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Report on the Trans.Safe requirements

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Trans.Safe Consortium

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Abbreviations

Abbrev.	*Description*
AGT	OCC department responsible for the automatic (driver-less) metro
CONV	OCC department responsible for the conventional metros
OCC	Operation Control Centre of the Nuremberg Transportation System
OFL	OCC department responsible for busses and trams
ST	OCC department responsible for the Service Telephone
UCD	User-Centered Design
VAG	Verkehrsbetriebe Nürnberg AG (Nuremberg Transportation System)

Executive Summary

The aim of Trans.Safe is to reduce the impact of negative effects of different types of work environments with high safety issues and elderly employees.

Backed up by an extensive literature research, an overview of the concept of stress, of different theoretical stress models, as well as physiological stress components and typical stressors at the workplace lays the basis for defining what Trans.Safe aims to do and to come to a common understanding withing the consortium of what stress actually is and how it can be measured. Furthermore, existing stress interventions at workplaces have been gathered as an inspiration of how to effectively fight stress.

It is an explicit goal of the Trans.Safe project to create a solution that is accepted by its users and fits into their daily lives and routines. Hence, methods of user centred design such as interviewing, shadowing, as well as context and stakeholder analyses, accomplish the literature research.

The resulting insights about the special conditions of the work environments in both target test fields of the Trans.Safe project (transportation control center + truck) provide a perfect starting point for the technical realization and testing of the Trans.Safe solution.

Results show that employees are exposed to different types of stressors, with many of them being very similar for the two test sites. Furthermore, truck drivers as well as OCC employees both face stressors arising from situations of overload as well as underload.

First requirements concerning the end-users' and stakeholders' needs and for delivering added value by solving real problems are proposed. These thoughts are further discussed in D2.3.

1 About this Document

1.1 Role of the deliverable

The present deliverable allows the reader to gain an in depth understanding of the work places targeted by Trans.Safe. It outlines the main stressors and needs of truck drivers as well as OCC employees. Ultimately, it serves as a basis for the technical solution by providing requirements towards the intervention. By collecting the results from field research it is the prerequisite for developing a concept in the deliverable D2.3. since it…

- delivers a detailed description of the special conditions of the work environment in both test fields of the Trans.Safe project.
- serves as a basic document to illustrate scenarios and use cases.
- proposes first requirements concerning the end-users' and stakeholders' needs and for delivering added value by solving real problems.
- allows to get detailed insights about target workplaces and stakeholder / end-user needs
- collects requirements for the technical solution

1.2 Relationship to other Trans.Safe deliverables

The deliverable is related to the following Trans.Safe deliverables:

Deliverable	Relation
D2.3	Report on Trans.Safe concept: This document presents use cases for the different work places covered by Trans.Safe. Lessons learnt from D2.2 will be taken into account when defining those use cases.
D3.1	Report on sensing and stress management concept: Background delivered in D2.2 will be used to refine the search for available/suitable sensor technology in D3.1.

1.3 Structure of this document

The document is divided into three main sections. After providing an overview of general aspects of stress at the work place and possibilities for intervention, the methodology of the user-centred design process is outlined. It forms the backbone of the results of user research, which will be shown in section 4. An outlook on recommendations for the development of Trans.Safe is provided in the last part of D2.2.

2 Background: About stress at the workplace

The aim of Trans.Safe is to reduce the impact of effects of physical work environments for decreasing stress levels of senior employees at their workplace. Backed up by an extensive literature research, the following section provides an overview of the concept of stress. The definition of stress and the reactions to stressors are manifold. Therefore, this chapter will help in forming a shared understanding for Trans.Safe of how stress can be defined and how it manifests itself. Accordingly, different characteristics of reactions to stress are outlined to identify possibilities to measure stress. The existing literature on typical stressors at work will further help identify which stressors should explicitly be checked for in the Trans.Safe users. The chapter closes with an outlook on possibilities for intervention. This will help inspire possible technical solutions for Trans.Safe.

2.1 The theoretical concept of stress

Stress is a multifaceted concept, which can be circumscribed as an adaptation of the body to changes in the environment (Selye, 1936). It means either a real or perceived perturbation to a person's physiological homeostasis or psychological well-being (National Research Council, 2008). The term "stress" usually refers to a reaction to a "stressor". Hence, *stressors* are events or circumstances that induce stress. The research on which D2.2 is based focused on identifying different types of stressors in the two test sites as well as on how the reactions to stressors manifest themselves.

2.1.1 Characteristics of stress – how do we react to stressors?

The general response to a stressor is a state of physical and psychological arousal, which by itself is adaptive. From an evolutionary perspective this adaptive reaction, also described as eustress, promotes survival. An increase in heart rate, blood pressure, perspiration and dilation of the pupils are exemplar biological consequences (Sanches et al., 2010). If, however, a certain stressor is too strong or the reaction to stress is inadequate - a state called distress - severe physiological, psychological and behavioral changes occur. This distinction between eustress and distress is an important characteristic when trying to fully understand the concept of stress. Distress is the negative type we normally refer to when we use the word, while eustress usually helps in keeping us motivated and performing.

It is important to note that stress is not limited to a biological response of the human body. Job-related stress often entails high levels of arousal and feelings of not being able to cope with the situation. Prolonged exposure to work-related stressors may lead to acute psychological, physiological, and/or behavioural changes (APA, 2014). In the long term, physiological changes include high blood pressure, a weakening of the immune system or insomnia. Anxiety or anger are typical psychological responses to stressors. A connection between physiological and psychological reactions can be seen by analysing the psychophysiological pathway of breathing. In psychologically very stressful situations, breathing may assimilate hyperventilation. This leads to a decrease in CO_2 exhaled and ultimately alters the stress level physiologically (Carayon, Smith, & Haims, 2001). Finally, an increase in risky behaviour can often be observed. Smoking, drinking alcohol or decreasing physical exercise are typical behavioural reactions to stressors (Schneiderman, Ironson, & Siegel, 2005).

Another characteristic of stress is that the same stressor may cause different reactions in different people. Stress, therefore, has a substantial subjective component. Depending on the individual perception of a stressor, personality styles as well as personal coping strategies and abilities or changes in the environment lead to different individual reactions.

Finally, a preliminary assumption of Trans.Safe was that difficulties at the workplace may be caused by overload as well as underload. In general, stressors at the workplace belong to one of two different categories: overload or underload. Sims (2002) classifies a situation as showing work overload "when too many activities are expected of an employee, given the time available and the ability level of the employee" (Sims, 2002 ,p116). Often neglected is the fact that, by leading to

monotony and boredom, underload can become a stressor as well. “The hardest job in the world is doing nothing – you can’t take a break” (ibid., p.117). Overload and underload can further be distinguished according to whether they are of a qualitative or quantitative type (Table 1). On the qualitative side, for example, a lack of mental stimulation can be just as stressful as cognitive overload due to the difficulty of a task. Employees experiencing underload may have difficulties to sustain attention, fall asleep or lose their motivation to work. Those assumptions in mind, the following sections on measurement and interventions will include aspects of underload, as well.

Table 1: Examples for Types of Stressors

	OVERLOAD	**UNDERLOAD**
Quantitative	time pressure	very few tasks
Qualitative	very difficult tasks	monotony

Description: Very demanding tasks or a high amount of information to be processed can lead to stress (overload). Additionally, however, very boring or infrequent engagement may lead to difficulties at the workplace, as well (underload).

2.1.2 Perspectives on causes for stress – where does stress come from?

In order to gain a clearer picture of how stress originates, we need to look at theoretical assumptions. The most prominent theories in stress research try to explain the development of stress from slightly different angles. While some underline the impact of job characteristics, others emphasize the individual differences in terms of perceptions of stressors or psychological processes during stressful interactions (Mark& Smith, 2008). One of the most basic models pertaining to the first group of models is the Person-Environment Fit model (French, 1973). It suggests that the individual’s skills, abilities and resources should be matched with the job demands and work environments. The bigger the subjective gap between the two domains, the higher is the risk for health problems and decreasing productivity, among others. This perspective is comparatively limited, however, as it does not specify subjective components of stress. The Michigan model (Caplan, Cobb, French, Harrison & Pinneau, 1975) therefore expands on the subjectivity of environmental stressors. The main focus lies on the subjective severity of factors concerning one’s role at work, including role ambiguity, role conflict or role expectations.

The Vitamin model (Warr, 1987) further specifies distinct ways in which different job characteristics influence health. The model postulates that analogously to the way vitamins work, some job characteristics, such as salary and safety, increase linearly with health up to a certain threshold. Others, such as autonomy or task feedback, are beneficial in medium dosages but may cause harm if they are excessively available or nearly absent. With respect to Trans.Safe, this distinction between job characteristics can help identify the most promising points of intervention. Therefore, those job characteristics, which are most closely related to negative health or work outcomes, will be focused specifically.

While contributing to the vivid debate about origins of stress in the workplace the three previous models have been criticized on grounds of empirical support and hence their predictive validity for health outcomes. Among the models more frequently used today are the Job Characteristics model (Hackman & Oldham, 1980) and the Demand-Control-Support model (Karasek, 1998). The first has been used for the development of the Job Diagnostic Survey, a questionnaire frequently employed to specify methods of job-redesign. Typical strategies for change are job enrichment or the development of feedback methods to foster skill variety or task significance, for example. The survey is based on the theoretical assumption that experienced meaningfulness, experienced responsibility and knowledge of outcomes ultimately influence outcome relevant factors such as motivation, absenteeism and satisfaction. The Demand-Control-Support model focuses on the balance between demands of a job and the level of control over it. The most stressful type of work is characterized by “excessive demands and pressures that are not matched to the worker’s

knowledge and abilities, where there is little opportunity to exercise any choice or control, and where there is little support from others" (Leka, Griffiths & Cox, 2004, cited in Kortum et al., 2001, p. 145). An important factor is that having little or no control over a situation is usually distressful. A job which is characterized by high demands and at the same time a low level of control poses an increased risk for negative health consequences (Huang, Robertson & Chang, 2004). The subjectivity of stress as well as the need for control makes the adjustability of a future stress releasing support device an essential characteristic to consider. An interesting empirical finding in relation to the theory is that lowest stress levels occur in situations of moderate to high demands and abundant job control. Given a working structure of social support, the model has a strong predictive validity.

Another theory, which similarly focuses on a concept of balance, is the Effort-Reward Imbalance model (Siegrist, 1996). Other than the demand control support model it claims that a *perceived* mismatch rather than a necessarily actual one determines health at work. According to Siegrist, a healthy job provides adequate rewards in terms of money, esteem, career opportunities and security in exchange for the effort on the side of the employee. The effort variable includes intrinsic factors such as need for control and over-commitment as well as extrinsic factors such as workload or job security. Research has shown that in situations of high effort and low reward emotional exhaustion was 21 times more likely to follow than in those with low effort and high reward (De Jonge, Bosma, Peter & Siegrist, 2000). While both models have good predictive validity, their major weakness is that they cannot explain variations in health outcomes due to individual differences of employees. The intrinsic variable in the effort part of the Effort-Reward Imbalance model is the only aspect, which may help in explaining why under the same external circumstances some individuals show negative health effects while others do not.

The Effort-Reward Imbalance model shows first signs of a transactional stress theory, which underlines the role of subjectivity and individual differences. Transactional models focus more on psychological processes in the dynamic relationship between an individual and its environment rather than on job characteristics alone. An example is the Theory of Psychological Stress and Coping (Folkman & Lazarus, 1980), with appraisal and coping being the main components of the person-environment interaction. According to this theory individuals are said to first individually assess the potential risk of a situation and to then find ways for coping and reframing future expectations of similar situations. This interaction shows that personal experiences, values and personality differences influence which stressors are perceived as such and how they are best dealt with. Cox's transactional model of occupational stress (1987; Cox, Griffiths & Rial-Gonzales, 2000) similarly describes the stress process as a problem-solving procedure, which is heavily influenced by personal appraisal strategies, coping styles, feedback and learning.

Current research efforts aim at combining the different approaches shortly introduced above. A combination of the Demands-Control-Support and the Effort-Reward-Imbalance model may for example help in clarifying if different types of demands have to be matched with the equivalent types of resources. This would imply that cognitive demands should be matched with cognitive resources and emotional demands with emotional resources, for example. Further research in form of the Demand-Induced-Strain-Compensation model (De Jonge & Dormann, 2003) may help shed light upon this question. The assumptions of the latter model suggest that it might be relevant if the type of the stressor and the stress releasing response of a future Trans.Safe device belong to the same category.

The common understanding of the origins of stress in Trans.Safe follows the trend in the scientific community to combine aspects of the aforementioned theories. At the heart of the intervention lies the development of a technical device to alleviate stress. Job characteristics, which can be modified collectively, are therefore a cornerstone for the concept of Trans.Safe. Additionally, subjective aspects will be incorporated in form of personas representing the specific target groups in terms of stressors and coping strategies. Individual perceptions and preferences will be reflected in the adjustability of the Trans.Safe device to personal needs. Following assumptions of transactional theories, Trans.Safe should ultimately aim at giving individual feedback on the stress level to facilitate the problem-solving process during and after a stressful situation.

2.1.3 Measuring stress & workload

Stress can be measured by a number of physiological parameters as well as self-report measures. Physiological stress responses include changes in galvanic skin response, heart rate and its variability, blood pressure, muscle tension, respiration and eye movement (Singh & Queyam, 2013). The autonomic nervous system controls the emotional responses to the surroundings as well as smooth muscles, the heart muscle and secretion of the glands. Hence, typical markers for stress can be found by measuring the circulatory, respiratory, muscular and endocrine systems (ibid.). Concerning electrodermal activity, a combined measure of galvanic skin response as well as the skin conductance level may give an insight into real-time changes as well as the tonic component (Sanches et al., 2010). Today, the vagally mediated heart rate varialbility (HRV) and the morning salivary cortisol level together with the salivary daily profile are physiological parameters to detect the impact of stress on the human body. (Hall, 2004; Kunz-Ebrecht, 2004; Irwin, 2006 & Thayer, 2010).

At the other end of the spectrum characterising the test sites lies underload. Its physiological measurement is more challenging in comparison to typical stress in the form of overload. In terms of vigilance, in over 50 % the first sign of decreased awakeness is slow lateral eye movement. Heart rate changes during drowsiness are however small. This indicates that eye tracking may be one of the best options to measure underload. New assistance systems for drivers include eye tracking as one of the main technical solutions to detect drowsiness and warn the driver before microsleep may set in.

Experiences in the field of assistance systems further show that the usability of a technical device decisively influences whether it will be used. This is crucial for Trans.Safe as the intervention depends on the input from the physiological measurement of stress. In terms of the acceptance of biofeedback sensors, they should be comfortably wearable, mobile, unobtrusive and require minimal or no maintenance (ibid.). If an interface is used for giving the users feedback on their stress level, a study by Sanches et al. (2010) has shown that it helps if the users can interpret their results themselves. By helping them become more body aware, they can find patterns in their stress reactions and map short-term stressors to long-term stress experiences. As a consequence, coping strategies may be applied more effectively. An interactive history of prior bodily states may further support this development. The upcoming deliverable D3.1 will provide more detailed information on the measurement of stress.

2.2 Stress at the workplace

YOUSE conducted an extensive literature research on typical stressors at the workplace as a foundation and theoretical starting point for the Trans.Safe research. Results of the research were used to decide for which stressors the research should explicitly look for in the two test sites. Guidelines for interviewing employees and other stakeholders were designed based on the results presented in the following paragraphs.

2.2.1 Typical stressors at the workplace

Previous research shows that stressors vary from physiological to psychological types not only in general life but also at work. According to the European working conditions survey (2010), repetitive hand and arm movements (63-64% affected) are amongst the most common physical hazards at the workplace. The Gensler Report 2013, a US workplace survey, found that major stressors at the workplace are noise levels (reported by 63%) and distractions by others (53%). It should be noted, however, that the number and quality of face-to-face conversations positively relates to performance. This indicates that there is a substantial interpersonal and hence psychological component of wellbeing at work. Further common triggers for stress are changes in the environment (Singh, 2013), which may be of special importance for truck drivers who constantly have to adapt to traffic, changing speed limits or unexpected obstacles on the road. Another factor of change is the introduction of new technology. The term “technostress” refers to “the physical and emotional burnout that result from a person’s inability to adapt to new technology” (Sims, 2002, p.117). Most importantly, employees suffering from technostress fear that

they could be more easily replaced due to an increasing influence of technology, that they will not be skilled enough to deal with the new technology, and that more information about them and their work will be directly accessible by managers. (ibid.)

In order to provide an overview of the most central stressors at work, extensive research over the last decades has resulted in taxonomies of work-related stressors. Studies in Air Traffic Control (ATC) suggest that demand, operating procedures, working times, working tools, work environment and work organization influence a worker's stress level the most (for a detailed composition of the factors see Table 2).

Table 2: Main sources of stress for Air Traffic Control (Costa, 1995)

Stressor Type	Examples for stressors
Demand	Number of aircraft under control; peak traffic hours; extraneous traffic; unforeseeable events
Operating procedures	Time pressure; having to bend the rules; feeling of loss of control; fear of consequences of errors
Working times	Unbroken duty periods; shift and night work
Working tools	Limitations and reliability of equipment; VDT, R/T and telephone quality; equipment layout
Work environment	Lighting, optical reflections; noise/distracters; microclimate; bad posture; rest and canteen facilities
Work organization	Role ambiguity; relations with supervisors and colleagues; lack of control over work process; salary; public opinion

Another taxonomy of workplace stressors by Leka, Griffiths & Cox (2003), adopted by the "Guidance on the European Framework for Psychosocial Risk Management" (WHO, 2008), includes many of the aspects of the study of Costa (1995), extending them to a more general work context (see Table 3). In combination with aspects of items taken from the Instrument for Stress-related Job Analysis (ISTA) (Semmer, Zap & Dunckel, 1999), these taxonomies form the basis for the stress questionnaire employed to guarantee a user-centred design process in Trans.Safe.

Table 3: Work-related psychosocial hazards (adapted from WHO, 2008)

Stressor Type	Examples for stressors
Job content	Lack of variety or short work cycles, fragmented or meaningless work, under-use of skills, high uncertainty, continuous exposure to people through work
Workload & work pace	Work overload or underload, machine pacing, high levels of time pressure, continually subject to deadlines
Work schedule	Shift working, night shifts, inflexible work schedules, unpredictable hours, long or unsociable hours
Control	Low participation in decision making, lack of control over workload, pacing, shift working etc.
Environment & equipment	Inadequate equipment availability, suitability or maintenance; poor environmental conditions such as lack of space, poor lighting, excessive noise
Organizational culture & function	Poor communication, low levels of support for problem solving and personal development, lack of definition of, or agreement on, organizational objectives
Interpersonal relationships at work	Social or physical isolation, poor relationships with superiors or co-workers, interpersonal conflict, lack of social support
Role in organization	Role ambiguity, role conflict, and responsibility for people
Career development	Career stagnation and uncertainty, under-promotion or over-promotion, poor pay, job insecurity, low social value to work
Home-work interface	Conflicting demands of work and home, low support at home, dual career problems

2.2.2 Stress interventions at the workplace

With increasing working hours and rising numbers of employees calling in sick due to stress related health issues, many organizations try to reduce the stress levels of their employees. They introduce stress management trainings or provide a reorganization of the workplace. In general, those interventions can be classified according to the addressed part of the work-person interface: While some interventions deal with stress caused by the characteristics of work organization and the physical work environment, others try to reduce stress reactions experienced by the worker in terms of coping trainings.

The latter approach takes individual differences in coping styles into account. While some individuals tend to be aware of the stressor and actively try to deal with it, others try to reduce stress by ignoring the problem. Popular distinctions in coping styles are the problem-focused versus emotion-focused coping styles (Folkman & Lazarus, 1980) or the 5-factor structure model by Vitaliano et al. (1985) (problem focused coping, seeking social support, blamed self, wishful thinking, avoidance). While a problem-focused approach mainly uses rational thinking, emotional coping helps in dealing with strong emotions in situations of conflict, for example. This illustrates that a planning process for a technical system designed to reduce stress could benefit from considering that the ways in which individuals deal with stress may differ.

People cope with stress individually!

Interventions can be categorized into primary, secondary and tertiary interventions. While primary interventions try to alter the sources of stress at work (eliminate risk), secondary interventions set in at a later stage and try to reduce the negative effects of existing stressors before they lead to

serious health problems. Tertiary interventions deal with already existing health problems by providing qualified health support (Murphy & Sauter, 2003).

In line with this this distinction between types of intervention, Kompier (1996) suggests a three-stage model of interventions. Firstly, the stress-producing situation should be eliminated or modified, or the individual removed from it. Additionally, the work organization and the workstation should be adapted to fit the individual characteristics of the employee. Ultimately, the person's resilience to stress should be strengthened, for example through physical exercise, meditation, relaxation or social support. A study of work related stress among bus drivers (ibid.), for example, proposes to enhance ergonomics of the driver's cabin, to introduce job rotation and combinations of jobs, to optimize timetables, shift schedules and the quality of break periods. Additionally, the management style and social work environment should be altered. Exemplary interventions are to ensure that the dashboard is easy to see and navigate, to provide adequate training for employees, introduce forward rotation in shiftwork (early/day/late shift) and to offer company physical fitness programs. A study of 124 bus drivers (Hamelink, van der Linde, & Taylor in ibid.) showed that those who participated in a company fitness program at least twice a week were less frequently absent from work in general. The social contacts with colleagues, which were fostered by the program, were particularly appreciated. With respect to physical activity, the Copenhagen City Heart Study (Schnohr, Kristensen, & Prescott, 2005) looked at the relation between physical activity (jogging), stress and life dissatisfaction in over 12 000 people. Results show that stress as well as dissatisfaction decrease significantly with increasing physical activity in leisure time. Results like these underline the importance of physical activity, which should be considered in any form of intervention provided by Trans.Safe.

Interventions can target at stressors, actual stress reactions or stress-related problems.

A meta-analysis conducted by Richardson & Rothstein (2008) shows that cognitive-behavioural interventions are among the most effective in stressful situations. Providing feedback on the personal stress level, for example, supports a cognitive-behavioural process of reappraisal of a situation. A study by Sanches et al. (2010) showed that while it proved to be challenging to find reliable biosensors to analyse stress symptoms, mirroring stress responses back to the person yielded very good results. They used interfaces to display a history of bodily states which could be scrolled through. Users responded particularly well to animated illustrations as the movement reminded them of their own heart rate or blood pressure. In addition to an overview of prior bodily states, real time feedback was particularly appreciated. Another study looking at the effect of a biofeedback game on patients with irritable bowel syndrome showed positive results as well (Leahy, Claiman, Mason, Lloyd & Epstein, 1998).The system related electrodermal activity of the skin to an interface displaying an animated gut imagery. Most patients achieved deeper states of relaxation after four 30 minute biofeedback sessions. Some hospitals in the USA use non-traditional techniques such as biofeedback devices to decrease patient stress. Devices with integrated thumb sensors measuring changes in heart rate are combined with audible and graphic interfaces, for example to guide breath in a calming way (O'Connor, 2012). The effects of breathing on stress relaxation are further supported by a study on breathing training for manufacturing operators (Sutarto, Wahab & Zin, 2012). Results showed that by making people realise their involuntary heart rate variations and teaching them how to breathe more effectively, stress could be reduced significantly. Depression, anxiety as well as stress decreased after five weekly sessions. Scores on self-report measures as well as physiological data confirmed the positive effect.

Mindfulness-based programmes may additionally help in reducing anxiety, aggression and anger. Furthermore, physiological measures such as cardiopulmonary symptoms and muscle tension seem to be positively influenced by meditation techniques, as shown for example by offering a mindfulness meditation-based stress reduction programme for cancer outpatients (Carlson, Ursuliak, Goodey, Angen & Speca, 2001).

Other interventions try to encourage employees to make an agreement with co-workers to watch each other for stress symptoms during critical incidents (Costa, 1995). Air Traffic Controllers in Switzerland have reported sitting up straight as one of the major reactions to stressful situations in order to cope with the acute pressure (Muehlethaler, 2014). Knowing this to be a stress reaction,

colleagues immediately see who is in a particularly stressful situation and may need support. An intervention by colleagues instead of supervisors may support teamwork and decrease a possible feeling of being controlled by superiors. For Trans.Safe this form of mutual caring for each other may be considered, especially for the test site OCC.

On a more workplace related side, a study conducted by BMW (2002) found that the presence of plants in offices and on production sites had positive effects on workers' health. The initial aim was to improve the climate without using air condition. In addition to that the plants proved to be effective room dividers, they helped in regulating lighting conditions by providing shadow, and reduced noise levels. The employees reported feeling more motivated, relaxed, and generally more comfortable (Mohrlang, 2012).

While there are many suggestions for interventions in case of overload, some explicitly try to deal with underload. One form of intervention which may help in situations of overload as well as underload is adjustable lighting. A research study conducted by Brigham and Women's Hospital has shown that short wavelength or blue light can improve alertness and brain performance. Daytime and nighttime 460-nm light exposure significantly improved auditory reaction time, reduced attentional lapses, and improved EEG correlates of alertness compared to 555-nm (green light) exposure. Subjective sleepiness was not affected during daytime. At night, alertness could be improved to near daytime levels by using 460 nm lighting (Rahman et al., 2014). Adapted screen colour may be one way of using those positive effects of lighting on situations characterised by underload.

Interventions should be designed to deal with overload as well as with underload!

There is some evidence that scented air is another option for increasing alertness. A virtual reality driving study confirmed earlier findings that odours such as peppermint and cinnamon help increase mental alertness, possibly by stimulating related areas of the central nervous system (Raudenbush, Grayhem, Sears & Wilson, 2009). According to the study peppermint scents prove to be particularly effective in increasing attention, lowering anxiety in driving tasks and decreasing frustration.

In addition to the methods presented so far, cognitive tasks seem to have a positive effect on alertness (Gershon, Ronen, Oron-Gilad & Shinar, 2009; Atchley, Chan & Gregersen, 2013). During periods of monotonous driving, interactive verbal tasks, for example, seem to increase alertness and improve driving performance. This effect occurs even if the cognitive tasks are not particularly demanding, as long as they are interactive.

2.3 Summary of the chapter

Stress is a bodily reaction, which may manifest itself physiologically as well as psychologically. Additionally, stress has a substantial subjective component, which means that the same stressor may cause different reactions in different people. An important characteristic of stress is that it may not only occur in situations of cognitive or physiological overload but also during phases of underload. Its measurement is complex and mainly conducted by evaluating biofeedback signals of reactions of the autonomic nervous system. Interviews and diary studies, for example, can further complement the measurement by adding a more subjective component. Typical stressors at the workplace were used as a basis for the analysis of the workplaces in Trans.Safe. Therefore, questionnaires could be designed to specifically look for stressors that were likely to be present, such as:

- **Stressors related to job content, e.g. variety of work**
- **Workload, e.g. information load (too high/too low)**
- **Problems with shift work**
- **The level of control employees have**
- **Attributes of the available equipment**

- **Collaboration and communication with others**
- **Possibilities of career development**
- **The balance between work and private life**

Regarding interventions, Trans.Safe will mainly focus on secondary interventions, trying to minimise adverse effects of stressors. The sources of stress may not be eliminated completely (primary interventions) due to some characteristics of the work places Trans.Safe cannot influence. An example would be the existence of shift work. Following the three stage model of interventions by Kompier (1996), Trans.Safe will set in at the second stage, primarily by modifying characteristics of the work station to fit individual characteristics of the employee. Furthermore, Trans.Safe will aim at increasing the employee's resilience to stress, for example through instructions for physical exercise, relaxation or social support.

As a basis for the development of user stories, a series of typical interventions will be considered:

- **Fostering Physical activity**
- **Looking for symptoms of stress amongst colleagues**
- **Providing feedback on the personal stress level**
- **Adjusting lighting**
- **Providing interactive cognitive tasks**
- **Explaining breathing techniques**
- **Increasing mindfulness**
- **…**

3 Methodology

One of the key aspects for the successful introduction of a new technical device is user acceptance. Usability and user experience are two key determinants of this acceptance. In Trans.Safe both usability as well as user experience are therefore considered in designing the technical solution. By including the end user and other stakeholders into the design process, a successful introduction of the future Trans.Safe device will be supported. The following section provides an overview of the user-centred design process in general (chapter 3.1) and the procedure for the Trans.Safe application in particular (chapter 3.2).

3.1 The User-Centred Design Approach

The benefits of user-centred design can be most clearly seen by looking at products that do not meet our needs as users. Some devices are very difficult to handle, such as inappropriate packaging, or difficult to navigate through, such as certain websites. Typical features of interfaces that have not been executed well are those that have an overload of or are missing functions, which are not intuitive, for which instructions are not understandable, or which are too complicated to use. It takes us longer to understand how those products work and we make more mistakes while using them. Overall, the acceptance of ill-designed products is lower.

A well-designed product arising out of a user-centred design process should help in providing an additional value to the user, fit well into daily routines and meet the user's needs. A non-discriminating, easy to use product that has a fun or motivating aspect is one of the central aims of user-centred design. Ultimately, it supports acceptance and therefore increases the chances of successful implementation of the device.

Integrating users into the developmental process is a very powerful approach to realize user-friendly innovations. According to the philosophy of user-centred design, there are certain steps which may be considered in order to complete the design process. In an iterative process, understanding, observing and designing are used to identify the central question of what the user's needs and requirements are and to get a feeling for the user's world.

In a preparatory phase goals of the product development can be defined, whilst taking into account attributes, needs and wishes of the users as well as the results of a prior context analysis. This preparatory part of the process is outlined in the present deliverable and forms the basis for a creation of product ideas.

In the following creative process possible solutions for the product are created. In this second phase of idea creation the process should be as open minded as possible, in order to create a wealth of ideas. It is only in the next phase, when a clear concept is formed, that ideas will be narrowed down to the most promising and realisable ones. Ideas are then represented in the form of prototypes, which are in the end evaluated by users. The following technical development of a new product entails rigorous testing before market launch.

This cycle - or parts of it - may be repeated several times to redesign the product. Ideas may be changed and goals reframed in several cycles of the development phases. This may for example be necessary when no idea seems adequate in the selection process and new ideas have to be created. The success of an idea depends on three main factors. Firstly, it depends on whether it reflects what users want or need. Secondly, it has to be technically feasible and thirdly, it has to be financially viable. Figure 1 illustrates the interconnection between those three aspects.

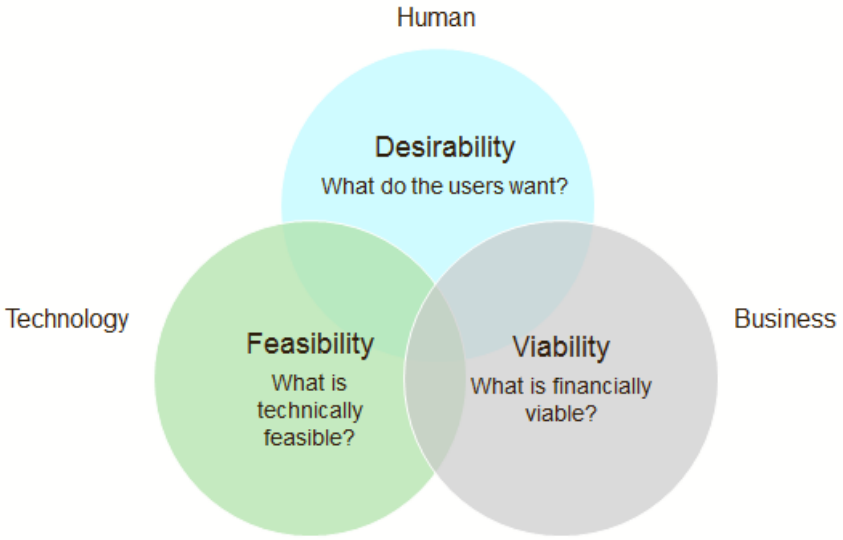

Figure 1: Influencing factors of idea selection

Another reason for repeating a part of the innovation circle is when new questions regarding the target group arise during the process of idea creation. Additionally, suggestions made by users in the evaluation process should thoroughly be considered and may lead to revisions of the prototype. This iterative procedure takes into account that the first solution to a problem may not be the best. Test cycles should be small scale and preliminary versions of the product should be tested frequently with potential users. Figure 2: The innovation process schematically illustrates the different phases of a user-centred development process. Arrows indicate the iterative nature of the process.

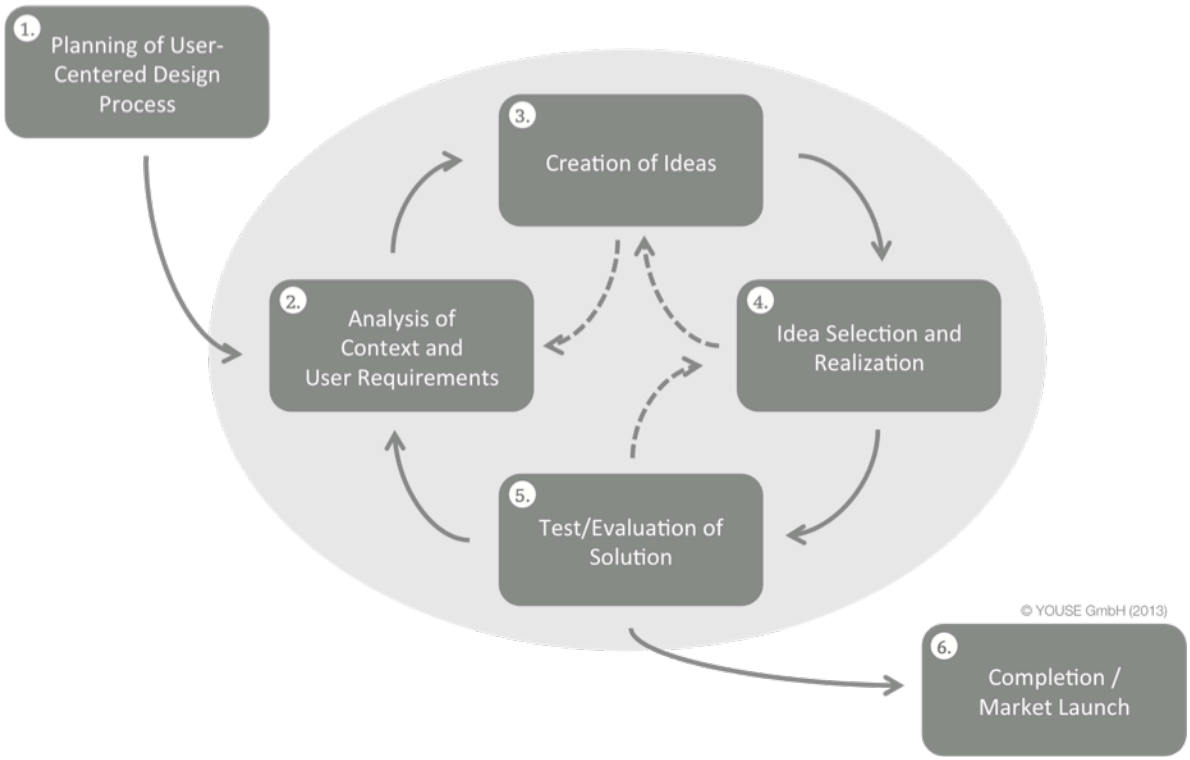

Figure 2: The innovation process

3.2 UCD in Trans.Safe: Understanding

In order to gain an in depth understanding of the users' needs, methods such as interviewing, shadowing, creating personas or analysing further stakeholders and the context can be used. During a shadowing session, for example, which means accompanying the future users in their daily routines, the observer can gain a better understanding of the users' needs and requirements for the development of the product. With the help of photo or video documentation and by taking notes, a wealth of information can be gathered. By mapping the interconnections between the users and other stakeholders an overview can further be created, showing how much relative influence different stakeholders have. This helps in identifying which stakeholders are important for the design of the product. Stakeholder maps for the two test sites can be found in Appendix C and D. In the case of Trans.Safe it is proposed that stakeholders are categorised into three different groups. Primary stakeholders are those directly affected by the changes made. They are the future users and will be involved the most in the user centred design process. Secondary stakeholders, such as families of the employees or professional associations, are indirectly connected to the intervention. They influence the plans and success of the primary stakeholders by providing them support or critique, for example. Tertiary stakeholders, such as public or government agencies, indirectly influence and benefit from changes in the companies themselves. One of their main intersections with Trans.Safe is the implementation of laws and regulations.

Taken together, the investigative methods create a basis for persona formation. In this case, profiles of common characteristics and behaviour are compiled to represent the future user. A thorough desk research on previous related findings and developments may complement the empirical results. Having the results of the empirical as well as the desk research in mind, ideas for development can be created, including aspects of technical feasibility and economic viability.

In order to gain a good understanding of the future Trans.Safe users and the context, a large-scale user research was undertaken. The basis for this research is provided by an in depth research on the concept of stress as outlined in chapter 2. Based on the research defining which stressors are relevant, standardized questionnaires were designed to guarantee a reusable form of inquiry across different workplaces. Interview questions are based on a combination of common typical stressors found in previous research, which are outlined in table 2.2 and 2.3. Typical stressors were presented to interview partners visually (see Figure 3).

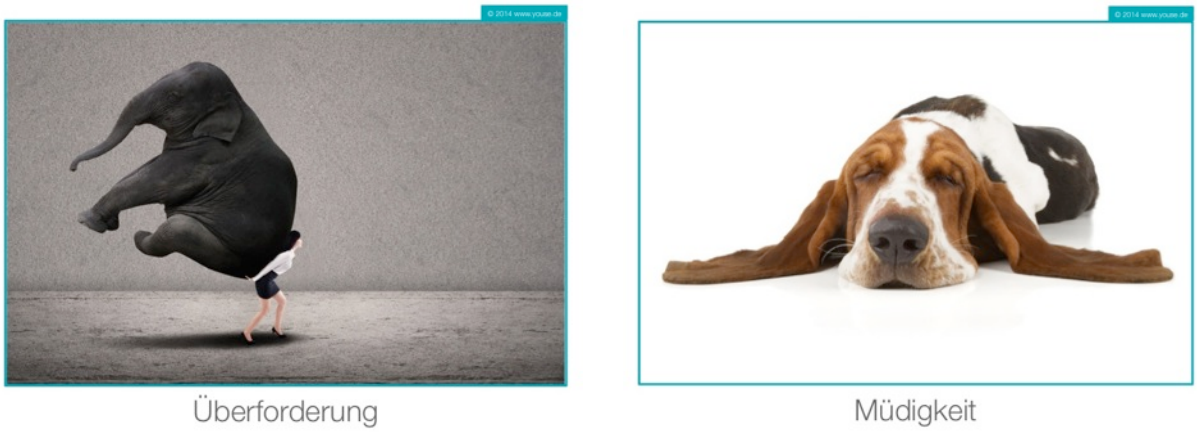

Figure 3: Examples of visual stimuli used in the interviews (left: overchallenge; right: fatigue)

Taken together, 21 interviews were conducted for the OCC and the workplace truck in total. Interview partners were different primary and secondary users, i.e. OCC employees, employers, relatives, and a worker's council. Furthermore, representatives of professional organizations, truck drivers, hauliers, a driving trainer and strategic procurement manager were interviewed for the workplace truck.

In addition to interviews, roughly 20 hours of shadowing of the primary end users were conducted to complement the impressions provided by the interview partners. Employees were observed in their natural work environment during day as well as night shifts. In a combination of notes, more than 900 photographs and 5 hours of video documentation, workers and their workstations were documented over a period of several weeks. Observations included shadowing OCC workers as well as accompanying a truck driver during a night shift.

As an additional context research further impressions on new developments in the truck industry were gathered on the IAA Utility Vehicles Fair in Hannover in September 2014, and participants for interviews were recruited or met in person there. Figure 4 gives an overview of the steps of data collection in the Trans.Safe project, integrating users and stakeholders into the innovation process.

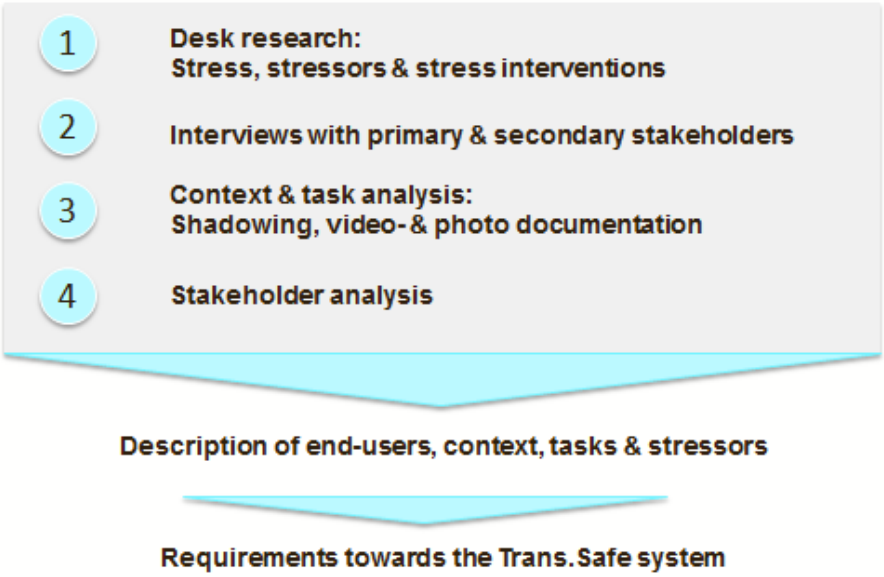

Figure 4: The research method applied in Trans.Safe

To prepare the phase of idea creation, several techniques of user-centred design were used. In order to create personas, clustered maps of post-its have been used to categorize stressors, likes and dislikes of the interview partners. Post-its were discussed and newly arranged in terms of an affinity diagram, which graphically clusters observations and results of the research to meaningful categories (Courage & Baxter, 2005).

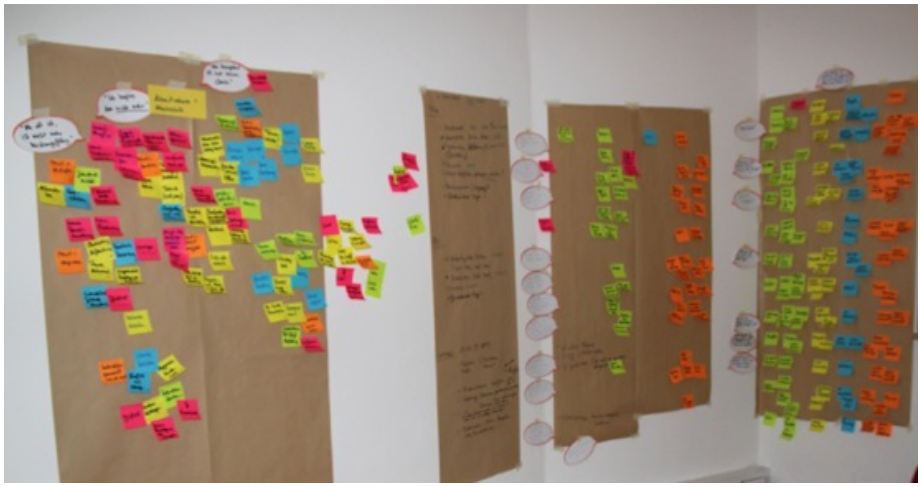

Figure 5: Creating affinity diagrams for the workplaces OCC and truck

In addition, Moodboards were composed to gain a better understanding of what the workplaces look like and to make the impressions from user research tangible to the other consortial partners. Additionally, stakeholder maps illustrate which type of people are involved in the workplaces and influence the employee in a more or less direct way. They were composed to choose possible interview partners in order to create a full picture of the workplace and the employee's situation. A final analysis of work tasks, stressors, needs, likes, dislikes and coping strategies (as summarized in this deliverable) provides a valid basis for the development of recommendations for the design of the Trans.Safe solution.

In a one-day workshop including all partners of the Trans.Safe project, members of the consortium learned about the user research results via presentations, videos, photos and engaged in a little theatre play mirroring a typical stress situation in the OCC. The consortium also engaged in creating personas and developing first ideas of possible user scenarios. In combination with results from this workshop, user stories were designed to help find out in the future which options are most feasible for further development (see D 2.3). The technical practicability in terms of techniques for the measurement of stress as well as possible interventions were also addressed in particular, sharpening the focus of what the Trans.Safe project will be about mainly.

Figure 6: Impressions from the consortium meeting in Munich focusing on user research insights

4 Results

The following results section provides insights from a user and stakeholder perspective on their workplaces, their needs and goals. It outlines the structure and dynamics of the target workplaces to allow for a better understanding of the given situations at those workplaces. Finally, it will help in deriving important requirements for the future development of the Trans.Safe intervention.

4.1 Test site “Truck”

The results are based on qualitative interviews with different types of truck drivers, depending on the form of employment and the size of hauliers. One of the truck drivers is self-employed; the others are employed by differently sized hauliers handling from less than 20 vehicles, to about 50 in a second category and, in a third category, even bigger fleets. The average age of the interviewed drivers is 59 years.

4.1.1 The workplace “Truck”

The driver’s cabin is more than a workplace; it provides a home for the driver on long distance trips. Inside the driver’s cabin are up to two beds, the cabin can be closed with curtains to increase privacy, and storage places are provided for food and personal belongings. Drivers are usually dressed casually in private clothes or company shirts. Those are only some of the characteristics of a driver’s workplace, which help illustrate the lifestyle of a trucker.

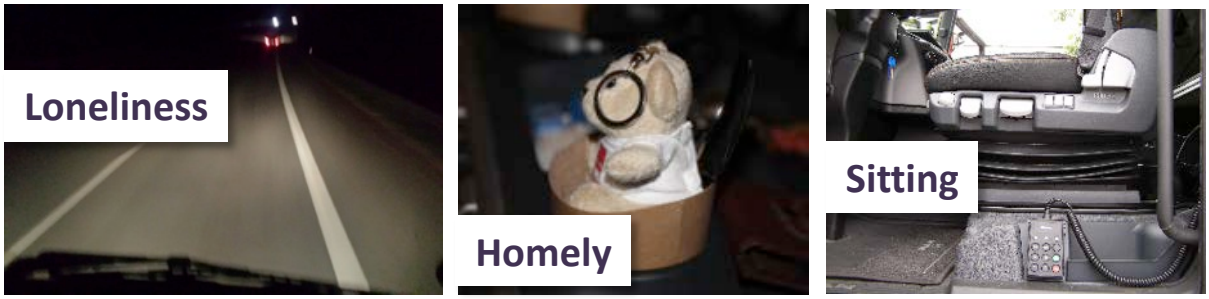

Figure 7: Characteristics of the lifestyle of a trucker

Further typical characteristics of a driver’s workplace are high incident rates connected to a generally high safety risk. Working hours are strictly EU regulated with a maximum of 56 hours per week, but only 90 hours in a total of two weeks. Daily working hours add up to a maximum of 9 hours with obligatory 45 minute breaks every 4.5 hours. If the truck driver interrupts the break and starts the truck, e.g. in order to move forward some meters to make more space for other trucks looking for parking space, the break time is reset to zero.

“I can only keep driving, I can’t fly...”

For two days per week, total daily working hours may be extended to 10 hours. EU law additionally regulates minimum daily rest periods of 11 hours, which may be reduced to 9 hours three times a week.

A driver’s work schedule and hence daily routine follows strict rules, dictated by law, economic profit maximisation and the scheduling of hauliers and delivery facilities. A moodboard illustrating the workplace in more detail can be found in Appendix A.

Figure 8: Trucks at a truck stop, which are mostly comfortless, draughty and merely functionally designed

4.1.2 End users: Truck drivers

Description. In Germany, there are 773.059 professional truck drivers in total, of which 29.000 are self-employed. The interviews for Trans.Safe were conducted exclusively with long distance drivers. The profession is dominantly chosen by men with only 4.2 % female drivers. With 32.1% being older than 50 years - with an upward trend - there will be an expected shortage in drivers during the next years. Due to their experience, older drivers are in high demand. Their accident risk is generally lower than for younger drivers, but strongly increases above the age of 65. Long working hours and further characteristics of the work place lead to the fact that the drivers are alone most of the time. After a long day of work, many drivers use their breaks at truck stops to socialize with colleagues, watch TV or speak on the phone with their families. The lifestyle is often rather unhealthy, with a high consumption of cigarettes, alcohol and junk food. Appendix E shows personas of typical truck drivers.

"a job for singles"

Activities. Overall, a truck driver's main activities besides driving are waiting until the truck is being fully loaded, and communicating with dispatchers, superiors or colleagues. During the breaks, social activities, eating and sleeping are the main activities. In some cases, drivers have to load or unload during a break. Our research shows that the main interests of the drivers themselves are to ensure a safe transport of their truckload, to receive respect and recognition for the job they do, and to avoid traffic related incidents such as traffic jams, accidents, or bad weather conditions. With respect to personal interests, their main goals are to receive better wages, stay healthy in order to be able to enjoy retirement or even to find ways to change jobs. This last issue points out that the stressors truck drivers face are severe.

Figure 9: A truck driver on his night shift, always accompanied by his toy devil.

Stressors. The job characteristics are reflected in drivers' self-reported stress levels which lie between 25 and 100 percent. While many situations are perceived as monotonous, the driver's job constantly requires attention. This leads to a constant, but low stress level, which is interrupted by

peak stress loads due to traffic volume or the behaviour of other road users. Amongst the strongest factors of stress are constant time pressure, aggressive road users and bad weather conditions such as heavy rain or snow. Further main stressors are long working hours, which lead to fatigue, as well as a lack of parking spots especially when the next truck stop is too far away to be reached before the next break has to start. Furthermore, difficulties arise due to unfriendly dispatchers or annoying sounds of technical instruments such as the lane departure warning system (which is usually switched off). In general, a lack of long-term prospects for professional development and very little free time lower overall job satisfaction.

Coping. In order to try and cope with the stressors, drivers report that they enjoy talking and joking with colleagues. In general social contact at the truck stops or calling the family back home are reported as main sources of relief for the drivers. Furthermore, smoking and drinking water or coffee are mentioned as interventions during or after stressful situations or events. Another strategy is to take a break or get a lot of sleep in between the shifts, as well as listening to music. There are some positive aspects, which may be additionally considered for the development of a future Trans.Safe system: Drivers usually enjoy the autonomy the job provides while driving - or what is left of it after increasing regulations. They like the feeling of “being on the road” and to visit different places. Additionally, most of them report that they like to handle a big vehicle.

4.1.3 Other stakeholders

In order to be able to analyse the truck driver’s situation from different perspectives, further stakeholders were included in the research process. Relatives were not included in this stakeholder analysis as they were difficult to contact. Interviews with hauliers from small to large-scale companies confirm many of the stressors mentioned by the drivers themselves. They regard changes in the profession especially concerning wages and time pressure as well as increasing traffic volume as main sources of stress. What is more, hauliers may change routes spontaneously because delivery times may change and drivers are required to adapt quickly to those changes. One of the main problems for hauliers is a lack of qualified personnel since the profession has become increasingly unattractive. Whilst the technical development of assistance systems inside the truck to support the driving task seems to support the drivers successfully, the overall development of wages and time pressure seem to outweigh technical improvements. Adherence to assistance systems is limited as well; especially the lane departure warning system is often switched off by the drivers due to its disturbing sounds. Some hauliers suggest introducing a system of offering premiums, for example for reduced fuel consumption, in order to increase wages indirectly. Hauliers additionally try to support their drivers by offering advice in difficult financial and personal situations, which are often linked to the job characteristics. Typical stressful situations for many drivers are when they are on their way back home for the weekend, but have to stop for their obligatory resting period, or when they have to work far away from home during holidays or family festivities. They often feel a lack of support by their families and friends, and social relationships become difficult to maintain.

With respect to the limits of a new technical device, hauliers mention that during the development of the device it has to be ensured that the driving task can still be executed safely. If possible, noise levels should be lowered, and the motivation of the drivers to stick to their job and drive safely and economically should be increased. Lighting has to be used wisely in order not to distract excessively, and the system should be able to increase the driver’s attention in order to keep the balance between over- and underload. A driving trainer who is responsible for the surveillance of fuel consumption and tire pressure mentioned that surveillance of the driver’s physical state would be of interest, although privacy concerns may arise. In no case should the employer be able to see the measurements. The evaporation of stimulating or calming scents seems to have low acceptance. The system should not be indoctrinating but health advice in terms of nutrition and physical activity tips may be beneficial.

4.1.4 Summary

A driver’s daily routine follows strict rules, dictated by law, economic profit maximisation and the scheduling of hauliers and delivery facilities. While many situations are perceived as monotonous,

the driver's job constantly requires attention. This leads to a constant but low stress level, which is interrupted by peak stress loads due to traffic volume or the behaviour of other road users. Interviews and shadowing show that truck drivers face main stressors such as social isolation, money problems, difficult situations on the roads, and long working hours - besides others. Drivers are stressed by situations which are particularly boring, like being stuck in a traffic jam, as well as during extremely difficult situations, such as when another truck in front is losing its load on the road or when weather conditions are severe. In order to cope with the main stressors many drivers enjoy talking to their colleagues or sleep, drink (water or alcohol) and smoke. Overall, there is a lack of new personnel and some think about leaving the profession as a possibility for further professional development, as well as wages are low. Most of them worry about being able to remain healthy until retirement. Health is therefore a major concern of the drivers.

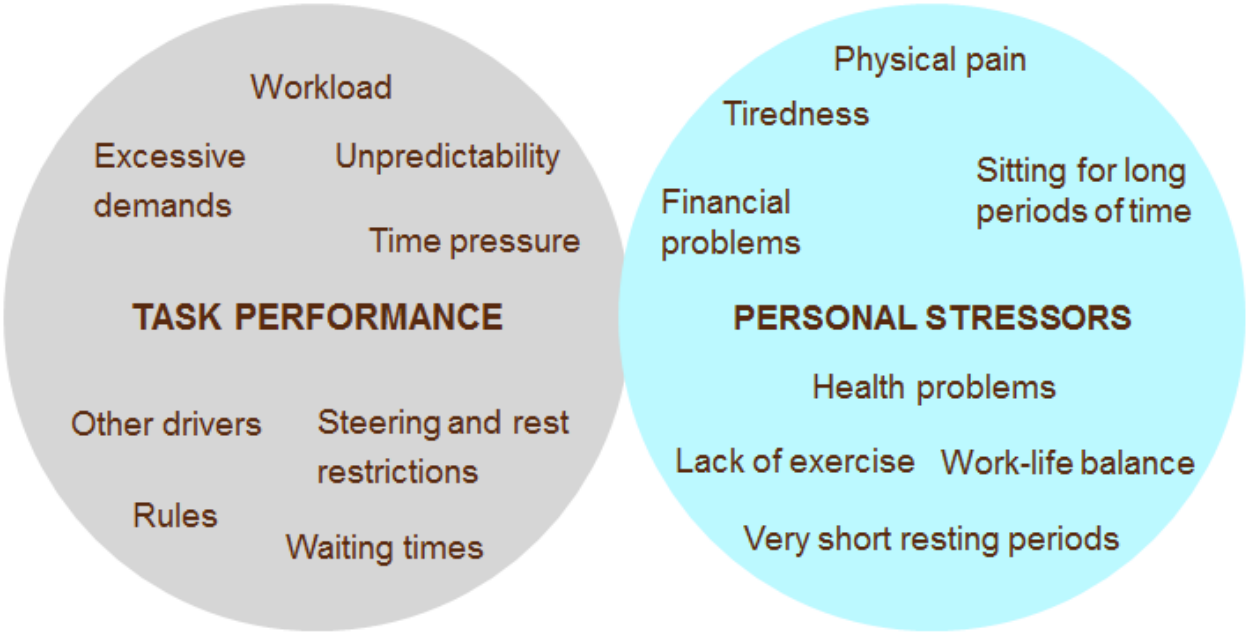

Figure 10: Typical demands and stressors of a truck driver

4.2 Test site "OCC"

The OCC is the operational control centre for the public transportation network of Nuremberg and its surroundings. The underground as well as the buses and trams are controlled and monitored by the employees of the centre. Additionally, customer requests regarding ticket prices, timetables or lost items are received by the employees of the service department telephone (ST) located in the OCC, as well. Thus, the control center is a huge room, working as a hub for a very wide range of tasks and information: Whether there are accidents or blocked streets, emergency calls, assaults, people on tracks, injured people or whether somebody just wants information on ticket prices - it all comes together at the OCC.

4.2.1 The workplace "OCC"

The variety of the operations controlled in the OCC is reflected in its spatial allocation: There are 5 different types of workplaces at the OCC, all of them located in one big room:

- AGT = autonomic metro (red, tube line U2/U3)
- CONV = conventional metro (light blue, tube line U1)
- OFL = buses and trams (yellow)
- ST = service telephone (purple)
- FGI = passenger information and security (green)

The colours in brackets indicate the area in Figure 10 where the employees handling the respective divisions are located in the room. Two of the three underground lines in Nuremberg drive automatically, i.e. without drivers. The AGT employees, who are located in the middle of the room (red), are responsible for those automated underground trains. The control of the conventional underground line U1 (CONV, light blue) is situated to the right of AGT, next to the entrance door of the OCC. The operations relating to the surface (OFL), including 70 buses and 5 trams, are situated to the left (yellow). The area of the service department operators (purple) is somewhat separated from the other areas, at the right side of the entrance door. The location of passenger information as well as security employees (FGI), who are responsible for announcements on the platforms regarding delays or answering emergency calls, is marked in green.

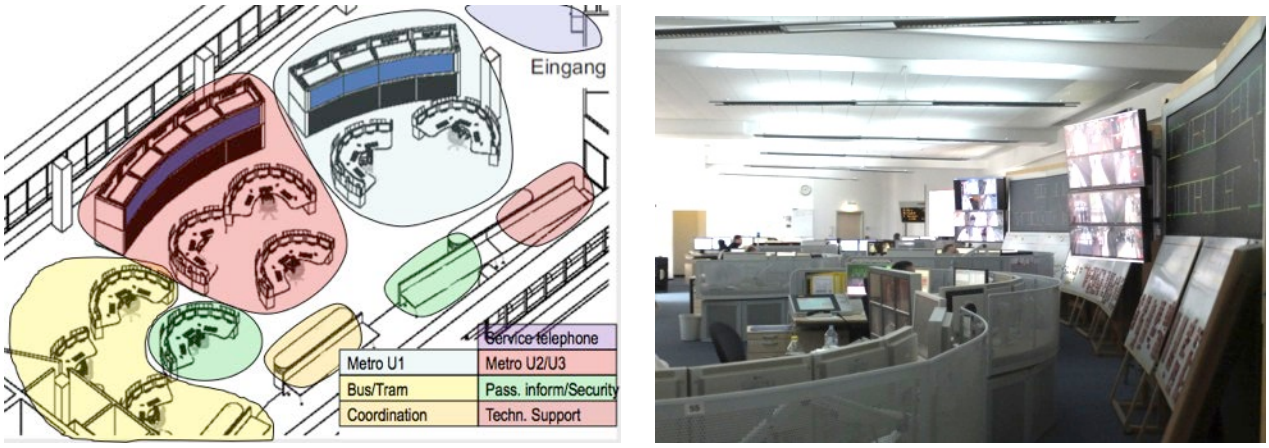

Figure 11: Workplaces at the OCC in Nuremberg, Germany

Description: The picture on the left shows a schematic overview of the OCC from above. Each semi-circle shape represents the work place of a single OCC employee. The view from the entrance door to the left side of the OCC (without ST) can be seen on the right.

One of the main characteristics of the OCC is that all workplaces are situated within one large room. There is no constructional separation between the different areas. The advantage is that communication between areas is relieved and information about disruptions or other irregularities are easily spread. For instance, employees of the service telephone know about possible delays or re-routing before passengers start calling. The environmental conditions, however, are very challenging, with respect to acoustics, room climate as well as lighting. Except for the telephone workers, the staff is not allowed to leave the floor of the building on which the OCC is situated during working hours. They must be able to return to their desk at any time. Most of the time, a supervisor is present, sitting in the back of the employees. There is no real space for privacy. On the other hand, employees treat each other in a very familiar and kind way, shaking hands with everybody at the beginning of the shift. Making jokes with each other and exchanging views on difficult tasks is rather common. From outside, everybody wearing a VAG uniform underlines coherence of the team. The Moodboard in Appendix B illustrates different aspects of the working place “OCC”.

“It feels like in a beehive“

4.2.2 End users: OCC employees

Due to the multifaceted work situation, the type of workers within the OCC varies. In general, the OCC employees work in a shift system. Every day is composed of 3 shifts, 365 days a year. With an average age of 48 years, the OCC faces an aging population of employees. On average, an OCC employee deals with 80 incidents a day (for AGT, CONV, OFL and FGI), a service department telephone worker (ST) with about 60 requests. With regard to the need for support, the

teams with the highest safety risk (CONV, AGT, OFL) and the team with the highest average age and sickness absence rate (ST) are the most interesting target groups for the Trans.Safe system.

The following paragraphs describe these target teams in terms of their composition, stress levels, main activities, stressors and aims in more detail. Figure 12 gives some impressions of the different work stations of the OCC's employees. The Personas in Appendix F allow a deeper insight into who those employees typically are and there needs and goals.

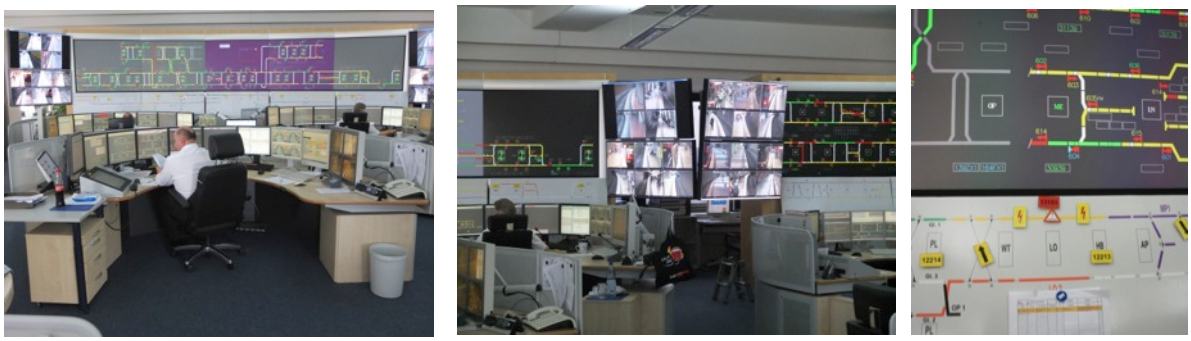

Figure 12: Impressions from different work stations at the OCC in Nuremberg, Germany

Team AGT (autonomic metro)

Description. A total of 22 employees of the OCC are qualified for the supervision of the automated underground lines. There are 3 employees working in a team at any time of the day. The average age of the employees in this division is 51 years. The safety risk in the AGT is high, but matched by a very high capacity of the team members with the lowest rate of sick leave.

Activities. The main activities are monitoring the regular operation and cooperating with service staff and drivers. In relation to this, the main events are detecting, monitoring and solving incidents and problems. AGT workers aim at ensuring passenger and staff safety at all times. Furthermore, keeping up driverless train operations as scheduled is a key task. They have to make sure that all trains are running and sticking to their timetables.

Stressors. As the amount of traffic varies significantly during the day, AGT workers have to adapt to changes quickly. Whilst there may be no activity at all during some times, phases with high traffic volume or incidents require very high amounts of alertness and ability to respond. Accordingly, the stress level often changes from 0 to 100 within seconds. A long stretch of monotonous and boring situations is sporadically interrupted by peak loads, depending on the events.

The main stressors in this group are headed by the general responsibility for the regular, safe operation. High expectations of the public and the company regarding the availability and punctuality of the metro service constitute a further stressor. An element of time pressure is added due to the short headway operation which leaves very little time for the operator to resolve a disruption before the next train arrives. Any disruptions have to be detected immediately. The maintenance activities at the lines during passenger operation times are a further stressor.

Team CONV (conventional metro)

Description. The total team responsible for the conventional underground lines is composed of 18 members, with 3 of them working at the same time together. They have an average age of 45 years. Like in the case of the AGT team, the high safety risk and high responsibility are matched by high capacities of the team members.

Activities. In terms of activities, the work situation is similar to the one described for the AGT team: Detecting incidents such as happenings at building sites, broken-down trains, technical break-downs, damage to persons, fire or aggressive passengers on the platforms or in the trains, is an overriding task. The main difference lies in the communication and cooperation with drivers,

who are absent in the AGT. The same applies to the aims, such as ensuring the safety of passengers and staff and dealing with varying workloads.

Stressors. The resulting stress level is characterised by stretches of monotonous and boring situations with interruptions of peak stress loads, depending on events. The sudden increase in stress from near zero levels is characteristic. While the contact with staff and other people, variety, responsibility and complexity of the job, as well as the challenge of solving problems are perceived as positive, there are major stressors for the team members: One of them is an overload of tasks, with too many things happening at the same time. Information overload is one of the connected difficulties. An enormous amount of time pressure in situations of high load aggravates the stress.

A characteristic situation with a high amount of stress is when maintenance works have to be conducted during operation. Furthermore, problems with the quality of digital radio communication occur. In some cases this delays communication. On the other hand, drivers who do not use the radio but call the landline instead increase the workload of the OCC worker. A more general issue is the ambiguity of competences, for example when drivers or other members of staff are not sure about whom to contact in certain situations. Additionally, the acoustics of the room and the noisy surroundings are a stressor for many employees. One of the main causes is when colleagues speak loudly on the phone or to each other. It is often also perceived as stressful to have to ask colleagues to speck with a lower voice. Another factor contributing to the noise level is the general amount of people within one room. A feeling of being less ‘exclusive’ is another side effect of a single big room. Additionally, the workstation arrangement may be optimised in order to increase the overview. In terms of free time management, OCC workers face similar challenges as truck drivers due to shift work and difficulties in vacation planning. Regarding privacy it is perceived as stressful that everything that is spoken has to be recorded for reasons of liability.

Team OFL (buses and trams)

Description. The section responsible for all bus and tram lines is located in between the two teams working with the different types of underground lines (AGT and CONV). Like the other two teams, it is composed of 3 members of a total of 16 at any time. The average age is 52 years. Compared to the other two teams, the safety risk is lower and the responsibility and connected capacities of the personnel on a medium level.

Activities. The main goals are however the same: ensuring safety, making sure operations run as scheduled, solving problems and dealing with incidents - and dealing with heavy and sometimes sudden changes in workload. The stress level changes between monotonous situations, which are frequently interrupted by medium peaks of stress and rarely by very severe incidents. This is due to the traffic characteristics over ground. The need to intervene arises from incidents ranging from operational problems caused by traffic jams, bad weather, damage to buses and trams, to damage to persons.

Stressors. Among the biggest stressors are bad weather conditions, which may lead to a breakdown of major parts of the traffic system and accidents, especially those including damage of a person. Furthermore, the amount of information coming in as well as the lack of leisure time due to shift work proves to be difficult. A particularly stressful situation may arise when someone has to deal with an incident on their own for some time. In addition, complaints by passengers, bad press and complaints of a coordinator are major stressors. The occasional discrepancy between personal and corporate priorities in situations with a high number of simultaneous tasks (e.g. eliminating disruptions vs. informing passengers) is another stressor. A number of further stressors are related to issues of communication. Many arise due to the dependency on third parties when solving a problem. In some cases a third party is not acting as supposed to (e.g. bus replacement taxis which do not take women with buggies with them), or poor decision making abilities of external colleagues (e.g. drivers) and language difficulties further complicate a situation. Limited support by external staff such as service staff, the police or the medical service may further obstruct the work in the OCC.

Coping strategies across the work places AGT, CONV & OFL

In trying to deal with the stress, many employees choose to speak to colleagues and family members. Social contact in terms of speaking and joking with colleagues is perceived as a major way of relaxing, especially after a stressful situation. The contact with people such as service staff and the drivers is mentioned as a positive aspect of the job, even though it may sometimes lead to increased stress. The feeling of good teamwork when tasks are allocated automatically is highly appreciated.

The large variety of tasks and the challenge of solving problems motivate many employees in their job. In cases of overload, concentrating on one task at a time and ignoring other less prominent ones for short periods of time helps during an acute stressful event. Whilst the flood of information coming in is perceived as a stressor, the fact that the job is rich in variety and complexity is appreciated. Experience in the job which helps in estimating how events may develop during an incident and a good local knowledge of streets are major sources of strength in stressful situations for OFL employees.

Since there is no immediate access to external staff, there is limited support for the AGT workers in case of an incident. However, in some cases the need to solve problems without being dependent on drivers is positively perceived as a challenge. The high level of responsibility also leads to a feeling of high self-competence, and solving problems can be a challenge in a positive way. Employees perceive their own expertise and experience which helps evaluating situations as great sources of stress relief.

Team ST (service department telephone)

Description. The service department telephone employees are situated in the same room as the other work places. They are however somewhat separated at the right side of the room. Nonetheless, they immediately realise when an incident is happening and can anticipate the surge of calls they will have to deal with in the following. In terms of their tasks, responsibilities and requirements, however, they differ fundamentally. Out of 11 employees in total, 6 work contemporaneously. The average age is 53 and the health of most of the employees is significantly limited. The team has the highest number of people on sick leave in the OCC. Unlike in the other departments, a significant part of the employees are women. The job itself has no safety risk and low responsibility. The stress level, however, is continuously high. Employees have to answer between approximately 60 and 180 calls per person per day. During times of strike the number of calls may even rise from 13.000 per month per team to about 25.000 per day. In those cases response rates accordingly drop to about 25%. Requests last anything between 20 seconds and 20 minutes.

Figure 13: Impressions of the Service department Telephone at the OCC in Nuremberg, Germany

Description: The pictures show an overview of the workstations of the ST workers (left) and a close up look at a workstation of one ST employee in particular. Many desks are decorated with a few personal items.

Activities. Their main tasks are answering timetable and train transfer requests, requests for ticket prices and helping with problems with ticket machines. Further tasks are helping to get back lost items such as mobile phones, pursuing passenger complaints due to irregularities in the service,

keeping an eye on incoming emails (disruptions, information), sending information flyers and handling the continuous flow of information between colleagues, including those from other workstations.

Every request is registered in a software system (done in parallel automatically) for internal statistics about the number and type of requests. It is however not allowed for the administration to control which workstation answers how many calls exactly. Requests come in from a large area including several cities around Nuremberg and often include information requests concerning external providers such as the national rail service which cannot be answered by the OCC telephone service.

Like at the other work stations in the OCC, the work spaces are not individual since employees rotate regularly, depending on the shift. Two employees have fixed workstations due to special health needs, including bigger screens. Employees are sitting most of the time, clicking through websites with a mouse in order to retrieve information and answer calls.

The main aims are answering the passengers' requests as competently as possible in order to satisfy customers. It is also a main source of satisfaction for the telephone workers to see how many calls they answered at the end of the day (they take private notes of the numbers), and how they could help people with their work. They additionally try to be prepared for possible complaints or queries of supervisors by taking notes of difficult passengers.

Stressors. The level of stress in this team is generally very high and the information flood coming in is connected to many of the workplace related stressors. The requirement to have a 90% answering rate of incoming calls is a major stressor. A particularly difficult situation arises for the person who has to sit at the entrance reception of the OCC whilst answering requests at the same time (one person per day, rotating). In general there is a lot of time pressure, since during one call many other callers are usually in the waiting line. The velocity of a blinking light on the phone indicates how many customers are waiting. This often leads to a feeling of not being able to offer the best possible service in terms of having the time to be empathetic. During events like strikes, redirections, disruptions of service, the beginning of the school year or changes of ticket prices, the situation aggravates. Similarly, on Sunday evenings, for example, when the team is smaller and many phone calls have to be answered alone, customers are wondering why it is taking so long for someone to pick up and the mood worsens.

The fact that the service department telephone workers have to speak all day long brings additional physical problems with it. Many suffer from a sore throat and headache or have sleeping difficulties at night. Like for the other OCC team members, the rolling shift system proves to be difficult to deal with. Some stressors are additionally related to the type of equipment provided. The wireless headset for the telephone, for example, is not perceived as being comfortable (especially when wearing glasses) and speech quality is reported to be poor.

In relation to the type of inquiry, many stressors arise. The first is not being able to give important information to the passenger because it is not yet public (e.g. in cases of strike). The second is when an employee cannot answer a question because the relevant information is not available (e.g. changes in information the employees themselves have not yet been informed of). The third is that it is generally difficult to keep up with the amount of detailed information to know, with constantly changing and new information. The fourth are unpredictable and complicated requests which pose a major challenge. The fifth are very complex requests which require a lot of different steps to be taken, for example finding out a telephone number, looking up a timetable including extra trains or rerouting and finding out the right person to contact.

In relation to customers it is very stressful to deal with those who are aggressive or offensive and are trying to get rid of their own frustration. Additionally, it is difficult to be dependent on the passenger in order to be able to close an inquiry. If a passenger does not pick up when he or she is being called back, the inquiry cannot be closed. Furthermore, some customers call repeatedly because they do not trust the information given, not knowing that their call ends up in the same room. In relation to this it is a main stressor if the employee has the feeling that the solution provided is not being understood by the customer.

Coping. In order to alleviate the situation, it is perceived as very helpful to communicate with colleagues. Humorous comments about difficult customers (or drawing comics of them) and

reciprocal information about who might call again are used to relieve some of the stress. The feeling of belonging together as a team and caring for each other (bringing water, sharing cookies) is strong. Colleagues in the OCC greet each other shaking hands every day. One of the employees used to have a drinking reminder, which indicated with a happy or a sad face whether it was time to drink more. It was perceived as fun and helpful but broke after some time. General ways of dealing with the stressors are to visit seminars and to rely on one's good local knowledge since many employees used to work as drivers before they had to quit and continue work in the telephone service centre.

4.2.3 Other stakeholders of the test site "OCC"

The occupational health and safety manager responsible for the OCC, who is taking care of all mechanical, electronic, physical and psychological stressors, offers additional insights. According to him, major stressors for all OCC workers are an extreme need for flexibility and a lack of predictability of the job. The speed of changes due to technical development leads to continuously new systems to work with, which results in problems especially for older employees. Confirming the psychological challenges the job entails, it is often difficult for employees to seek assistance without having a feeling of being seen as "weak" by colleagues. An enormous stressor regarding the main tasks is the pressure to restore the functioning of the normal service as quickly as possible once there is an incident. Furthermore, problems regarding climate and noise were confirmed. Lighting was often perceived as too bright while ergonomic standards suggest otherwise. Additionally, the colour of lighting is perceived as too cold (blue), employees prefer a feeling of cosiness. In general there is a large amount of individual differences in preferences regarding aspects concerning the facilities.

The high amount of work going on and the number of people in one room make concentration more difficult and the load of information leads to an overload of the sensory channels. In reaction to this many employees start speaking loudly and move around hectically on their chairs. Large amounts of the communication between and within teams take place vocally. Some report having problems to sleep because they cannot stop thinking about work and whether they acted correctly at all times during work. This was confirmed by relatives of the employees who regard the job in the OCC as generally very demanding. A works council member added that very long stretches without any activity were perceived as very challenging as well, being a typical situation of under load. Switching to full attention and action if an incident occurs is very stressful. Problems with the quality of radio communication were confirmed. The number of screens and lower wages for younger colleagues are further stressors within the whole OCC. In general, OCC workers have a very high reputation but often do not feel like having it.

4.2.4 Summary

The OCC is characterised by a variety of different work stations. The amount of information coming in, reflected by the extremely high number of screens and other technical devices, for example, is related to many main stressors. The only work station which differs significantly in terms of tasks and stressors from the others is the service department telephone. In general, OCC workers have a very high reputation but often do not feel like having it.

Basic Insights and Requirements:

- Trans.Safe device must be discrete and the intervention or feedback only visible to the user
- Users are not always aware of being stressed > enhancing consciousness
- Workers are used to being permanently observed (supervisor sitting in the back, everything spoken is recorded)
- Device shall not interrupt or deliver an additional stimulus during stressful situations > otherwise overload
- Device displaying successfully managed situations would be nice

Characteristics of the OCC workplace

- Users / senior workers are mainly sitting. When stress occurs, some workers start moving around on their chair, e.g. from back to front, left to right
- The workplaces of CONV (manual train), AGT (automatic train) and OFL (bus, tram) consist of a big, almost 180 degree working table with many monitors, phones and radio communication device in front of them (see photos in the Moodboard on confluence)
- The work is characterized by phases with low workload, interrupted by unforeseen phases with extremely high workload and many parallel tasks including a lot of communication with other parties (and colleagues) and fast decisions
- In general, the main light inside the OCC is only 200 lux, but each person has the possibility to switch on individual light (approx. additional 200-300 lux). The workers prefer a rather dark surrounding, some even complain about the 200 lux.

Stressors

- All workers suffer from the noisy surrounding and report troubles with concentration (disturbances, loud phone calls, colleagues talking to each other, alarms, audible signals)
- Typical stressors: phases without any tasks, but demanding ceaseless vigilance, alternating with phases of high workload and many parallel tasks, time pressure, rolling shifts, high responsibility, depending on other colleagues one cannot control (or with different priorities), social isolation / problems to keep up friendships due to irregular working hours (including weekend and public holidays)
- Immediate stressors during the daily routine: people on the tracks (1/day), items on the tracks (1/week), rioting passengers or assaults on drivers (1/month), disturbances due to bad weather (4/year), huge events (e.g. soccer games) (1/week), false alarms or people playing tricks (4/hour)

Coping strategies

- Communicating with colleagues, families, friends
- Acting out their anger (loud)
- Relying on many years of experience of how a situation is going to develop and how to deal with it (+ good local knowledge)
- Enjoying situations of having dealt with a problem or request successfully

4.3 Commonalities of the two test sites

For both test sites (except for the service department telephone), there are phases of underload as well as overload, which are both perceived as being stressful. Truck drivers as well as OCC workers have to be able to adjust their actions quickly according to changing circumstances. In both cases social and interpersonal aspects are among the leading stressors, even though the types vary. While truck drivers have to deal with being alone for long periods of time, OCC employees have a general lack of privacy – but mainly enjoy the contact with their colleagues and other people. Speaking with colleagues and family about difficulties in their job is a great source of relief for both, truck drivers and OCC workers alike. All of them are under a relatively high level of surveillance, with the trucks being connected to hauliers at all times and the OCC workers being recorded. In general, employees of all work places face problems with health, belong to an ageing group of employees and have hence comparatively low ambitions concerning professional development.

5 Conclusions: Requirements towards the Trans.Safe System

With respect to the limits of a new technical device, it has to be ensured during the development of the device that the driving task and the work of the OCC employees can still be executed safely. If possible, noise levels should be lowered, and the motivation, especially of the truck drivers, to stick to their job and drive safely and economically should be increased. Lighting should be used wisely in order not to distract excessively, and the system should be able to increase the employees' attention in order to keep the balance between over and underload. In terms of further surveillance of the employee, privacy concerns have to be considered (yet employees are already used to being controlled in some way). A further outcome of the interview sessions is that the evaporation of stimulating or calming scents seems to have low acceptance. The system should not be indoctrinating but health advice in terms of nutrition and physical activity tips may be beneficial. Concerning the OCC, there should not be introduced any further monitors or displays of the workload ahead (especially for ST).

Important laws and regulations, which have to be consulted and respected for the development of Trans.Safe, are break and steering times, regulations of professional associations in the respective countries, accident prevention regulations, occupational health and safety regulations, the (German) Occupational Safety and Health Act, and codes of conduct of the companies using the system. Figure 13 shows an overview of the most important aspects, which should be considered for the development of the future Trans.Safe concept.

<table>
<tr><th colspan="2">Compulsory</th><th colspan="2">Optional</th></tr>
<tr><th>Truck</th><th>OCC</th><th>Truck</th><th>OCC</th></tr>
<tr><td colspan="2">Not another monitoring (in terms of control)
Anonymous
No paternalism
Barrier-free
Age-friendly
Can be integrated into work surrounding
Nonintrusive
Quiet
No discrimination
No disturbances during the stressful event
Simple technique</td><td colspan="2">Offer rewards
Foster interaction
Foster body awareness
Support health & back pain
Provide bio feedback
Enhance well-being</td></tr>
<tr><td>Individually adjustable
Meeting the lifestyle
No text
No beeping sounds
Not indoctrinating
Not bright
Motivating
Minimum space requirements
Do not remind of past mistakes</td><td>Discreet
No additional stress
Simple instruction/handling
No interference of technical equipment
Provide additional benefit
No display of workload</td><td>Help in improving the image of the profession
Help relieve aggressions
Entertain & inform</td><td>Offer stress education
Provide support and guidance
Propose breaks
Increase attractiveness of the job
Adjustable lighting
Adjustable temperature</td></tr>
</table>

Figure 14: Requirements towards the Trans.Safe system

Description: The left side of the figure shows compulsory requirements for the development of a Trans.Safe device for both test sites separately (bottom) and those which are relevant for both test sites alike (upper part). The right side focuses on optional requirements.

The next steps towards the development of the Trans.Safe intervention will focus on taking the findings of D2.2 together to develop use cases for possible interventions. Figure 15 illustrates a starting point for the development of specific cases for application. Depending on the specifics of the underlying situation (accident, high noise level, night shift etc.), an array of interventions is proposed in the circular segments. Based on this matrix possibilities for the realization in terms of

technical devices will be added. Additionally, ways of interaction with the device will be suggested. The development process will be carried on with a discussion of different scenarios to test them for technical as well as financial feasibility. In a dialogue with the stakeholders, it will be determined whether the preliminarily chosen interventions fit their needs and requirements. The development of the Trans.Safe concept will be described in Deliverable 2.3.

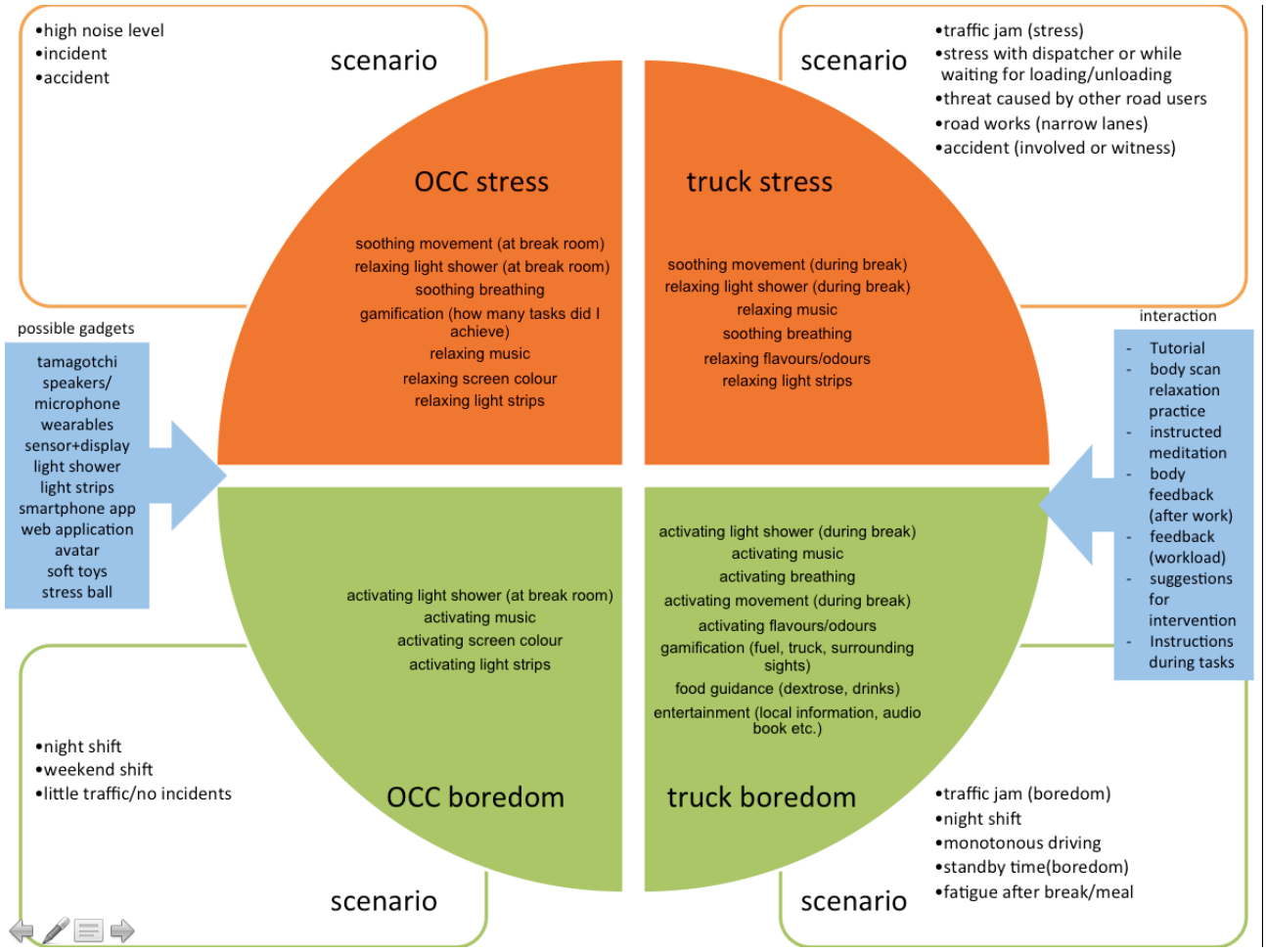

Figure 15: Matrix for the development of user scenarios

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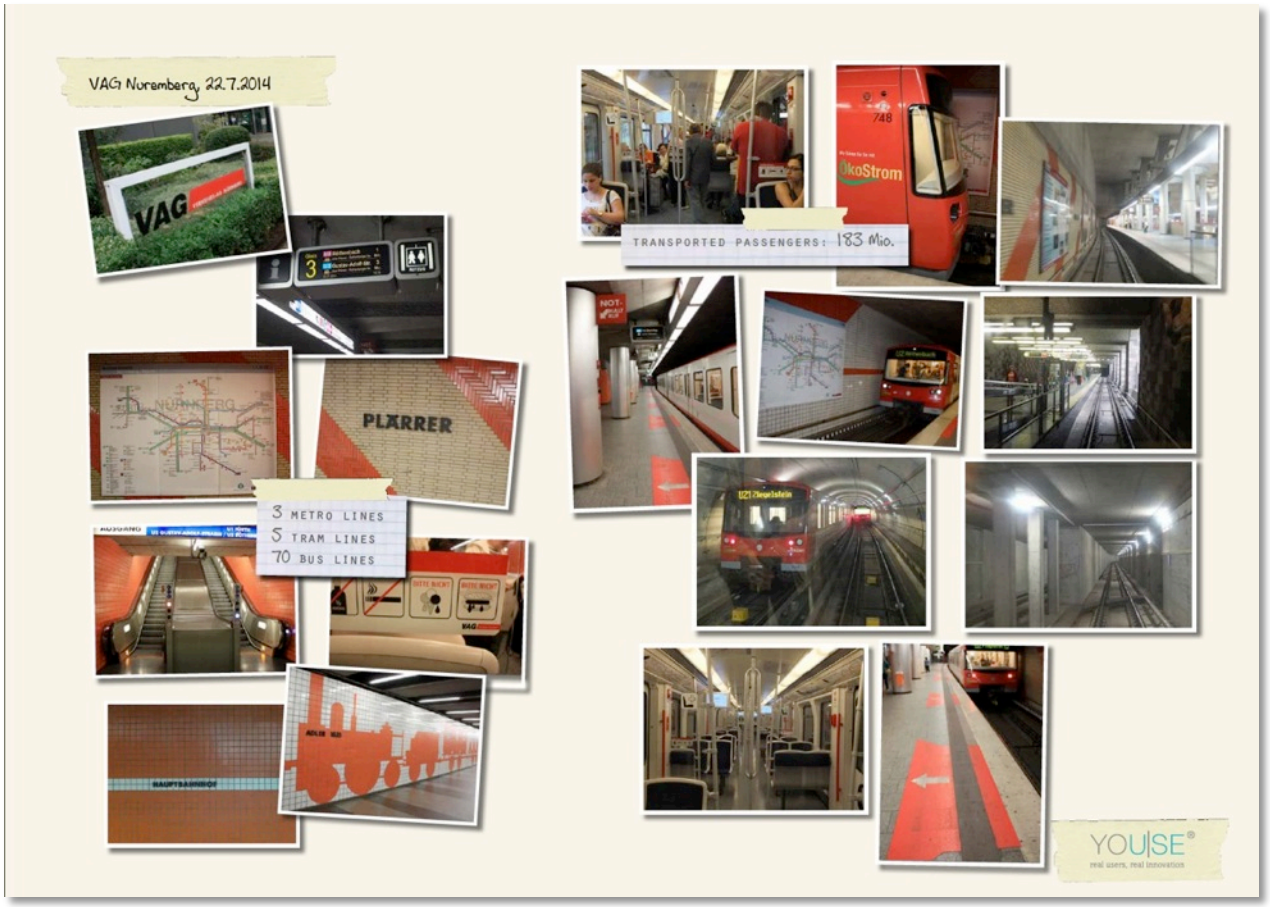
Appendix A

Moodboard for the test site “truck”’

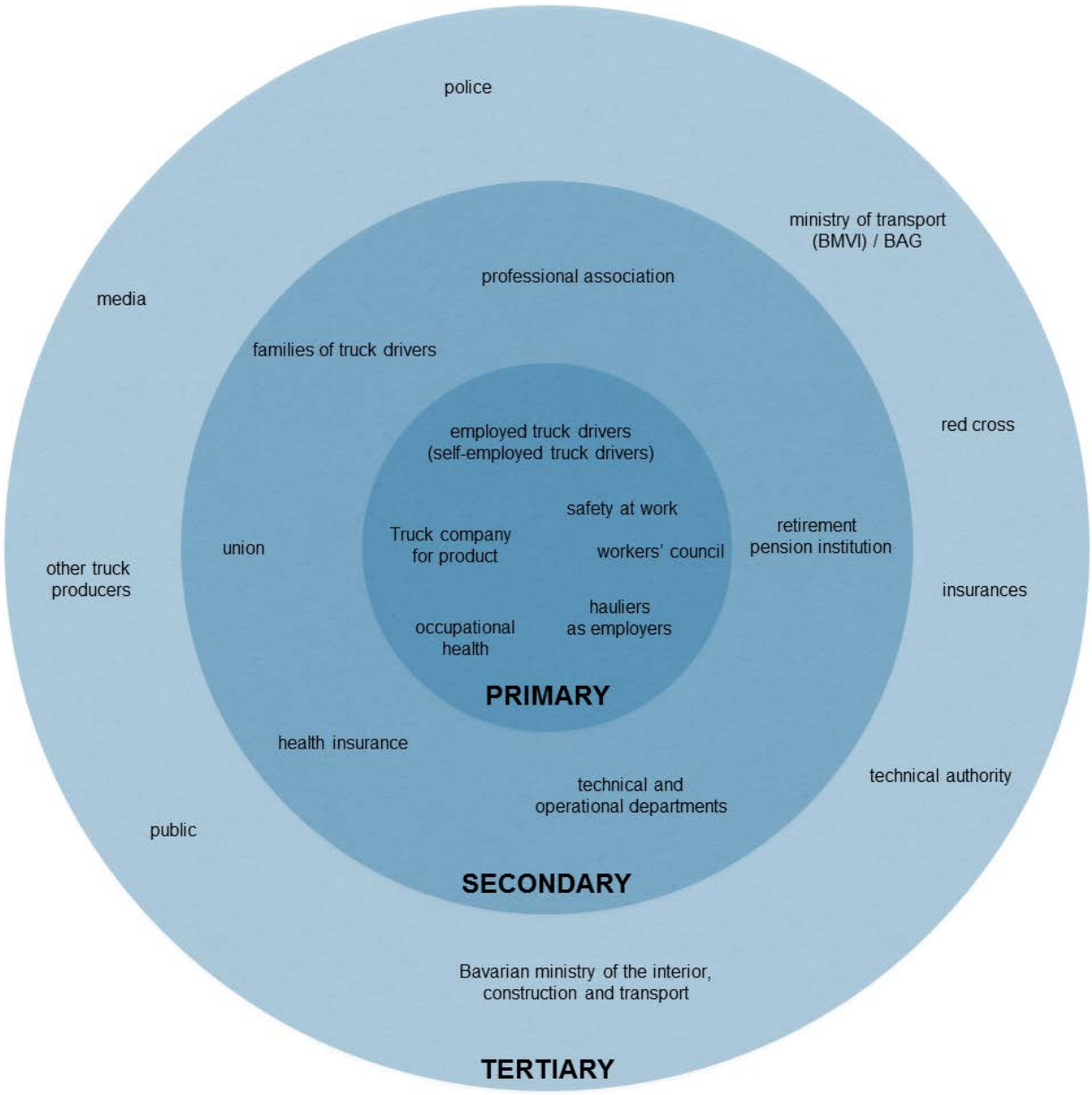
Appendix B

Moodboard for the test site “OCC”



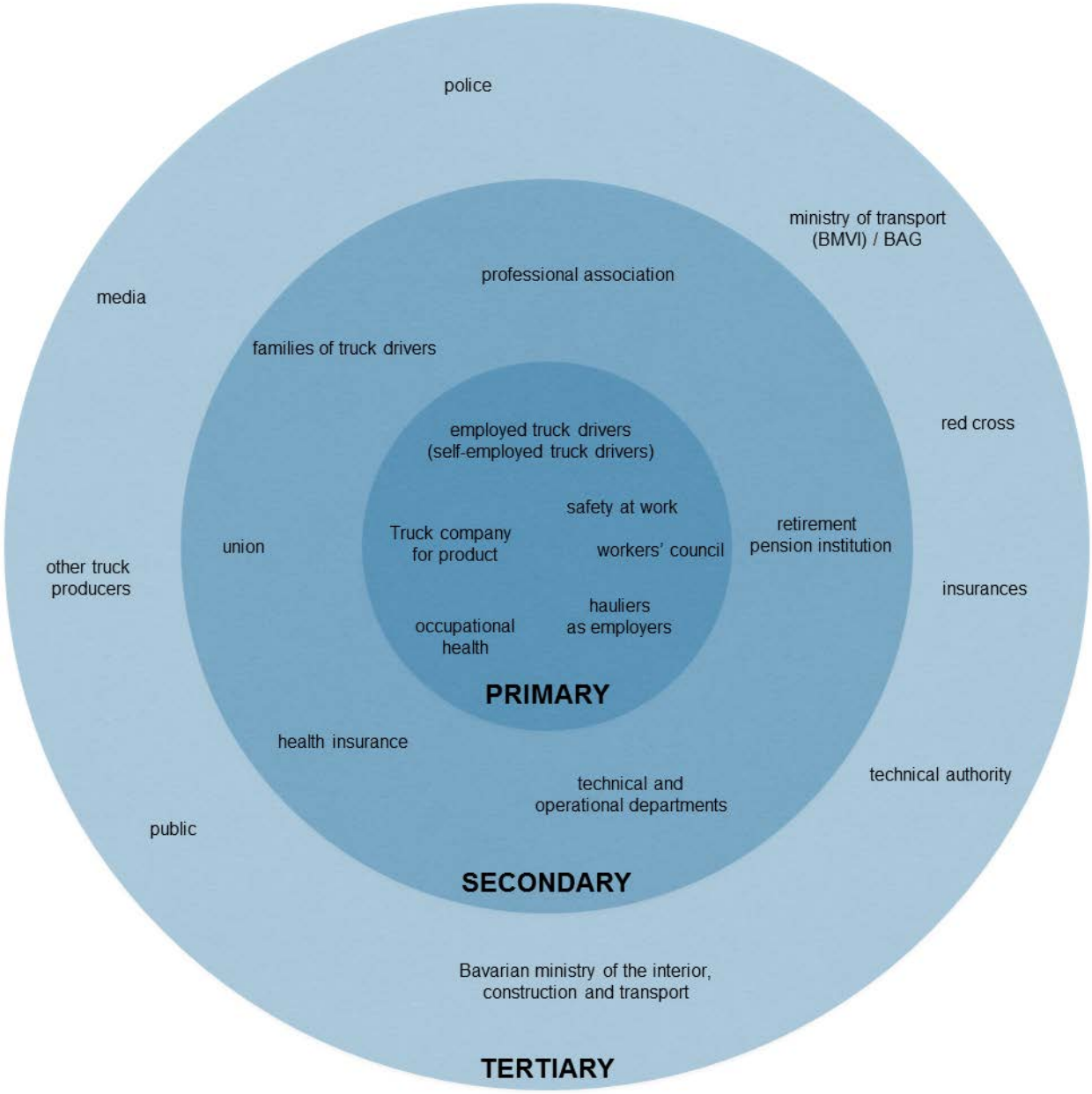
Appendix C

Stakeholder map for the test site “truck”



Appendix D

Stakeholder map for the test site “OCC”



Appendix E

Example of a Persona from the test site “truck”

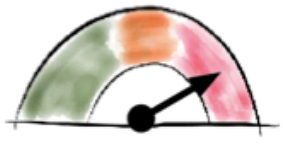
Robert Mead

occupation	long distance lorry-driver
age	59 years
weight / size	105 kg / 1,80 m
relationship status	recently (re-) married
children	none
living situation	owns a house in the countryside
technical affinity	+++

“I work to live”

my mobile phone

personal stress resource



Health. Mister Mead’s health status is low to medium, while his fitness level and sleep quality is average. Usually he can sleep well with some interruptions before morning shifts.

Job. He has been driving trucks for 30 years. While driving he fears missing out on something and also being disrespected from others, because of the bad manners of other truck drivers.

Hobbies. He has many hobbies like travelling with his own camper, hiking, cycling or just having a drink at a bar with his friends. He also likes exploring foreign countries and technical devices of all kinds.

Fears. Furthermore he doesn’t like the fact, that he is not having enough time together with his wife, so he thinks about quitting his job.

Goals. Robert’s main goal is to change the job as soon as possible or if it that doesn’t work to learn to deal better with stress. Another aim for him is to stay fit to keep being able to go hiking and travelling when retired.

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Appendix F

Example of a Persona from the test site “OCC”

John Idler

occupation	Disponent AGT
age	57 years
weight / size	80 kg / 1,80 m
relationship status	divorced, in a relationship
children	1 son
living situation	owns a house in the country side
technical affinity	++

“I can sleep when I am dead”

Health. Although Mister Idler is 57 years his health status is very good with a high fitness level and very good sleep quality, because he does a lot of sports, he eats a lot of fresh fruits and he always tries to get enough sleep.

Job. At the OCC, where he has been working for 20 years he enjoys to work with people together and being part in a good team is very important for him. But he also likes to be a “performer”.

Hobbies. Mister Idler likes to do outdoor activities like going for long walks or long-distance running with his dog he likes the most. He travels a lot through whole Europe with his own caravan. If he’s not “on the road” in his leisure time then he looks after his own garden and cares it.

Fears. He fears for personal conflicts at the workplace and he doesn’t want to spend leisure time with his colleagues. Additionally he is afraid of becoming unfit, because he was suffering from a slipped disc many years ago.

Goals. His goals are to have everything under control within a harmonic atmosphere with the people around him. In general he wants to stay healthy and fit and enjoying a good life. At retirement he wants to travel to every single European country with his camper.

my mobile phone

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