?

9. När du inte vet du ska göra eller inte hittar information, vilka möjligheter till hjälp och stöd finns då i din omgivning?

10. Har du möjligheter att komma med åsikter och klagomål om systemen?

11. Vilka möjligheter har ni att påverka utvecklingen av systemen?

12. Hur ofta sker förändringar i systemen?

13. Då ni ständigt arbetar med teknik, hur upplever du att tekniken påverkar arbetsmiljön på din arbetsplats?

Appendix 2 - USOT

USOT

Ett utvärderingsverktyg för system-användbarhet
i operativ trafikstyrning

Framtaget för Trafikverket av Nina Knez som en del av en E-uppsats i Human-Computer Interaction,
Uppsala Universitet, VT 2015

1. Introduktion

Datorbaserat arbete blir mer och mer vanligt på olika arbetsplatser i vårt samhälle. Detta har lett till att högre krav har ställts på människan att kunna förstå och använda sig av de system som används i deras yrke. Forskning har visat att datorbaserat arbete kan leda till teknikstress och belastning på människans kognitiva funktioner som till exempel minnet, orienteringsmöjligheter och problemlösning, med andra ord en så kallad kognitiv arbetsbelastning. Detta kan leda till ökad arbetsbelastning i den psykosociala arbetsmiljön vilket i sin tur kan resultera i hälsoproblem och missnöje hos de anställda (Agervold, 2001). Stress och en högre arbetsbelastning kan orsakas av det datorbaserade arbetet om systemen som används inte är utformade i enlighet med definitionen på användbarhet (Salvendy, 2012), det vill säga om systemen är utvecklade med brister i hur de stödjer användaren på olika sätt. I datorbaserade arbetsmiljöer så måste det därför uppmärksammas att systemen måste vara utvecklade så att de stödjer människans kognitiva förmågor, färdigheter och arbetsuppgifter. Om systemen inte är designade på ett välgjort sätt, så att det finns brister i användbarheten så kan detta resultera i sämre prestationer hos användarna, säkerhetsrisker, hög felfrekvens vid utförande av arbetsuppgifter, låg tillfredsställelse och stress (Lind et al., 1991). Trots den tidigare forskning som visar på att datorbaserat arbete och brist på användbarhet kan ha negativ inverkan på användarens kognitiva förmågor så är det ofta inget som uppmärksammas i psykosociala arbetsmiljöutredningar.

Tågklarerarna är de som arbetar med optimering och styrning av tågtrafiken på trafikstyrnings-centralerna runt om i Sverige. Tågklarerarna styr alla handlingar som behövs för att tågen ska åka på ett optimalt sätt, från styrning av signaler, växlar och järnväg. De ökande kraven som ställs på tågklarerare idag att ha optimal kontroll och kunskap över varje arbetssituation indikerar hur viktigt det är att de system som används vid trafikstyrningen stödjer användarna på ett användbart sätt. Syftet med utvärderingsverktyget USOT (förkortning för *Utvärderingsverktyg* för *System-användbarhet* i *Operativ Trafikstyrning*) är att användas för att utvärdera vilka kognitiva och psykosociala arbetsmiljöproblem som kan uppstå vid arbete med de system som används för operativ trafikstyrning. Denna utvärdering visar då på hur systemstödet ser ut och hur användbara systemen är i förhållande till de kognitiva krav som ställs på användarens, vilken kontroll användaren har och vilka slags sociala stöd och datorbaserade stöd användaren har i sitt arbete. För att utveckla instrumentet så utfördes intervjuer och observationer med tågklarerare som ansågs vara representativa för trafikstyrningsyrket. Tanken är att verktyget ska kunna användas som grund i mätningar av användbarheten i operativa trafikstyrningssystem i relation till människans kognitiva förmågor, och som grund för vidare utveckling och anpassning till andra perspektiv inom användbarhet.

Utvärderingsinstrumentet USOT är utvecklat genom en kombination av tidigare utvärderingsinstrument, en arbetsplatsstudie av tågklarerarnas arbete och arbetssätt och rena system-observationer för att finna de frågor som är relevanta för utvärdering av system som används vid trafikstyrning. Instrumentet ska användas regelbundet med antingen utvärderingar en gång om året, vid systemändringar, eller när organisationen själva anser att det är nödvändigt att ha en utvärdering av användbarheten. Instrumentet kan användas för att utvärdera olika förhållanden. Antingen kan den användas för att jämföra arbetsförhållanden mellan användare, mellan nybörjare och expertanvändare eller hur ser fungerar generellt på de olika kontrollcentralerna. Instrumentet ska användas som en manual för utvärderaren att tolka och analysera användarnas svar. Detta innebär att användaren endast ska ta del av enkäten (kapitel 3) medan resterande delar är till för utvärderaren.

För att använda instrumentet så är det viktigt att följa följande steg i ordning:

1. Läs igenom kapitel 2 för att få en djupare förståelse inom kognitiva arbetsplatsproblem och hur dessa och Krav-kontroll modellen tillsammans med användbarhets heuristiker är tillämpade i instrumentet.
2. Enkäten i kapitel 3 bör bli besvarad av så många användare som möjligt. Enkäten består av 16 skattningsfrågor som alla är relaterade till användbarheten av systemen och de kognitiva krav, användarens kontroll och det stöd som kan påverkas av datorbaserat arbete. Frågorna är utvecklade med en grund i Krav-kontroll modellen, de kognitiva arbetsmiljöproblem och Nielsens användbarhets heuristiker som presenteras i nästkommande del av instrumentet (se kapitel 2). Frågorna är utformade utifrån de resultat som framtogs vid en arbetsplatsstudie om hur tågklarerare arbetssituationer såg ut, hur de använder systemen, vad de tyckte om systemen och hur systemen stödjer de i deras arbete. Frågorna är inte presenterade i ordning efter teman som kognitiva krav, kontroll och stöd eftersom det skulle kunna påverka deltagarna och deras svar. Frågorna är i stället ordnade slumpmässigt så att deltagarna inte blir påverkade av varje tema eller mönster som kan bildas då relaterade frågor kommer i följd. Även om frågorna inte är ordnade efter de tre dimensionerna så är de fortfarande i en logisk ordning så att deltagaren lätt kan förstå. Detta rekommenderas enligt Trost (2007) som också säger att med hjälp av liknande frågor, även om de har olika innebörd, ger god tillförlitlighet i enkätstudier. Svaren på frågorna besvaras på en Likert-skala som är en vanlig metod för att mäta attityder hos respondenter i arbetsplatsstudier (Wikipedia, 2015c). Mätningen har en skala i siffror som gör att utvärderaren får ut ett index över alla frågor. Respondenten får svara genom att välja vilken grad i skalan som passar bäst för de som svar på frågan. Mätningen består av ett ordinal-skala, vilket innebär att det är samma storlek mellan de olika numren i skalan (Wikipedia, 2015c). Det är en sex-gradig skala, 0-5, vilket ger respondenten en chans att ta en mer negativ eller positiv ställning i frågorna. Detta gör det också lättare att tolka och analysera resultaten. Svarsalternativen består av en sida som går mot en positiv attityd och en som går mot en negativ attityd. Alternativen är antingen "Ja, alltid" och "Nej, inte alls" eller "Ja, fullt ut" och "Nej, inte alls". Denna typ av svarsalternativ är bra för detta utvärderingsinstrument eftersom utvärderingen inte handlar om de tekniska funktionerna inom systemen utan i stället användarnas subjektiva synpunkter som blir indikatorer på hur användbara systemen är. Enkäten avslutas med en öppen kvalitativ fråga (fråga 17) för att fånga användarens fulla åsikt om hens användning av systemen. Genom att kombinera kvantitativ med kvalitativ data så kommer det att ge en större insikt i användarens tankar. Detta beror på att den öppna frågan i slutändan kan ses som en förslutning av hela enkäten som kombinerar alla svar och är en slags förklaring som kan förklara varför användaren har svarat på det sätt hen svarade i undersökningen. Enkäten kan bli besvarad av användarna genom att de själva besvarar den för att göra utvärderingen mer tids reducerat. Eller så kan utvärderaren sitta med användaren och fylla i den tillsammans.
3. I kapitel 4 finns en beskrivning av hur resultaten ska tolkas och analyseras. Strukturen för hur frågorna formuleras är viktig för hur lätt det är att analysera resultaten.

Instrumentet ska användas av personer med tidigare kunskap inom människa-dator relaterade fält eller arbetsmiljöfrågor. Detta är på grund av att en kunskapsbas inom kognition, användbarhet och människor i samspel med teknologi gör det möjligt för utvärderaren att på bästa sätt kunna tolka resultaten. Det kommer att vara lätt att förstå och därför lättanvänt. Då instrumentet inte är så stort så kommer det inte att ta så lång tid att använda det i en utvärdering. Detta är bra eftersom myndigheten då inte behöver lägga alltför mycket tid i utvärderingen eftersom tid till detta inte alltid finns.

2. Bakgrund

Det är viktigt att varje medarbetare som kommer att genomföra ett arbete inom en viss situation förstår händelseförloppet och deras möjligheter till att styra och påverka arbetsprocessen. Detta för att kunna nå de mål som ställs för arbetsuppgifterna och inom produktionsplanen. Olika faktorer i arbetsmiljön kan hindra detta och en av dessa faktorer som kan leda till ett antal problem är de kognitiva arbetsmiljöproblemen. Kognitiva arbetsmiljöproblem uppstår när olika faktorer i arbetsmiljön hindrar personer som arbetar där från att använda hens kognitiva förmågor att utföra arbetsuppgifter på ett tillfredsställande och effektivt sätt. Dessa problem kan påverka arbetssituationen för de anställda på olika sätt. Det kan påverka deras förmåga att förstå, att samla in information, att ha kontroll, att få en överblick och att påverka eller kontrollera delar av den situation de arbetar i (Lind et al., 1991). Definitionen av de kognitiva arbetsmiljöproblemen grundades av Lind, Nygren och Sandblad (1991) för att ge en större förståelse för arbetsmiljöproblem såsom kontroll, stress och bundenhet inom området människa-datorinteraktion. De menar att kognitiva arbetsmiljöproblem är vanligare vid användningen av datorbaserade system i arbetsprocessen. De har därför identifierat nio olika klasser av kognitiva arbetsmiljöproblem som hänför sig till detta samspel. Klasserna är:

1. **Avbrott i tankegången**
   Interaktionen med systemen tillåter inte användaren att fullt ut kunna fokusera på den faktiska arbetsuppgiften, utan tvingas lägga en hög grad av sin kognitiva kraft på förståelse och hantering av systemen.

2. **Orienteringsproblem**
   Användaren har problem med att förstår var i systemen hen befinner sig och hur hen ska hitta tillbaka till ett tidigare tillstånd i en arbetsprocess om ett avbrott sker i arbetet. Detta är vanligt om användaren inte ser vart de är i systemen eller om det inte visas i systemen hur den tillfälliga positionen eller informationen är relaterad till helheten.

3. **Kognitivt tunnelseende**
   Människans hjärna fungerar på ett sätt som gör att människan har svårt att ta full hänsyn till information som inte är synbar eller inte tillgänglig när det kommer till beslutsfattande. Detta leder till att den information som är tillgänglig är den information som användaren lägger mest vikt vid och kan därför glömma bort annan information som kan vara relevant för att ta ett beslut. Detta är vanligt vid snabb beslutsfattning vid stressade situationer.

4. **Belastning på korttidsminnet**
   Människan kan bara hålla ett visst antal enheter i minnet samtidigt. Om en användare tvingas hitta information på olika platser, i olika system och sedan binda informationen samman så kommer det bli belastningar på korttidsminnet. Detta innebär att användaren måste hoppa från en skärm till en annan vilket tar tid och oftast tröttsamt.

5. **Onödig kognitiv belastning**
   Detta problem uppstår då systemen inte stödjer användarens mönsterigenkänning och genom automatiska söktekniker. Användaren måste då läsa av all information i varje system för att förstå innebörden av det. Detta kan uppstå om system och information inte är sammankopplade på ett enkelt sätt.

6. **Spatial förvirring**
   Om spatial information som färger, position, rörelser eller former är oklar, inte existerar eller ändras i systemen så förlorar användaren chansen att kunna använda sig av spatial kodning av information för att lättare förstå den. Då försvinner användarens möjligheter till att snabbt kunna läsa av information i systemen.

7. **Inkonsekvent informationskodning**
   Inkonsekvent kodning av information i form av färg, positioner, former i olika system gör det svårt för användaren att förstå informationen vilket leder till onödig kognitiv arbetsbelastning. Elementen i gränssnittet måste vara designat så att de stämmer överens med koncepten i arbetssituationen.

8. **Problem med tidskoordinering av värden**
   Om en användare inte kan associera ett informationsvärde med en särskild tidpunkt eller olika informationsvärden med varandra vid en särskild tidpunkt på ett enkelt och snabbt sätt så kommer användaren utsättas för tidspress och onödig kognitiv arbetsbelastning.

9. **Problem att identifiera status av en process**
   Det är ofta viktigt för en användare att snabbt kunna identifiera statusen av en arbetsprocess i en viss arbetssituation. Om detta inte är möjligt så kan det komplicera arbetet för användaren genom att det blir svårt att planera arbetsgången framåt, att snabbt vara i rätt arbetskontext eller att växla mellan arbetsuppgifter på ett effektivt och enkelt sätt.

Kognitiva arbetsmiljöproblem kan leda till ohälsa som till exempel långvarig stress (Lind et al., 1991). Divisionen av de kognitiva arbetsmiljöproblemen gör det möjligt att relatera de olika problemen med designmetoder för att kunna hitta indikatorer på hur gränssnitt utformas och om de stöder mänsklig kognition så kognitiva arbetsmiljöproblem inte kommer att inträffa (Lind et al., 1991). Detta har gjorts i utvecklingen av detta utvärderingsverktyg USOT genom att relatera problemen med Nielsens 10 användbarhetsheuristiker vid observationer av system som används vid operativ tågtrafikstyrning. Neilsens användbarhetsheuristiker används vid utvärdering av system-användbarhet. Målet med den heuristiska utvärderingen är att använda principerna för att göra sig en uppfattning om vad som är bra och dåligt med gränssnittet i ett system. Denna typ av användbarhetsutvärdering ses som en "expertgranskning" eftersom det krävs bakgrunds kunskap om användbarhet eller mänskliga faktorer för att kunna utföra en bra utvärdering (Tucker, 2004). Heuristikerna är relaterade till de kognitiva arbetsmiljöproblem som kan uppstå vid användning av system för operativ tågtrafikstyrning.

Behovet av ett utvärderingsverktyg för att utvärdera användbarheten från ett kognitivt arbetsmiljöproblem- och psykosocialt arbetsplats perspektiv för system som används för operativ trafikstyrning finns. Då utvärderingen ska kunna ske billigt och effektivt så måste verktyget vara lättanvänt. Det aktuella verktyget USOT grundar sig inte bara i teorier om kognitiva arbetsmiljöproblem och användbarhetsheuristiker utan även i Karasek och Theorell (1990) Krav-kontroll modell. Denna modell är vanlig vid utvärdering av den psykosociala arbetsmiljön och anses därför vara passande för detta verktyg. Krav-kontroll modellen används för att utvärdera vilka kognitiva krav som ställs på användaren, vilken kontroll denne har och vilket stöd hen får från omgivningen och systemen som används vid arbete. Den mentala belastningen är det mest centrala kravet enligt Karasek och Theorell (1990), eftersom den hänvisar till hur mycket mental kraft som behövs för att utföra en uppgift vilket kan öka vid exempelvis tidspress. Detta krav är också en av de mest centrala eftersom det också kan relateras till informationsbehandling och gränssnittsanvändbarhet som mängden oordning eller störning i en arbetsuppgift som den anställde måste reda ut för att allt ska bli organiserat på nytt. Definitionen av kognitiva krav är faktorer i den psykosociala arbetsmiljön som ställer krav på användarens kognitiva förmåga. Detta innebär att om de kognitiva krav blir högre, kommer användaren ha en högre mental arbetsbelastning (Karasek & Theorell, 1990). Den del av modellen om kontroll hänvisas till två aspekter enligt Karasek och Theorell (1990). Dessa är; hur stor social kontroll användaren har över beslutsfattandet, och hur stort utbud av erfarenhet och kompetens användaren har tillgång till i sitt arbete. Dessa två aspekter utgör tillsammans användarens möjlighet att kontrollera eller fatta beslut över en viss situation och de krav som anges i deras arbete. När det gäller databaserat arbete innebär detta att det användarens kontroll grundar sig i den kompetens och kunskap användaren har om systemen och vilka möjligheter hen att vara delaktig i förändringar när det gäller system funktioner och gränssnitt (Karasek & Theorell, 1990). Hultberg et al (2006) menar att det är viktigt att definiera kontroll som om det är användaren som har kontroll över de system hen använder eller om det systemen som styr hur användaren kan arbeta. Den sista dimensionen av Krav-kontroll modellen är stöd. Stöd enligt Karasek och Theorell (1990) innebär socialt stöd på arbetsplatsen genom hjälp och interaktion från kollegor och chefer. Det är viktigt att varje medarbetare finner stöd i sin arbetsplats från olika samhällsaktörer. Om det är brist på socialt stöd kan det påverka användarens trygghet och tillfredsställelse för sin arbetssituation. Krav-kontroll modellen är genom en integrering med teori om datorbaserat arbete i utvecklingen av verktyget UDIPA för psykosocial arbetsmiljö utvärdering också integrerad med datorstöd (Thorner, 2011). Om användaren saknar stöd på olika sätt från de använda systemen, kommer deras arbetssituation påverkas på ett negativt sätt och deras arbetsprestationer kan minska tillsammans med en ökning av deras stressnivå. Om användaren har höga kognitiva krav som ställs på hen, eller är under mycket stress, är det viktigt att det finns goda möjligheter till kontroll och stöd.

Det finns många faktorer som kan påverka varje individs arbetssituation och effektivitet i olika arbetssituationer. Kognitiva arbetsmiljöproblem, bristande användbarhet i system och de olika aspekterna som nämns ovan i Krav-kontroll modellen är några exempel på dessa faktorer. Levi (2001) beskriver även andra faktorer som kan påverka stressnivån för en individ. Han menar att det är särskilt en stark koppling mellan information och stress. Både om det finns för mycket information (kan göra det svårt att bearbeta all information och se vad som är relevant för en viss situation) eller för lite information tillgänglig (kan leda till osäkerhet för individen) vilket kan leda till stress. Detta kan relateras till användning av datorer och system i en arbetssituation. Systemen måste vara användbara och ge användaren rätt mängd information och stöd som behövs för dem att på ett enkelt och effektivt sätt genomföra sina arbetsuppgifter (Levi, 2001).

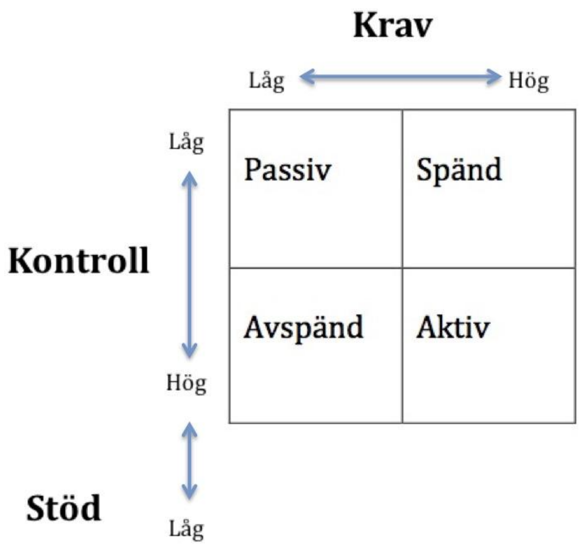
Vidare presenteras de olika delarna av Krav-kontroll modellen så som den är tillämpad tillsammans med dess ursprungliga dimensioner för det aktuella utvärderingsverktyget USOT. De olika dimensionerna är tillämpade så de är relevanta för den miljö där verktyget ska användas i. Detta är framtaget i en arbetsplatsanalys genom observations intervjuer för att fånga användarnas synpunkter och arbetssätt i de system som används för tågtrafikstyrning. Nedan listas de faktorer för dimensionerna krav och kontroll som kan påverka användaren i sitt arbetssätt, samt de faktorerna som påverkar vilka möjligheter användaren har till stöd.

- **Krav**:
  Då relevant information är svår att få tillgång till på ett enkelt sätt,
  Då problemlösning kräver högre kognitiv belastning på grund av att lösningen kräver att användaren använder sig av parallell informationshämtning,
  Då "klipp och klistra" information från olika system är nödvändigt,
  Då systemen felar,
  Då det är svårt att orientera sig runt i systemen,
  Då systemanvändningen kräver att användaren lär sig alla funktioner i systemen,
  Då tolkning av information i systemen kräver en högre mental kraft

- **Kontroll:**
  Användarens möjligheter till kontroll och styrning i systemen,
  Användarens kunskap och erfarenheter om användning av systemen,
  Användarens möjligheter till att styra genom planering,
  Användarens möjligheter till att influera utveckling av systemen,
  Användarens möjligheter till att kunna agera i stressade situationer

- **Stöd:**
  Användaren kan få stöd genom utbildning av systemen,
  Genom praktiskt stöd för att hantera problem i systemen,
  Stöd genom sociala interaktioner med kollegor och omgivningen,
  Stöd genom feedback av systemen,
  Stöd genom tillräcklig visuell information i systemen

Figur 1 visar hur Krav-kontroll modellen ser ut och hur de olika dimensionerna förhåller sig till varandra. Kombinationen av de tre dimensioner: kognitiva krav, kontroll och stöd skapar fyra möjliga tillstånd: den aktiva, den avspända, den passiva och den spända (Figur 1). Dessa förutsättningar är möjliga förutsättningar för den enskilde arbetaren i sin arbetssituation (Karasek & Theorell, 1990). Det avsända tillståndet kännetecknas av en hög grad av kontroll, låga psykologiska krav och risken för stress är liten. Individer i detta tillstånd har både tid och befogenhet att utföra sitt arbete och leva upp till de krav som ställs på dem. Det aktiva tillståndet kännetecknas, såsom det avspända tillståndet, av en hög grad av kontroll men de krav som ställs på varje enskild individ är höga. Inom detta tillstånd kan utmanande situationer bildas för individen och deras möjlighet att styra förhindrar att stress eller arbetsbelastning kan förekomma. Detta tillstånd är därför bra eftersom det kan leda till utveckling, arbetstillfredsställelse och hög produktivitet. Det passiva tillståndet kännetecknas av situationer med låg grad av kontroll och krav. Arbetssituationen saknar utmaningar som gör användarnas arbetssituation otillfredsställande i fråga om att försöka sina egna idéer och utvecklas. Denna typ av arbetsvillkor kan påverka individens kompetens om de arbetar i det under en längre tid. Det påverkar då deras kompetens och deras motivation att fortsätta arbeta. Detta tillstånd utgör därför ett stort psykosocialt arbetsmiljöproblem. Det sista tillståndet, det spända tillståndet har de mest negativa hälsoaspekterna av alla tillstånd. Tillståndet kännetecknas av mycket höga krav och en mycket låg grad av kontroll. Risken för långvarig stress är mycket hög om man arbetar med detta villkor på arbetsplatsen (Karasek & Theorell, 1990).



Figur 1. Krav-kontroll modellen av Karasek och Theorell (1990).

3. Enkät för utvärdering av systemanvändbarhet i operativ trafikstyrning

Denna enkät syftar till att undersöka dina upplevelser om hur dator-baserat arbetssätt kan stödja eller hämma ditt arbete i olika situationer. Med dator-baserat eller datorstött arbetssätt menas alla de datorsystem, webbsidor och det intranät som används som huvudmedel eller hjälpmedel i ditt arbete. Datorsystem är det ord som används för att beskriva det dator-baserade arbetssättet. Ditt deltagande i undersökningen är fullständigt anonymt.

För att delta i undersökningen vänligen besvara följande frågor genom att ringa in det svar som passar dig bäst. Enkäten avslutas med en fråga där du har möjlighet att kommentera mer fritt för att utveckla dina upplevelser.

1. Upplever du att din utbildning är tillräcklig för att du ska kunna arbeta i datorsystemen på ett tillfredsställande sätt?

0 1 2 3 4 5

Nej, inte alls Ja, fullt ut

2. Upplever du att du har tillräckliga färdigheter och kunskaper för att kunna utföra dina arbetsuppgifter i datorsystemen på ett tillfredsställande sätt?

0 1 2 3 4 5

Nej, inte alls Ja, fullt ut

3. Behöver du i ditt arbete använda flera datorsystem för att kunna utföra dina arbetsuppgifter?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

4. Upplever du att du har tillgång till all relevant information du behöver på ett enkelt sätt i datorsystemen för att kunna utföra dina arbetsuppgifter?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

5. Behöver du inhämta information från flera olika platser i datorsystemen för att kunna utföra dina arbetsuppgifter?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

6. Upplever du att du har tillit till att datorsystem fungerar vid stressade situationer?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

7. Upplever du att datorsystemen ofta felar?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

8. Litar du på att datorsystemen fungerar som de ska när du behöver dem?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

9. Upplever du ofta stress eller irritation vid användning av datorsystemen?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

10. Upplever du att du får en större arbetsbörda om systemen ofta är komplicerade?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

11. Upplever du att datorsystemen innehåller information som är svår att förstå eller som är otillräcklig?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

12. Upplever du att det är svårt att navigera i datorsystemen?

0 1 2 3 4 5

Ja, alltid Nej, inte alls

13. Upplever du får tillräcklig feedback från datorsystemen om hur du kan använda dig av dem för att lösa en arbetsuppgift?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

14. Upplever du att du genom användning av datorsystemen har möjlighet till att planera ditt arbetssätt?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

15. Upplever du att du har möjlighet till tillräcklig hjälp från dina kollegor och din omgivning då det uppstår problem och om datorsystemen då inte kan ge dig tillräcklig information?

0 1 2 3 4 5

Nej, inte alls Ja, fullt ut

16. Upplever du att du kan framföra synpunkter som påverkar utvecklingen av datorsystemen?

0 1 2 3 4 5

Nej, inte alls Ja, alltid

Fråga 17 är den avslutande frågan som du finner du på nästa sida.

17. Beskriv hur du upplever användningen av datorsystemen i ditt arbete. Stödjer eller hämmar de dig när du vill utföra en arbetsuppgift på ett enkelt och effektivt sätt? Varför?

Tack för din medverkan!

4. Tolkning och analys av resultat

I detta kapitel finns instruktioner om hur du kan tolka och analysera resultaten från enkäten i kapitel 3. Frågorna i enkäten är relaterade till krav, kontroll och stöd (se kapitel 2) på följande sätt:

- **Krav:** Fråga 3-5, 7-8, 11-12
- **Kontroll:** Fråga 2, 6, 14, 16
- **Stöd:** Fråga 1, 9-10, 13, 15
- **Fråga 17** är en avslutande kvalitativ fråga som används som en avslutning där svaren om vilka krav som ställs, vilka möjligheter till kontroll och stöd som finns kan bindas ihop och besvaras mer utförligt.

Alla svaren på skalan är ordnade så att om respondenten svarar med ett lågt värde (0-2) indikerar det att användbarhetsproblem i datorstödet och kognitiva arbetsmiljöproblem existerar. Om respondenten svarar med ett högt värde (3-5) betyder det att de har en positiv inställning till sin arbetsmiljö vilket tyder på god användbarhet. Detta gäller oavsett vilket slags svar som står under siffran som till exempel "*Ja, alltid*", *"Nej, inte alls*", osv. Användbarhetsproblem indikeras då av förhållanden såsom höga kognitiva krav, låg grad av stöd och kontroll medan god användbarhet indikeras av de motsatta förhållandena (se kapitel 2, Figur 1).

Om resultaten visar tecken på kognitiva arbetsmiljöproblem, det vill säga om respondenterna svarar med ett lågt värde (0-2) på frågorna, så kan resultaten även tolkas utifrån de olika arbetsmiljöproblem som existerar (se kapitel 2). Detta kan då ge mer djupgående slutsatser om vilka specifika kognitiva arbetsmiljöproblem som användarna är drabbade av. Alla kognitiva arbetsmiljöproblem kan uppkomma i utvärderingen. För att få en klar bild av vilka som specifikt drabbar den individuella användaren eller hela gruppen användare så är det viktigt att fråga 17 är med i analysen. I fråga 17 kan nämligen mer specifika uttalanden om systemanvändbarheten uppkomma.

Ett exempel på frågor i enkäten som direkt kan kopplas till några kognitiva arbetsmiljöproblem (se kapitel 2) om respondenten besvarat med ett högt värde är:

- **Frågorna 3-5** kan kopplas till *Orienteringsproblem, Kognitivt tunnelseende, Belastning på korttidsminnet* och *Onödig kognitiv belastning,*
- **Fråga 7** till *Avbrott i tankegången* och *Onödig kognitiv belastning,*
- **Fråga 8** till *Avbrott i tankegången* och *Inkonsekvent informationskodning,*
- **Fråga 11** till *Inkonsekvent informationskodning,*
- **Fråga 12** till *Orienteringsproblem,*
- **Fråga 13** till *Inkonsekvent informationskodning*
- **Fråga 14** till *Onödig kognitiv belastning*

En sista del av analysen där de fyra olika tillstånden, det Aktiva, Passiva, Avspända eller det Spända (se kapitel 2, Figur 1) tillståndet tolkas är bra för att få en djupare insikt i vilket arbetsförhållande användaren har. Detta ger då indikationer på hur datorstödet fungerar utifrån hur arbetsförhållandet är. Detta kan tolkas på följande vis efter en sammanställning av respondentens svar:

- **Aktiva tillståndet**
  Respondentens svar visar på att det finns en hög grad av kontroll och av krav. Detta arbetsförhållande resulterar ofta i att användaren utsätts för många utmanande situationer i sitt arbete, men trots det inte riskerar att drabbas av stress på grund av att hen har en hög grad av kontroll.

- **Passiva tillståndet**
  Respondentens svar visar på att det finns en låg grad av kontroll och av krav. Detta arbetsförhållande resulterar ofta i att användaren saknar utmaningar i sitt arbete vilket kan leda till att användaren inte utvecklas och att arbetstillfredsställelsen blir låg.

- **Avspända tillståndet**
  Respondentens svar visar på att det finns en hög grad av kontroll och en låg grad av krav som ställs på användaren. Detta arbetsförhållande möjliggör ett effektivt arbetssätt för användaren då de både har befogenhet och tid att arbete för att uppnå de krav som ställs på dem.

- **Spända tillståndet**
  Respondentens svar visar på att det finns en hög grad av krav som ställs på användaren men att användaren har en låg grad av kontroll. Detta arbetsförhållande är det mest krävande och det sätter stor press på användaren som vanligtvis är drabbad av ett flertal kognitiva arbetsmiljöproblem. Att arbete i detta arbetsförhållande under en längre tid medför stora risker för långvarig stress.

5. Fortsatt arbete

Efter att utvärderingen är gjord så är det viktigt att fortsätta utreda och att vidta rimliga åtgärder för att lösa de problem som kan existera i det arbetssätt som de anställda jobbar med, i den dator-baserade arbetsmiljön. Det är viktigt att ta fram en långvarig handlingsplan där långsiktiga lösningar kan presenteras och tillämpas. En sammanslagen bedömning av skattningsfrågorna i enkäten tillsammans med den avslutande övergripande frågan kan ligga som underlag för utvärdering av datorstödet i den psykosociala arbetsmiljön. Det kan även vara en del av framtida forskning och utveckling för att nå ett arbetssätt och en användning av systemen som faktiskt stödjer användaren fullt ut.

Vidare utredning tillsammans med kunniga systemutvecklare, gränssnittsdesigners, interaktionsdesigners och människa-datorinteraktionsspecialister kan vara nyttigt för att få fram nya designförslag för hur systemen bör se ut och fungera. Dessa förslag eller användarkrav kan framkomma genom utvärdering med instrumentet USOT. Då utveckling av nya system ofta kan pågå under en längre tid så är det viktigt att USOT används ofta för utvärderingar av användbarheten i de system som används för trafikstyrning. Om det kontinuerligt sker utvärderingar så kan man få fram en baslinje över hur datorstödet generellt ser ut för fler användare. Lämpliga åtgärder kan vara att även utvärdera och förbättra det arbetssätt som används eller den utbildningen som ges om de existerande systemen. Att se över de regelverk som används av både användare och inom olika delar av organisationen kan också vara till nytta för att se om något i grunden till hur arbetssättet är bör förbättras.

Lycka till!