SESSION 3B :

HUMAN FACTORS IN DIFFERENT TRANSPORT MODES

PERCEPTIONS OF PORTUGUESE DRIVERS ABOUT THE USAGE OF MOBILE PHONE WHILE DRIVING

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ABSTRACT: It already has been proved that the use of the mobile phone while driving has a negative impact on the driving performance, increasing the risk of being involved in a car accident. The present study investigated the patterns of use of the mobile phone while driving, the prevalence of hands-free systems use and also the perceived hazard using the mobile phone while driving. The main findings were that the rate of mobile phone use by Portuguese drivers is very high, since 88.6% of the drivers admitted to use it while driving. The perceived level of hazard in talking on a hands-free mobile phone while driving was much lower compared to hand-held mobile phone, revealing that drivers still have the wrong perception that, with the hands-free system, the risk of being distracted is significantly reduced.

1. INTRODUCTION

In the United Nations Economic Commission for Europe (UNECE) area, every year, more than 120 thousands individuals are killed in road crashes, with a consequent social and economic impact [1]. One of the leading causes of motor vehicle accidents is driver distraction, defined by Patten et al. [2] as the drivers' involvement in doing things that are not related to the primary driving task and that disturb attention needed when driving safely. According to a naturalistic study carried out in the United States [3], distraction caused by the involvement in a secondary task contributed to over 22% of all crashes and near-crashes occurred during the period of the study.

A series of studies, summarized in an overview prepared for the European Commission [4], showed the negative effects that the usage of mobile phone has on the driving performance. The principal repercussions on distraction are physical (manipulation of the mobile phone), visual (gaze directed to the mobile phone), auditory (ringing of the phone) and cognitive (performance of two mental tasks at the same time).

Despite the significant negative impact of mobile phone on driving performance, few EU countries conduct systematic surveys of car telephone use by drivers [4]. In Portugal, to the knowledge of the authors, none of such studies had been yet performed and, in addition, the use of the phone is not pointed out as a cause of crashes in the road safety database [5]. However, the road safety impact of mobile phone on driving should be considered because, being 110% the average penetration rate of mobile phones in Europe in 2007 [6], Portugal is no exception reaching an impressive record of

148.9% [7].

Given those assumptions, this study focused on the mobile phone usage by a sample of Portuguese drivers. The aim was three-fold: to investigate the patterns of use of the mobile phone while driving, to find out the prevalence of hands-free systems use and, finally, to understand the perceived hazard in using the mobile phone while driving.

2. METHOD

2.1. Participants

The sample consisted of 769 Portuguese drivers that have already used the mobile phone while driving.

The participants' age ranged from 18 to 73 years old (mean=30; S.D.=8.8) and more than half of the sample consisted in males (61.2%). Participants had, in average, 12.3 years of driving experience, ranging from a minimum of 0 to a maximum of 53.

2.2. Variables

The internet survey first assessed some demographic variables such as age, gender and driving experience. Then, the survey continued posing questions about the use of the mobile phone while driving, the usage of the hands-free system while driving and the perceived level of dangerousness of the mobile phone use while driving.

2.3. Procedures

The questionnaire was developed by the Technical Research Centre of Finland (VTT) in the frame of the European project INTERACTION. The survey was carried out via web by a polling company in 8 European countries (Austria, Czech Republic, Finland, France, Netherlands, Portugal, Spain and United Kingdom) and in Australia, but only the data gathered in Portugal will be used in this article. The data collection was carried out between March and August 2010. The data was analysed, based on descriptive statistics, using the software SPSS v.20 (Statistical Package for Social Sciences).

3. RESULTS

3.1. Mobile phone use patterns

Overall, 769 respondents (74.2%) admitted to use the mobile phone while driving, only 99 (9.6%) mentioned not to use it. The results that are going to be presented will only consider the respondents that reported to have ever used the mobile phone while driving (N=769).

Concerning the frequency of use of the mobile phone while driving, most participants (28.5%) mentioned to use it frequently (at least, once a day), 22.8% use it regularly, 25.6% occasionally and finally only 17% revealed to use it rarely.

The type of road in which the drivers favoured more the use of the mobile phone was the highway, with a frequency of 34.7 %. In main and rural roads and in city roads, the percentage of participants were respectively 16.3% and 13.1%.

The drivers were also asked about the frequency with which they engage in some specific tasks with the mobile phone while driving (Table 1). Overall, answering a call on the mobile phone was the activity most frequently undertaken by the participants (the answers “Frequently” and “Regularly” overall sum up the 41.8% of the replies).

Participants reported to use the mobile phone for reading and sending text messages while driving less frequently compared to making or answering a phone call (Table 1).

Table 1. Frequency of various types of MP use while driving (%) [N=769]

	Frequently	Regularly	Occasionally	Rarely	Never	N/A
Make a MP call	15.1	12.7	26.1	32.5	6	7.6
Answer a MP call	20.7	21.1	29.1	21.3	0.4	7.4
Read a SMS	9.8	15.9	25.7	29.3	12.2	7.1
Send a SMS	7.2	9.1	19.5	32.9	23.8	7.5

3.2. Hands-free system use

Concerning the hands-free systems, more than half of the sample (68.8% of the participants) owns it for the mobile phone, whereas 23.7% mentioned not to have it.

The enquiry asked to the respondents who owned a hands-free system how often they used it and a great percentage (46.3%) reported to use it *for all or almost all calls*, 6.8% answered using the system *for none or almost none of the calls,* 6.5% *for less than half of the calls*, 6.6% *for more than half of the calls*, 2.3% answered to use it *for about half of the calls*, and 1% didn’t know.

The types of hands-free systems that are more used while driving are the *ear-piece connected via wire* (21.5%), the *wireless ear piece by Bluetooth connection* (19.4%) and the mobile phone in *loud-speaker (*17%).

3.3. Perception of the level of hazard

The last part of the questionnaire focused on the hazard perceived by the participants in taking some actions with the mobile phone (Table 2). In general, the data revealed that dialling a mobile phone was perceived as more dangerous than answering a call with the device. On the other hand, concerning the usage of the mobile for texting, writing an SMS was perceived more dangerous than reading. Comparing the perceived dangerousness between dialling/answering the mobile phone and writing/reading an SMS, the last couple of actions is evaluated as considerably more dangerous by the drivers taking part in this study.

Looking at Table 2, the most interesting result is the perception that participants had about the dangerousness of using the hands-free devices for calling. Several studies [2, 8, 9] reported that the usage of hand-free devices for calling does not eliminate driver's distraction. However, in this study, Portuguese seemed not to be aware of those findings, considering that they rated "Talking on a hands-free mobile phone" as much less dangerous than "Talking on a hand-held mobile phone" (the answer "Extremely dangerous" was selected by 2.7% of the sample for the former statement and by 44.7% of the sample for the latter one).

Table 2. Level of perceived hazard for different MP usages (%) [N=769]

	Extremely dangerous	Very dangerous	Moderately dangerous	Somewhat dangerous	Not at all dangerous	N/A
Dialling a MP	33.4	30.8	25.2	7.3	1.4	1.9
Answering a MP	21.8	30.4	28.2	13.7	3.9	2
Talking on a hand-held MP	44.7	31.1	16.9	4.6	0.3	2.4
Talking on a hands-free MP	2.7	6.5	21.8	44.1	22.5	2.4
Writing an SMS	62	22.5	11.4	1.6	0.5	2
Reading an SMS	43.2	33.8	16.4	3.8	0.4	2.4

4. DISCUSSION

Globally speaking, the usage rate of mobile phone among Portuguese drivers is quite high. Considering the total valid answers to the questionnaire (that is, not considering 16.2% of the total sample), it was pointed out that 88.6% of the drivers admitted to use the mobile phone while driving. This percentage is higher compared to other studies performed in different countries, like Spain [10], Finland [11,12] and Qatar [13].

The participants mentioned to favour more the usage of mobile phone on highways compared to the other road environments (main and rural roads and city roads). This result is different from Gras et al. [10] which reported a more frequent use on urban roads in comparison to highways. The tendency to favour the usage in highways might be justified being such road environment less dynamic with regards to traffic or, perhaps, being lower the risk of being caught by the police in using the mobile phone while driving.

With regard to the action undertaken with the mobile phone, drivers stated to engage more frequently in making/answering a call than in reading/sending SMS. Those findings are in accord with previous results [10,14].

It seems that the effects of the measures adopted to reduce the mobile phone while driving have no or little effect on it.

It was found that large part of the drivers use the hands-free system for all or almost all calls (46.3%). However, it is important to state that a lot of respondents (31.5%) didn't answer to this question. In Spain, Gras et al. [10]

found that only 14.3% of the drivers use the hands-free device for calling while driving whereas, in a study carried out in New Zealand [15], the 17.2% of the sample. From these results, it seems that Portuguese drivers use the hands-free systems more often than Spanish and New Zealand drivers.

The sample clearly considered talking on a hand-held mobile phone extremely dangerous (almost half of the participants). These findings confirm other results obtained in previous studies [10, 16].

It has already been concluded by several studies that the use of both hand-held and hands-free use of mobile phones while driving significantly increases the risk of having an accident [17, 18]. However, in this research, the perceived dangerousness of talking on a hands-free mobile phone was low (22.5% of the sample considered that talking on a hands-free mobile phone is not dangerous at all and 44.1% considered it only somewhat dangerous). These results demonstrate that Portuguese drivers have the wrong perception that, with the hands-free system, the risk of getting distracted while using the mobile phone decreases. This misjudgement might be related to the fact that people associate distraction more with the physical action rather than with the cognitive process intrinsic to a phone call. According to the article 84 of the Portuguese law, the use of hand-held mobile phone while driving is forbidden. However, hands-free devices are allowed, except the ones that cover both ears. Using the mobile phone while driving is a severe offence, which might lead to a minimum driving inhibition of one month until one year and a fine ranging from 120 to 600 Euros [19]. If the legislation bans hand-held mobile phone use but allows the use of hands-free systems, people might be pushed to use the hands-free systems with the flawed feeling that those devices will solve the problems related to distraction.

5. CONCLUSIONS

Globally, the results obtained show that people are only partly aware of the risk associated with mobile phone usage while driving. Notably, concerning the use of hands-free devices, people appeared not to be informed about the related concerns. Then, it might be relevant to develop strategies for informing drivers about the issues related to the mobile phone use while driving (e.g. campaign development), particularly on the problems derived from hands-free systems use while driving.

Being a survey, the main limitation of this study is represented by the fact that the results are purely based on the opinions of the drivers and no objective data are available. According to the results obtained it seems that the effects of the measures adopted to reduce the mobile phone while driving have no or little effect on it.

However, in order to confirm the findings, a naturalistic driving study has been just completed. Furthermore, it is planned to further analyse the questionnaire results to see the effects of variables such gender and age on the usage of mobile phone while driving.

6. ACKNOWLEDGMENTS

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RESILIENCE IN THE DESIGN OF MODERN TRANSPORT SYSTEMS

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ABSTRACT: The high scale and complexity of transport systems represent today an important challenge in terms of safety and operational control. Rather than relying on centralised control and rigid processes, safety and operations management practices must be able to account for increasing degrees of variability and uncertainty. Using resilience engineering as a theoretical framework, research was conducted within the engineering planning system of the UK rail industry, aiming to improve the ability of this system to cope with uncertainty whilst maintaining high standards of safety and efficiency. The outcome of this research is then discussed as a good practice with potential application in other domains of rail systems.

1. INTRODUCTION

Transport systems are today recognised as large scale complex sociotechnical systems. These characteristics are at the source of many organizational and technological problems, which have shown the need for a change in systems design and management practices, particularly in the domain of safety management.

Resilience engineering has been recently proposed as a safety management approach that focuses on the development of means for better coping with the variability and uncertainty inherent to large scale complex sociotechnical system. This approach places both safety and efficiency at the core of every aspect of systems design and management, and considers that a dynamic balance between these two (opposed) requirements must be maintained through constant adjustments to changes in the operational environment. This ability to adjust can only be achieved by designing for flexible processes, yet maintaining a degree of robustness necessary for safety barriers to resist business and production pressures. Hence, along with safety and efficiency, systems design and management must also contemplate the need for a balance between operational flexibility and stability.

Research conducted within the UK rail industry aimed at integrating resilience engineering concepts [1]. The focus was set on rail engineering, in particular on the processes and organisational structures which supported the planning of the engineering work necessary to maintain and modernize the rail infrastructure. This paper summarises the main findings of this research in order to illustrate the potential contribution of resilience engineering towards responding to high complexity challenges. In particular, the analysis of the planning system as a top-to-bottom and cross-organisational decision making process is highlighted, in order to illustrate the need for flexible and adjustable support to planners' decisions.

2. RESILIENCE ENGINEERING

Resilience is defined as "the intrinsic ability of a system to adjust its functioning prior to, during or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions". Because it is based on the adjustment prior, during or after events, this concept must encompass a certain timescale, which underlines its dynamic nature. Thus, resilience is a process through which a balance between safety and efficiency is achieved and maintained, rather than a quality or condition of a given sociotechnical system. This balance must be built around as much efficiency as possible, maintaining operations close to the limits of system capacities and making the most of the resources available, whilst devoting enough attention and resources to safety as to avoid exceeding system capacities. Within this scope, resilience engineering consists on the development and implementation of the tools necessary to integrate and maintain resilience in system operations.

One of the main repercussions of high complexity is the underspecified nature of systems operations. The large number of human, organisational and technical aspects, together with their fast pace changing behaviour, imposes serious limitations to the ability to fully understand and monitor system operations. Thus, maintaining operational control must recognise high variability and uncertainty as constant challenges. As often discussed by Hollnagel *et al*, one of the aims of resilience engineering is the ability to cope with variability of system operations and uncertainty about possible outcomes.

Managing a balance between safety and efficiency under high variability and uncertainty conditions relies on the information available at all hierarchical levels and organisational areas, and how this information supports decision making with an adequate visibility of operational conditions. As stated by Woods & Hollnagel, progress on safety ultimately depends on providing workers and managers with information about changing vulnerabilities and the ability to develop new means for meeting these.

3. THE RESEARCH CONDUCTED

Little previous work had been dedicated to the understanding of planning and of its impacts on the safety and reliability of engineering work. As pointed out by Wilson *et al* , many of the risks, failures and general issues regarding the performance and safety of rail engineering work can be more or less directly traced back to planning problems. Understanding the planning process was therefore, considered an essential step in addressing the current demands for high efficiency, reliability and safety in the railways. To this end, three main objectives were considered:

- Develop a description of rail engineering planning as a complex sociotechnical system and identify its critical human and organisational factors.
- Investigate planning performance in view of the support it provides to the delivery of engineering work in terms of the efficient allocation of resources (namely access to the rail infrastructure) and the safety and reliability of the work carried out.
- Promote safety and efficiency in rail engineering through improved planning, using resilience engineering concepts as a framework.

An in-depth understanding of human and organizational factors relevant to rail engineering as whole was developed from several interview based methods. The performance of the planning system was then investigated using quantitative data driven from archival sources. A questionnaire was also developed, aiming at the assessment of resilience related factors in planning. The discussion of both the qualitative and quantitative data in view of resilience engineering literature led to conclude on the nature of the main system interactions within rail engineering and supported recommendations to achieve an enhanced potential for resilience.

3.1. The rail engineering planning system

In broad terms, planning activities can be considered as a response to the unavoidable need to manage resources in view of certain objectives. Because materials, time and money (among others) are always limited and therefore, cannot be made available whenever desired, priorities must be anticipated so that resources can be allocated accordingly.

Within the UK rail industry, the planning process has an average duration of 90 weeks, going from the definition of a basic scope of work, down to all the necessary details of work delivery. This process focuses on managing and forecasting access to the infrastructure, both for operational and engineering purposes. The organisation which has ownership of the rail infrastructure, and is responsible for all its operational and safety aspects, is also in charge of planning. Engineering planning aims to schedule within a given year, all engineering work identified as necessary to either comply with maintenance needs or respond to enhancement targets. Throughout this scheduling process, resource limitations must be taken into account, in particular, the access to the rail infrastructure which must be negotiated with train operating companies. Thus, whilst aiming to optimise resource allocation (machinery, haulage, staff and access, among others), the planning process must request as much information as possible from stakeholders (contractors, maintenance units, among others) regarding the engineering work to be carried out, in order to establish priorities and ensure the safety and reliability of access and work on the rail infrastructure.

Within the scope of this research and in line with Pinedo, the planning system was described as a complex decision making process, ranging from high level strategic business decisions down to the definition and scheduling of work details and its delivery on the rail infrastructure. This process is developed based on a top-to-bottom and cross-organisational structure within the organisation which detains the rail infrastructure. However it relies on the participation and input of a wide range of stakeholders both from within and outside this organisation. For instance, from within the organisation, a network of maintenance units and planning units are geographically dispersed in order to cover the extent of the rail infrastructure. From outside the owner of the infrastructure, organisations such as engineering contractors and train operators, among others, provide crucial input to the decisions made throughout the whole process.

Figure 1 represents the relations identified between planning and the main stakeholders from both within and outside the organization that detains the rail infrastructure. The dash line between planning and train operators represents a strictly informal, yet important flow of information within the system. Within the remainder communication channels, although the solid lines correspond to formal flows of communication, parallel informal contacts were often identified between all stakeholders.

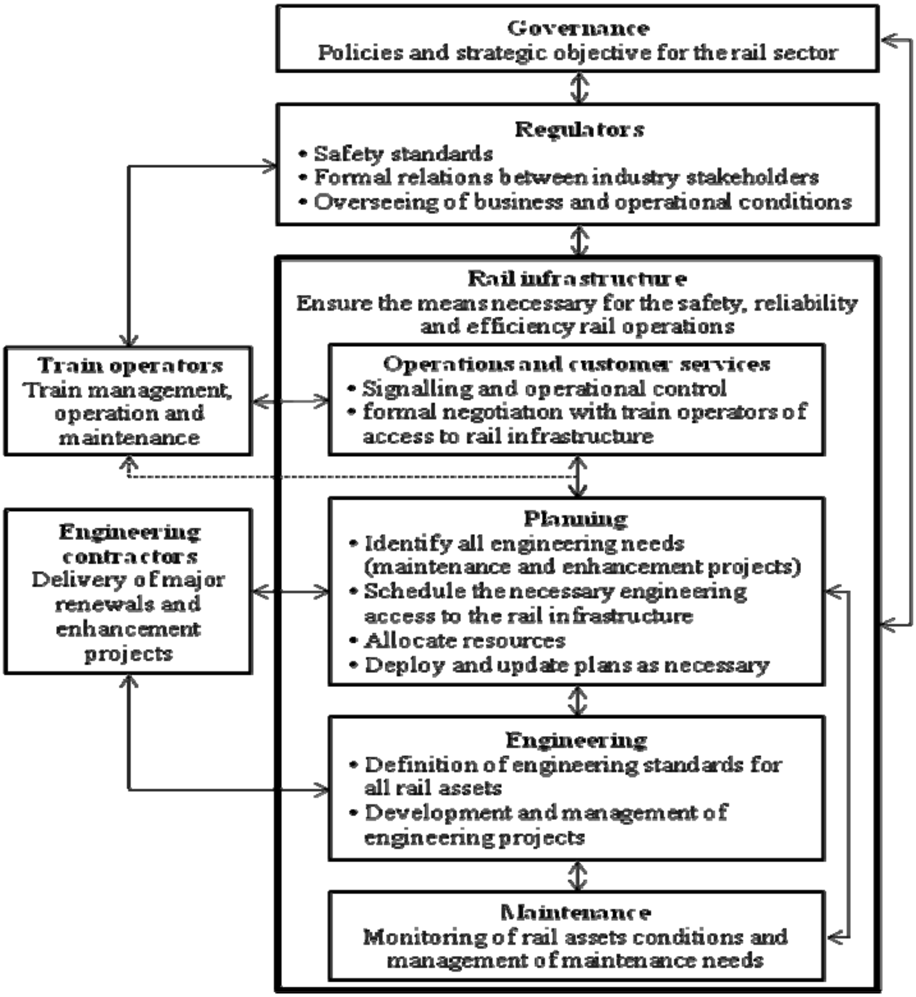

Figure 1: relations of planning with stakeholders

In line with the concept of sociotechnical system responsible for safety management introduced by Rasmussen, Figure 1 represents planning as a system which on the one hand, must cope with business pressures and safety boundaries generated at higher hierarchical levels, and on the other hand, with the demands for access to the rail infrastructure put through by maintenance, engineering and train operators. Within this context, the planning system operates around the following three railway access demands:

- Make the railway access as much available as possible to train operators, in order to comply with political and public demands for increased services.

- Ensure the access necessary to carry out maintenance and inspection work on the railway, in compliance with safety and engineering standards.
- Ensure the access necessary to carry out major engineering projects, set in accordance with the modernisation and capacity enhancement programs negotiated with governance.

It is clear that these three access demands compete against each other, which means that planning must be capable of negotiating priorities and allocate access and other critical resources in the most efficient way, whilst ensuring adequate safety conditions to access and work on the railway.

3.2. The main research outcome

The research methods used provided data on a wide range of domains and from both the different hierarchical levels and organisational areas, and across the geographical distribution of planning. The main results can be summarised as follows:

- Managing planning changes is the single most complex challenge that planners are faced with. The organisational fragmentation and geographical dispersion generate poor and unsynchronised information flows at different system levels and boundaries, which contributes to an increased uncertainty in decision making. Such degrees of uncertainty are the cause of frequent revisions of planning decisions, which leads to the need to also revise and change planned work.
- Little organisational and operational autonomy is given to planning teams working at different levels of the process. This was found to contribute to a relatively low control of planners over the development of the process, mainly by allowing stakeholders to impose late changes and often to provide poor information regarding work to be carried out on the infrastructure. Hence, planners were found to have little ownership over the process, which also contributes to an increased uncertainty.
- High volumes of planning changes were identified as a main cause for the erosion of planning robustness and reliability. Planning performance indicators regarding the volume of planning changes per number of work items undergoing planning were found to have a positive relation with the occurrence of incidents and irregularities during engineering access to the rail infrastructure and work delivery.
- Planning experience was identified as an important support to the development of informal work relations and contacts. Planners resort to such communication channels to obtain prompt and reliable information that can support their decision making. Thus, in parallel to the formalisation of agreements between planning stakeholders, an informal flow of information provides the means for an efficient and flexible problem solving. In this sense, these informal communications support planners in reducing and controlling uncertainty in decision making.

From a resilience engineering perspective, it became clear that the high organisational and process complexity of planning, as well as its duration and wide geographical scale, were important barriers for enhanced system resilience. On the other hand the factors which most contributed to resilience were found to have their origin in planners expertise and the informal flows of information which it supports.

The scale and complexity of the railway system is entirely compatible with the principles of underspecification and uncertainty. A certain degree of local autonomy can support an efficient response to unforeseen issues and provide the means necessary to flexibly adjust planning according to such needs. This is expected to enhance critical aspects of resilience such as the ability to respond to unexpected events, as well as the ability to quickly recover from abnormal functioning. While the usefulness of local autonomy and flexibility is undeniable, some level of centralisation is also necessary to coordinate needs at a national level, aiming to optimise resource allocation and avoid waste and inefficiency. Thus, the level of resilience is reliant on the ability to manage a dynamic balance between local flexibility to adjust planning decisions to emergent needs, and a centralised rigidity that can reinforce deadlines and achieve national efficiency and coordination.

The management of planning changes is at the core of the balance between local flexibility and centralised rigidity. The key issue is generating information that can support the understanding of what changes should be accepted as improvements of resource allocation, and up until which point in time and stage of the process these changes should be admitted without compromising robustness and safety of the plan and long-term engineering commitments. This information should also support the identification of changes that can be admitted beyond this point, as adjustments to unforeseen issues, and those that should be rejected for safety reasons (making “sacrificing decisions” against excessive business production pressures).

4. CONCLUSIONS

The challenges of high complexity are today discussed within a wide range of industrial domains. Particularly in the transport sector, the growing number and diversity of interdependencies between numerous industry partners, raises equally complex challenges in terms of operational control and overall system safety and reliability. Although restricted to the sociotechnical system that supports engineering planning, the research conducted has shown the potential of resilience engineering as a framework towards better coping with complexity in other domains of the railways. For instance, the level of interoperability envisaged for the European rail network has often demonstrated to be an endeavour that goes beyond the issues of implementing new technologies and organisational structures.

Overall, the investigation of engineering planning showed that centralised and rigid control processes, which most safety models tend to enforce, have a limited ability to cope with high variability and uncertainty. The resilience based approach used in this research supported recommendations towards a more flexible and local control of the planning process.The cooperation and communication at different levels and stages of the engineering work cycle, namely between planning, delivery and operations, represents a valuable contribution towards the ability to avoid something bad from happening, the ability to survive by minimising the impact of incidents and the ability to recover quickly to normal operations. Planning should be the source of management of uncertainty for work delivery, either by minimising it or by providing means to cope with it. Decision making in planning must manage uncertainty in such a way that it is not transferred down to delivery. A balance should be achieved between self-contained tasks that can locally reduce complexity of decision making, and the integration and articulation of the whole planning decision making process so as to avoid fragmentation and excessive complexity of the planning system.

Within the scope of the European rail network, among many other aspects, the ERTMS (European Rail Traffic Management System) is likely to radically transform the current paradigm of railway operational control. Because safety under ERTMS will no longer be based on block systems and track sections (the principle of one section, one train), one of the foreseeable consequences is the ability to develop a more flexible (and efficient) use of rail access for both train operations and engineering purposes. Within this context, an approach such as the one used in this research, can support the shift towards a more flexible and yet safe railway system.

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HUMAN CENTRED DESIGN PROCESS FOR THE DEVELOPMENT OF A BUS DRIVER SUPPORT SYSTEM

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ABSTRACT: Functionalities made available through Information and Communication Technology (ICT) can support various aspects of the children safety on their way from/to school: e.g. localization of vulnerable road users around the bus at bus stop, support of the bus driver activity by dedicated informative and assistant systems and awareness of surrounding traffic by real time warnings.

The present study followed a human centred design approach for setting up the concept of a school bus Driver Support System (DSS), based upon investigation on drivers' needs and requirements regarding potential functionalities displayed by this system. In a first step, a survey conducted among a sample of French bus drivers allowed understanding and specifying the context of the school bus driving task. Based upon the results, an ergonomic mock-up displaying an integrated set of ICT functionalities has been developed.

In a second step, acceptability and usability of this mock-up have been evaluated through a survey conducted among French, Italian and Swedish bus drivers population. The data gathered allowed setting up design recommendations regarding development of ICT solutions in order to improve children safety through the development of a bus driver support system.

KEYWORDS: Children safety, ICT design, Intelligent Transport System, School bus drivers, Ergonomic mock-up

1. INTRODUCTION

Going to and from school with school transport is a daily activity done by a lot of children within Europe. In Sweden this number is estimated about 250 000 children, in Poland approximately 700 000, in Austria about 450 000 while there would be 4.5 millions in Germany and 4 millions in France [1].

Even though protecting the children - one of the most vulnerable transport system's users – is of great importance for all societies, solutions to increase safety of bus transport to school is a highly underinvested area in many EU-countries, even if several measures for children are recommended in the EU-report Road safety in school transport (2004). Concerning the use of support systems for school transport related to children boarding, exiting or walking to/from or waiting at the bus stop, a literature review showed only few scientific papers evaluating such systems ([2], [3], [4], [5]).

In this framework, the European Safeway2School project aimed to design, develop, integrate and evaluate technologies for providing a holistic and safe transportation service for children, from their door to the school door and vice versa, encompassing tools, services and training for all key actors in the chain.

This research has been developed as part of this project, focusing on the concept of a school bus driver support system (DSS) aiming at displaying informative and warning information to assist the driver in his task.

2. OBJECTIVES and METHOd

The purpose of this research is to understand school bus drivers context, their needs and their requirements in order to develop efficient and adapted ICT functionalities, aiming at increasing children safety and drivers comfort.

There are already several and detailed principles and guidelines that have been set up to describe the modalities to warn and to inform a driver in the framework of the development of sophisticated and complex in-vehicle systems [6]. In addition to this set of generic rules valid for any on-board system, a dedicated investigation has to be conducted to precise the type of specific requirements related to safety and comfort constraints typical of a school transport context.

The method followed to investigate this issue is based upon the ISO norm 13407 [7] development methodology entitled “Human centred design processes for interactive systems”. This ISO 13407 norm provides guidance on achieving quality in use by incorporating user centred design activities throughout the life cycle of interactive computer-based systems, incorporating human factors and ergonomics knowledge and techniques.

In this framework, four user centred design activities have been identified:

- To understand and specify the context of use
- To specify the user and organisational requirements
- To produce design solutions
- To evaluate designs against requirements.

The iterative nature of these activities is illustrated in Figure 1.

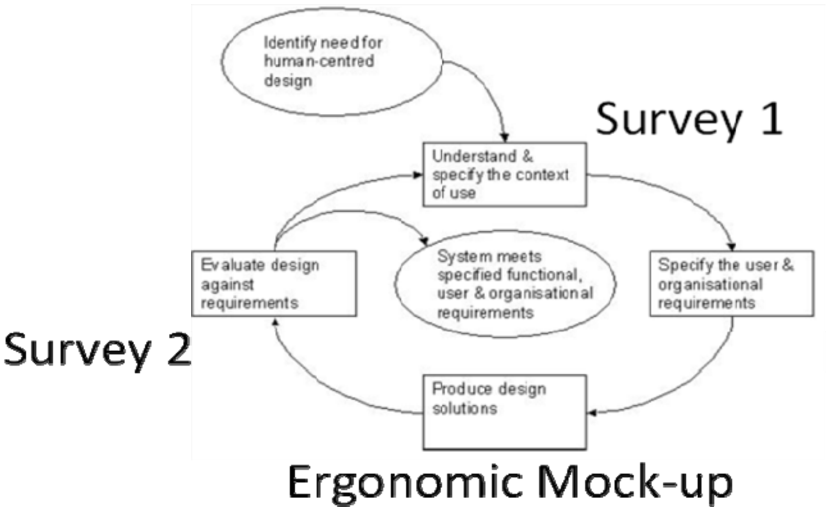

Figure 1: ISO norm 13407 development methodology

This principle has been applied in the framework of the school bus Driver Support System by running the following steps:

- a first survey among school bus drivers has been conducted in order to better understand and specify their context of use and their potential needs regarding functionalities that could be provided by the DSS,
- based upon the results of this investigation, the functionalities and the HMI requirements of the DSS have been specified
- prototypes of ergonomic mock-ups have been designed presenting design solutions for each functionalities
- a lab test has been conducted for the development of a dynamic ergonomic mock-up using the 2D map display HMI integrating the various uses cases and the needs and requirements of bus drivers identified at the first survey
- a second survey has been conducted among a sample of bus drivers in France, in Italy and in Sweden in order to test and validate the design solutions integrated in the ergonomic mock up.

3. UNDERSTAND AND SPECIFY THE CONTEXT OF USE: SURVEY 1

3.1. Participants and Questionnaire

The survey was conducted in two French bus companies, one managing exclusively school transport, covering rural school transport, as well as urban school transport, the other one based in the city in charge of urban public bus transport, with some of their lines stopping in front of schools.

Overall, the questionnaire has been filled out by 28 drivers from the two bus companies, aged between 27 to 63 years who have been working in the companies between 1 to 32 years.

The questions were related to the following aspects of the context: characteristics of the route, including visibility of bus stops, density of the traffic, speed and regulation, disturbance about children and pedestrians surrounding the bus, usefulness of identifying of children at bus stop and inside, opinion about information on seat belts fasten, support for management of time schedule and proposition of future technological solutions to assist their driving task.

Interviews have been carried out in focus groups and through individual questionnaire.

3.2. Main results

The following table summarised some of the main results related to characteristics of the rural, urban school and public transport in addition to needs and requirements about potential ICT functionalities of a school bus DSS.

Description of the feature/ function	**User group**	**Driver's need/opinion**
Visibility of bus stop	Rural school transport	Low visibility on principal axis
	Urban school and urban public transport	No high difficulty to perceive bus stops
Bus stop characteristics	Rural school transport	Not always materialized with a signpost.
	Urban school and urban public transport	Bus stop materialized with ground markings, requiring to stop on the road
Knowledge about the route to follow	Rural, urban school transport and urban public transport	Use a list of bus stops with the corresponding schedule time.
Information about the children/ Pedestrian around the bus	Rural school transport	Useful with a visual alarm (in the front and in the back of the bus, in addition to the dead angles)
	Urban school transport	Useful in the cases where children cross the street in front of the bus
	Urban public transport	Useful if the system detects exclusively persons in danger, and not objects around the bus
Warning for surrounding traffic	Rural, urban school transport and urban public transport	Favourable to alert surrounding traffic when the bus arrives at and leaves the stop
Warning about speed limit	Rural school transport	Useful only if alarm is not intrusive
	Urban school and urban public transport	Useless in the city due to slow speed
Warning for important delays using automatic messages	Urban public transport	Useful to communicate delays of 15 minutes to the company
	Urban school transport	Useful only in case of important delays: traffic jam or incident on roadway
	Rural school	Not favourable to send automatic

	transport	messages of delay. Prefer to use mobile phone to explain reasons about the delay to the company and to the school.
Detection of children about to arrive at the bus stop	Rural school transport	Not favourable excepted if children are located too close to the bus
	Urban school transport	Not favourable to wait children for a long time
System to identify and to count children getting on board	Rural school transport	Favourable to count children but not to identify them with picture
	Urban school transport	Useful system in order to know activity of the bus line and to be able to adjust the frequency of the buses
Information about children waiting at the bus stop	Rural school transport	Not useful
	Urban school transport	Favourable if many bus lines correspond to the same bus stop

This first investigation allowed showing that the driving context for bus drivers is quite complex and under high constraints in terms of timing. The overall opinion about potential support brought by ICT functionalities is diversified and quite indecisive. Part of this uncertainty was linked to reluctance to modify activity as a consequence of the system implementation; part of it was linked to the difficulty to conceive in which way this system can be supporting the task.

Objective of the mock up development was to overcome this last concern, by illustrating in a concrete and dynamic way the system interface displaying a number of functionalities to be able to test their acceptability.

4. DEVELOPMENT OF ERGONOMIC MOCK-UP

The ergonomic mock up of the Driver Support System has been developed with different design options of HMI.

The objective of these mock-ups was:

- To test the integration and the organisation of the various available functions on the screen.
- To assess the HMI usability and acceptability by bus drivers in an iterative process by conducting a second survey in relation to the designs.

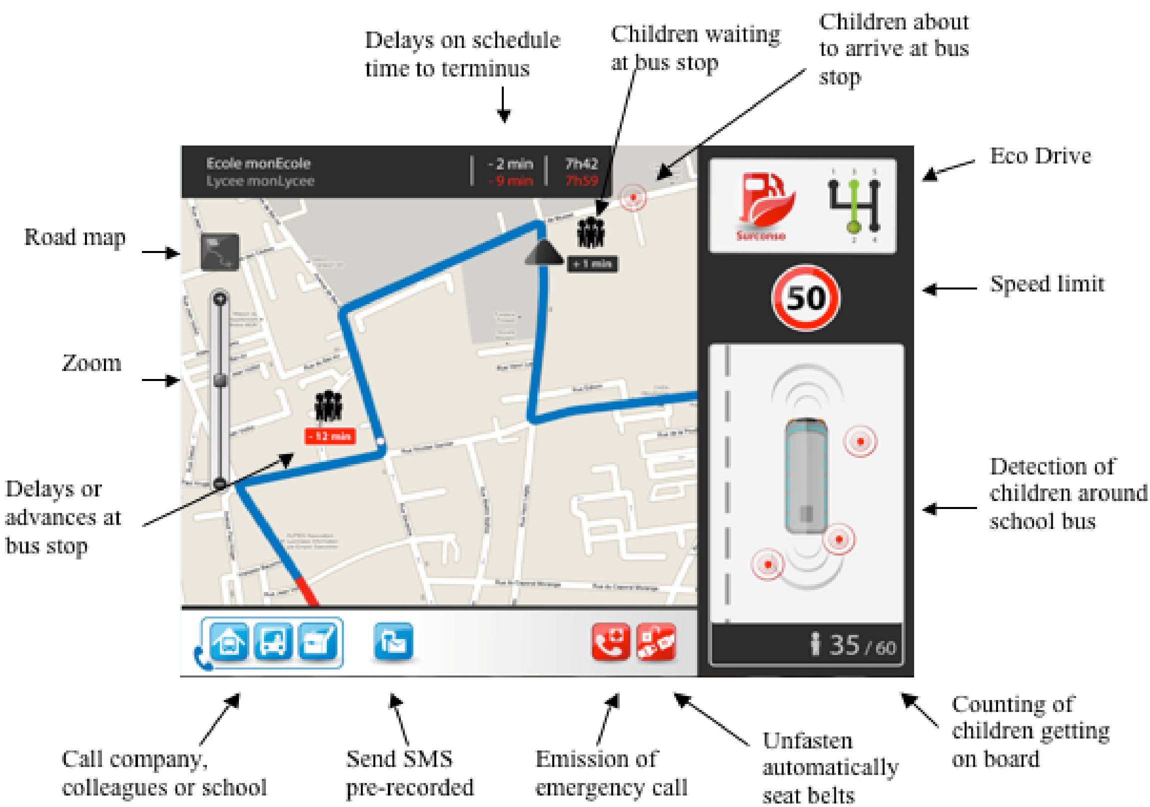

Figure 2: Functionalities implemented in the DSS ergonomic mock-up developped in the framework of Safeway2School project

Several versions of the mock up display (2D, 3D, without pictograms) have been tested in the lab, and after several iterations, 3 versions of the dynamic ergonomic mock up have been selected to be presented to the bus drivers samples.

5. EVALUATE DESIGN AGAINST REQUIREMENTS: SURVEY 2

A survey has been conducted regarding the understandability, acceptability and usefulness of the warning and notification messages displayed on the dynamic ergonomic mock up. The survey has been conducted among a sample of school bus drivers in France, in Italy and in Sweden. The objective was to gather opinions and preferences of the school bus drivers in relation to the DSS concept (utility of each function during the ride), as well as the human machine interface (easy or not to understand, to read and to perceive).

Figure 3: Test of ergonomic mock-up usability and acceptability by school bus drivers

5.1. Main results

Only some main results of this investigation are presented in this paper; all the detailed results in addition to the description of the protocol and the entire set of questions are available in the Safeway2School report [8]. Due to limitation of space, only results from urban school transport company are presented in this paper.

5.1.1. French participants

The questionnaire has been filled in by 27 drivers, aging from 24 to 63 years and with working experience in the bus companies was between 2 and 28 years (figure 4).

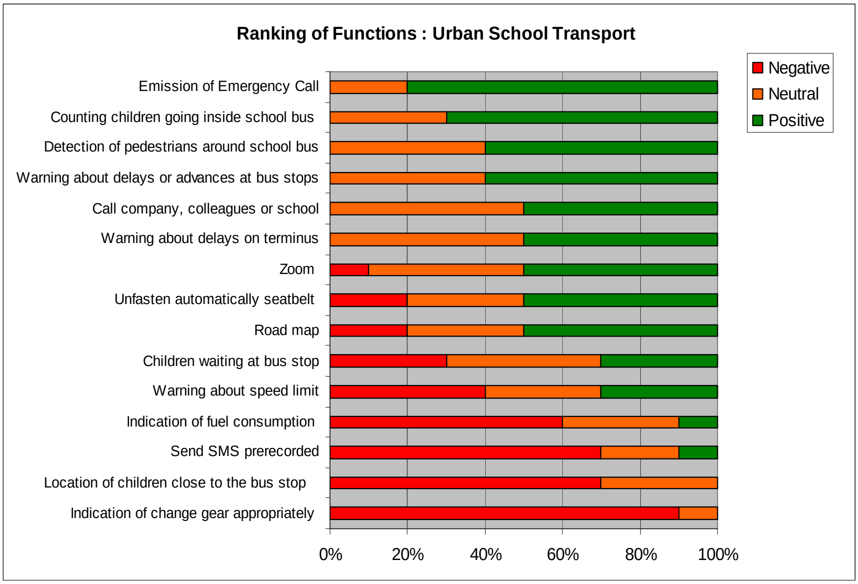

Figure 4: Ranking of functions by level of satisfaction for French urban school bus drivers

5.1.2. Italian participants

The age of these 10 drivers was between 30 and 45 years and their seniority in the bus company between 3 and 11 years (Figure 5).

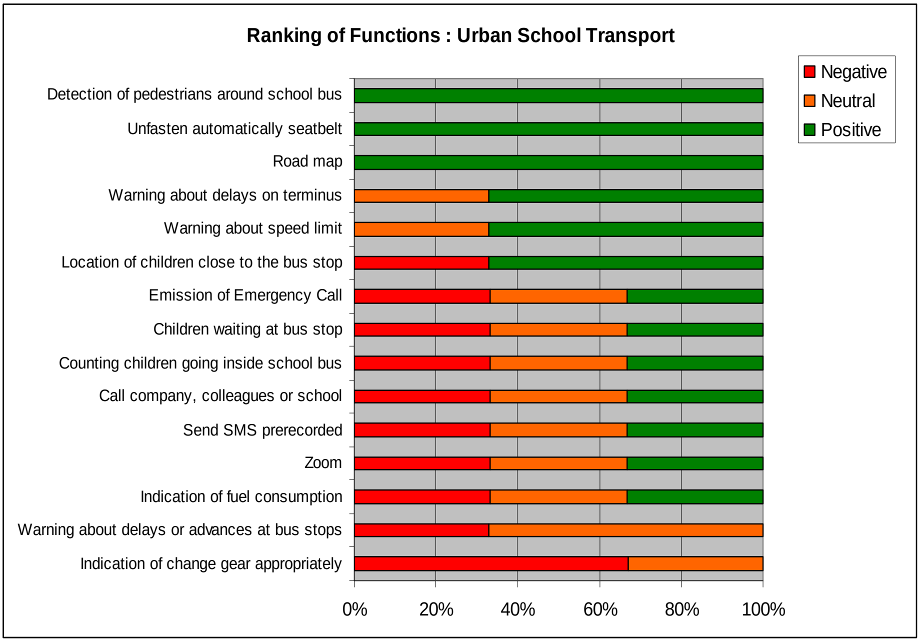

Figure 5: Ranking of functions by level of satisfaction for Italian urban school bus drivers

5.1.3. Swedish participants

The average age of the10 drivers was 48,7 years with an average seniority in the bus company of 18 years (Figure 6).

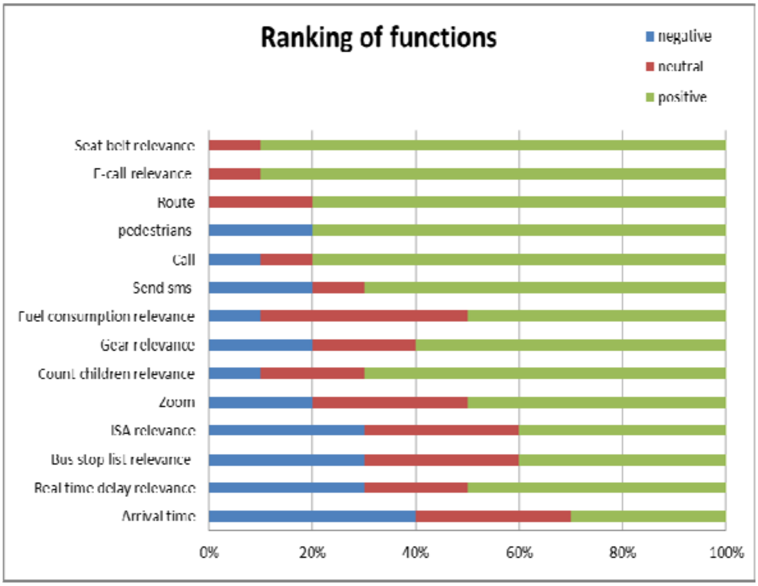

Figure 6: Ranking of functions by level of satisfaction for Swedish urban and rural school bus drivers

5.1.4. Similarities between the 3 countries

Location of pedestrians/children around the school bus: most of the bus drivers have positive opinion about this function that was judged useful, especially when children are located in the rear area of the bus and when pedestrians and children are crowded around the bus. Some French bus drivers indicated they have enough experience not to rely on electronic support, some Swedish ones rejected the principle.

Unfasten automatically seatbelt: This function has been identified after the analysis of the first survey, where the French drivers explained that one of their concern was the difficulty to release quickly all the children from the bus in case of crash because of the fasten seat belts. They proposed a system allowing unfastening all the seat belts by a simple push of button. The relevancy of this proposition was confirmed widely by the Italian and the Swedish population in the framework of the second survey.

Zoom and road map: school bus drivers of the 3 countries have a similar mixed opinion about these functions: part of the sample was positive, part was neutral and part was positive. Indeed, the view of the successive bus stops located on a map has been found relevant by drivers with low experience or having a new route, while regular and experienced drivers found it unnecessary.

5.1.5. Differences between the 3 countries

Information about children/pedestrian waiting at bus stop: Swedish bus drivers appreciated this function; warning about existing children at bus stop would allow them to adapt their speed when getting close to the stop in dark condition with low visibility. Italian bus drivers judged this function useful especially for a driver having a new route. French bus drivers were in favour of using this function only in the case where the same bus stop was used by several bus lines.

Location of children close to the bus stop around the street corner (a badge allows each child to be detected by the driver when walking to the bus stop even if he/she is not still visible but close): this function was appreciated and judged useful by Swedish bus drivers in case of darkness and bad weather conditions. Indeed, in Sweden, the weather can be so cold that it is dangerous to let a child in the country side. Italian bus drivers were more or less in favour of using this function to avoid that children miss the bus. French bus drivers judged this information not being relevant because it could encourage children to be systematically late at bus stops.

Send pre-recorded SMS: sending automatic SMS was not evaluated as being useful by Italian and French, due to the will for this population to explain in detail reasons of the delay linked to the context, and raising the potential ambiguity of pre-recorded messages, while Swedish drivers identified this functionality as a good opportunity to gain time.

Call company, colleagues and school: the function of calling external actors was moderately appreciated by the school bus drivers, especially the French ones and even worst the Italian ones. All of these drivers were belonging to urban school transport, and the negative opinion came from lack of time and potential distracting effect of phone call in heavy traffic.

Warning about late or early arrival at bus stops: this function was poorly appreciated by drivers from the three countries, as the possibilities to catch delays is highly restricted (precisely defined route, speed limit, …), leading bus drivers to feel powerless. The only positively rated information was the one in case of early arrival at bus stop where bus drivers can regulate better the route, by waiting children and driving slowly. But in case of delay, bus drivers thought generally that this information can be a problem of distraction during driving and a stress factor.

Warning about delays on arrival at the terminus: While Italian and French bus drivers considered useful to have a warning in case of delays on arrival time at the school, to increase their awareness and to be able to adjust their speed when it is necessary, the Swedish sample of drivers considered that this warning is stressful, especially when it is not possible to catch the delay, and rejected it.

Eco driving: these functions (fuel consumption and change gear information) were more or less appreciated by Swedish bus drivers but not at all by French and Italian bus drivers. Indeed, some Swedish drivers judged it useful in order to take care of the environment, whereas French and Italian bus drivers considered these functions as optional. Some drivers thought that it could contribute to improve driving style. Furthermore, it has to be noted that some French school buses are now equipped by automatic gearbox, so the eco-driving advice related to the appropriate change of gear would be not useful for them.

Speed limit: this function was not appreciated by French and Swedish bus drivers, especially with an auditory alarm, the first one considering they never overcame speed limit in urban area and the second one considering it could scare children. However, some Italian bus drivers judged it useful for the safety of children on board.

Automatic counting of children while boarding inside the bus: the function was not considered as very useful, but was not rejected either by Italian and Swedish bus drivers, while the French drivers appreciated it. Considering the details of the results, it appears that there is an important difference between rural dedicated school bus and urban public transport school bus: in the first case, the driver knows the children, so this function is less useful than in the second case where the information of exact number of children allows to adjust the frequency of the bus on the line, and so increase the quality of the management and avoid to have crowded bus.

6. CONCLUSION

This investigation allowed first of all identifying the diversity of opinions related to the implementation of a DSS in relation to the cultural backgrounds of the bus population at the European level. Nevertheless, some of these functions were unanimously positively rated, mostly regarding road safety such as detection of pedestrians around the bus.

Secondly, following questionnaires results and confirmed through exchanges and discussions with the drivers, it was identified that part of the level of acceptability of these functionalities is strongly connected with the high timing constraints and the stress of the task. The issues were managing and controlling both children safety and time schedule at the successive bus stops and at the final destination. Some of the functions were more or less rejected by some drivers with the concern of a potential impact by increasing their level of stress.

This approach brought concrete data regarding the priorities of ICT functionalities to be implemented to support the school bus drivers based upon an analysis of their context, needs and requirements. The diversity of opinions linked to the cultural belonging at the European level has been also identified and will have to be taken into consideration in a perspective a future implementation of these functionalities.

7. ACKNOWLEDGMENT

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The Italian survey has been conducted by Chiara Ferrarini & Roberto Montanari , UNIMORE and the Swedish survey by Tania Dukic & Ana Annund, VTI.

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