

POTENTIAL USERS' INTEREST IN REAL-TIME ROAD WEATHER INFORMATION

Insights from Finnish Lapland



Intelligent Road

safety by arctic know-how

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ABSTRACT

The Intelligent Road System is a technical solution, which aims at informing drivers about locality specific real-time road weather conditions while they are travelling on roads in the north. This study intends to provide the Intelligent Road project respectively the implementation partners with a comprehensive overview of potential users' interest in receiving real-time weather and road condition information. Particularly local everyday road users, professional drivers and tourists en route in the north were chosen as prospective research populations. Their incitements in using such a real-time road weather information system were investigated along with the particular information they would like to receive while being on the road and their evaluation of a technical application displaying this on-spot specific data.

In order to obtain a broad overview of various road users' information needs concerning road weather, a mixed methods approach, embracing surveys, semi-structured interviews plus an online poll was chosen. Specifically, the concurrent embedded strategy was employed to widen the perspective on the subject matter. The primary data source informing the study is quantitative in form of online surveys. In total, 229 responses were received, composed by 217 responses of local everyday drivers and 12 professional drivers operating in human as well as in freight transportation. The supplementing qualitative part of the research comprises semi-structured interviews and a poll in an online forum addressing mainly tourists travelling in Lapland. The interviews and the poll responses were analyzed in a qualitative, summary focused content analysis.

The findings suggest that those three distinct road user groups consider it generally very important to acquire real-time and location specific road weather information and approximately the same proportion of respondents is also interested in employing a technical solution displaying this information while being on the road. Potential users evaluate especially road condition information, the recent state of a road's winter maintenance and slipperiness warnings as significant. With respect to a technical solution displaying real-time road weather, potential users opt primarily for a smartphone application followed by digital road signs.

Moreover, the study uncovered several opportunities and challenges for developing the Intelligent Road System from potential users' point of view. Foremost, road weather data has to be converted into accessible and tangible information so that road users can adjust their driving behavior according to the weather conditions. Potential users suggested frequently that the Intelligent Road System should not only encompass real-time road weather but also deer crossing and other occurrences on the roads for becoming a truly supportive system enhancing the overall traffic safety. A major concern of potential users in employing a technical solution displaying such information is the eventual distraction of drivers. For the Intelligent Road System to become a germane tool assisting road users in travelling safer in the north, road weather data has to be converted into intuitive information while its technical solution is compatible with other road information systems plus offers customization options for its end-users.

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1 INTRODUCTION & RESEARCH OBJECTIVE

In the north, weather conditions are unpredictable and often lead to dangerous situations and accidents on the roads. Especially during wintertime, weather has a significant impact on traffic and driving conditions in terms of reduced visibility and slipperiness due to snowy, slushy or icy roads (Toivonen–Kantonen 2001). Those adverse weather conditions undeniably elevate the danger of fatal traffic accidents (Kilpeläinen–Summala 2007) with estimations in a heightened risk varying from four (Salli et al. 2008) up to twenty times (Malmivuo–Peltola 1997). Numerous studies point out that slipperiness can be argued to be the most significant weather-related accident causing factor (Kilpeläinen–Summala 2007), also because drivers frequently underestimate the road's friction during winter (Salli et al. 2008) accompanied by unadjusted driving behavior and driving over speed limits (Heinijoki 1994). Anttila, Nygård and Rämä (2001) highlight in their analytical study of crashes during wintertime that bad weather and slippery roads habitually surprise drivers. Thus, an important contribution for enhancing traffic safety is not only weather forecasting but also to make accurate, real-time information about weather and road conditions available to drivers while they are on the road.

The Intelligent Road System is a technical solution in form of a Road Weather Information System (RWIS), which is designed to fulfill this task by informing road users about the current driving situation through a variety of channels based on real-time data. Through the provision of locality specific road weather information, fatal accidents might be prevented and the overall traffic safety in the north might increase. This information system is realized by Arctic Power in cooperation with research institutes and universities (the Finnish Meteorological Institute, Luleå University of Technology) and various private partner enterprises. The operations are co-financed by the EU's INTERREG IVA program.

The paper at hand aims at providing the Intelligent Road project respectively the implementation partners with a comprehensive overview of potential users' interest in receiving real-time weather and road condition information. For supporting the technical development, qualitative and quantitative data from three distinct groups of road users was gathered: professional drivers in human as well as in freight transportation, local everyday

road users and tourists. An additional assignment in this part of the project was the collection of relevant road weather related literature, serving as a basis for a scientific publication of the Intelligent Road project.

This study illustrates different road-users' readiness and inclination to using technical solutions and applications for obtaining real-time road and weather information, a specification of data needed while being on the road along with users' evaluation of how this information can be technically displayed in the best way. Those research results can be used not only in developing the technical system in a user-driven manner but also in supporting the promotion of this specific application in its commercial realization amongst private corporations. The task is approached through the following three research questions:

- Is there an interest in receiving real-time information about weather and road conditions while being on the road?
- What kind of information concerning weather and road conditions do road users need?
- What would be a suitable technical solution for presenting road weather information to the users?

2 DEVELOPMENT OF RWIS IN FINLAND & THE INTELLIGENT ROAD PROJECT

A Road Weather Information System (RWIS) embraces a network of weather stations, forecasting services plus the supporting infrastructure in form of roadside equipment, the remote processing unit that receives the data and converts it into information and the communication system that transmits the data (Ballard 2004, 190). RWIS offer a wide spectrum of application possibilities, ranging from supporting efficient road maintenance, updating automated or manual alert messages on digital road signs, activating self-operating de-icing systems on bridge decks, to web-based traveler information systems (Ballard 2004, 191). Especially winter maintenance benefits from RWIS in reducing the need for routine patrols, in enhancing the effectiveness as well as the proactive use of anti-icing and salting of roads and in improved scheduling of maintenance personnel (Bradshaw Boon–Cluett 2002, 11–12). Furthermore, a substantial RWIS network provides a higher quality of observational data for improved weather forecasting, thus information, which is more accurate, can be disseminated to road users for enhancing safer car travels. This issue gains particular importance considering the elevated accident risk caused by slippery roads during wintertime (see Toivonen–Kantonen 2001). Overall, RWIS play a central yet increasing role in contemporary road management and winter maintenance not only concerning cost savings but also in ameliorating the security of road traffic.

In Finland, the development and the usage of RWIS dates back to the early 1970s and the European COST 30 project, Electronic Aids on Major Roads, where ice-warning systems were tested (Pilli-Sihvola–Lähesmaa 2004, 70). Due to positive and encouraging pilot results, RWIS were installed in the beginning 1980s in Finland's major cities and the primary responsibility for the development of the Finnish RWIS was taken over in 1987 by Finnra, the Finnish Transport Agency (Toivonen–Kantonen 2004, 51). Since 1992, the whole country is included in the system and the first road weather cameras were mounted during the same year. The amount of road weather stations rose rapidly; in the winter of 1994–1995, already 200 stations were in use. In the beginning of 1995, an Image Product application was introduced, which made it possible to monitor images of weather and driving conditions and in the following year, the storage of road weather information was centralized in one database server. (Toivonen–Kantonen 2004, 51.) Since then, RWIS have been constantly developed further in their technical sophistication as well as in their

scope of application as the latest solutions of RWIS for example automatically display suitable speed limits on digital road signs (Pilli-Sihvola–Lähesmaa 2004, 71).

Those weather information systems were initially developed for road authorities in making winter maintenance more effective yet cost-efficient. As already stated, road weather information is also of great significance for everyday road users when travelling as well as for professional drivers in human and freight transportation. Nowadays, the Finnish Transport Agency provides and operates an extensive RWIS with its data being displayed on the organizations' correspondent web site including besides constantly updated road weather announcements also information about road conditions, traffic flow, border traffic, road works as well as real-time recordings of road cameras (see Finnish Transport Agency 2013).

However, the obtainable data of above-mentioned RWIS do not cover exact real-time and on-spot information, which would be easily accessible for road users while they are actually on the road. The Intelligent Road Project develops an integrated system (The Intelligent Road System) seeking to inform drivers about the location specific conditions of the weather and the road ahead. This innovative approach of the project is distinctive to aforementioned RWIS concerning the collection and broadcast of accurate road weather information, which is composed by stationary weather stations and forecast data plus mobile on the road data, provided by sensors installed in vehicles. The primarily intended users of this technical solution are local everyday drivers and professional human as well as freight transportation companies.

The center of the Intelligent Road System receives and processes data from external weather services, road weather sensors as well as from road users, whose vehicles are equipped with optical friction sensors and infrared thermometers. This real-time data is sent to in-car display systems or mobile devices as well as to digital road signs, displaying warnings and/or speed limit regulations. (Intelligent Road Project 2013.) Figure 1 below illustrates the components and the function of the system.

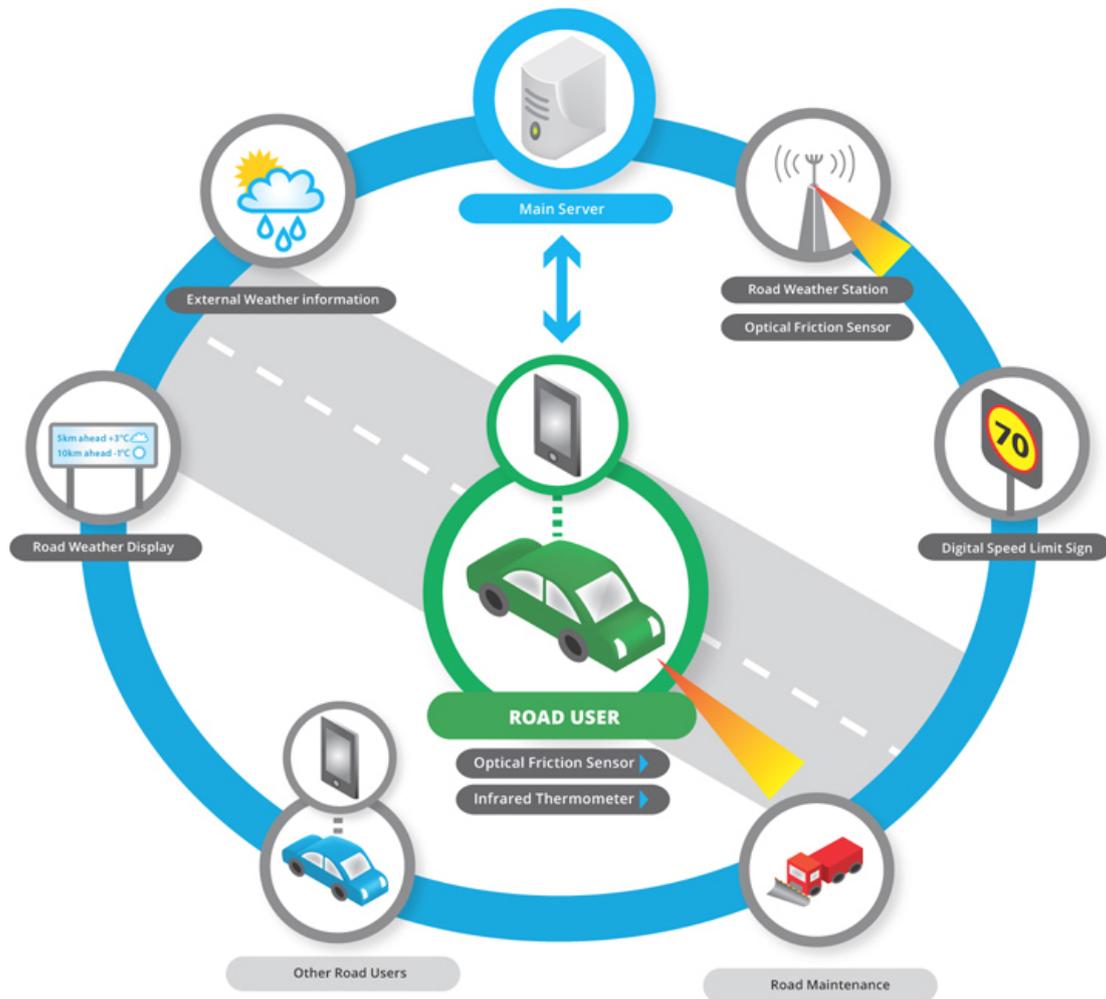


Figure 1. The Intelligent Road System (Intelligent Road Project 2013)

3 DATA GENERATION & ANALYSIS

In this chapter, the research design is outlined. First, the mixed methods approach is introduced, which provides the study with quantitative as well as with qualitative data supporting each other. Specifically, the concurrent embedded strategy, as a subcategory of mixed methods approaches, was employed to widen the perspective on the subject matter. The primary data source informing the study is quantitative in form of online surveys. In total, 229 responses were received, composed by 217 responses of local everyday drivers and 12 professional drivers operating in human as well as in freight transportation.

Secondly, semi-structured interviews and online polls as methods for gathering supplementing qualitative data are presented. Here the focus was on gaining relevant information from tourists driving in the north. Representatives from a car rental firm as well as from Rovaniemi's Tourist Information were interviewed and an online poll in a German language online forum concerned with travelling in Finland was launched. The transcripts of the interviews and the poll responses were analyzed in a qualitative, summary focused content analysis.

3.1 Mixed Methods Approach

In order to receive a broad overview of various road users' information needs concerning road weather, a mixed methods approach, embracing surveys, semi-structured interviews plus online polls was chosen. The authors emphasize the use of the words 'data generation' in opposition to 'data collection' to bring out the constructed nature of a research process, in which researcher(s) play a decisive role (Germann Molz 2013). Data is 'not just out there' and metaphorically waits to be collected as ripe berries. Instead, researchers actively produce the data together with the interviewees, determine the answer scope through the questionnaires' design and subsequently interpret and process the obtained data into textual research results.

Mixed methods combine qualitative and quantitative approaches for gaining an ample understanding of research problems in a philosophically pragmatic manner (Creswell

2009, 203). Specifically the concurrent embedded strategy was selected to provide the study with qualitative as well as quantitative data supporting each other and thus widening the perspective on the subject matter (Creswell 2009, 215). This concurrent embedded strategy characteristically employs one phase of data gathering, where qualitative and quantitative data are generated simultaneously. One method is dominating the research process and the main source of information while the second method delivers supporting data as a composite assessment of the research problem (Creswell 2009, 214). Table 1 below specifies this study's data composition. The primary source of information is quantitative in form of surveys for reaching a great variety plus a large amount of professional as well as local everyday drivers for investigating their incitements of using real-time weather information systems while driving. Qualitative data as a secondary data source generated through semi-structured interviews and online polls provides additional insights especially into tourists' information needs concerning weather and road conditions in the north.

Table 1. Mixed Methods: Qualitative and Quantitative Data Sources

<p style="text-align: center;"><i>Primary</i></p> <p style="text-align: center;">Quantitative Data</p>	<p>Online questionnaires in Finnish and English language intended for local road users and professional drivers (human as well as freight transportation)</p>
<p style="text-align: center;"><i>Supplementing</i></p> <p style="text-align: center;">Qualitative Data</p>	<p>Online poll inquiry among German speaking tourists driving in Finnish Lapland</p> <p>Semi-structured interview with a car rental firm in Rovaniemi</p> <p>Semi-structured interview with Rovaniemi Tourist Information</p>

3.2 Surveys

For reaching local road-users as well as professional drivers in a short time period plus receiving a broad overview of their needs concerning road weather information, structured online questionnaires were created and sent via email to potential respondents. The survey contained yes/no answer options, multiple choice and scale questions in addition to two open-ended questions. The specific questions were concerned with:

- Drivers' judgment of the importance of receiving real-time information about weather and road conditions
- The value of different weather and road condition information
- Driver's assessment of suitable options of technical solutions displaying road weather related real-time information
- Drivers' willingness to use technical solutions for being informed about real-time weather and road conditions

One of the key issues in using a survey as a research method is sampling (Hammond–Wellington 2013, 139). According to Altinay and Paraskevas (2008, 89) sampling is:

The process by which researchers select a representative subset or part of the total population that can be studied for their topic so that they will be able to draw conclusions regarding the entire population.

Hence, a common technique for spotting information-rich cases that can illuminate the research questions is purposive sampling, which belongs to the category of non-probability sampling (Altinay–Paraskevas 2008, 101). Non-probability sampling can roughly be described as selecting cases according to reasons other than mathematical, statistical or random probability. Regarding purposive sampling, the researcher opts for cases according to his or her own judgment and particular research interest. (Bloor–Wood 2006, 154.)

Especially human as well as freight transportation companies are key road users, thus emails entailing the questionnaire were sent to those firms operating all over Finland. For gaining local drivers' opinions, the online questionnaire was sent to staff and students of Rovaniemi University of Applied Sciences (RAMK), to staff of Lapland's vocational college (LAO), to staff of Rovaniemi's municipal education and training consortium (REDU) and to the Intelligent Road project's partner organizations and institutions. The potential

respondents are all expected to have a driving license and are therefore active traffic participants concerned with the road and weather conditions in the north. No differentiations relating to age or gender of the respondents were made. Table 2 beneath depicts the response rates of the samples.

Table 2. Online Questionnaire Response Rates

Human (taxi/bus) and freight transportation companies (n= 82)	Response rate: n=12 ~14,6% of the total sample
RAMK+LAO+ REDU (n~4100)	Response rate: n=207 ~5,1% of the total sample
Partner institutions and organizations (n~ no information)	Response rate: n=10

3.3 Semi-Structured Interviews & Online Poll

The qualitative part of this research consists of semi-structured face-to-face interviews with representatives of a car rental company and the Rovaniemi Tourist Information amended by a poll in an online forum. Also here, purposive sampling was employed to receive relevant data. The tourist information and the car rental firm are dealing on a daily basis with tourists driving in the north and know therefore about their information needs concerning weather and road conditions. For reaching tourists directly in an easy manner without great costs, a poll in a German language online forum related to travelling in Finland was launched.

Interviews are an expedient means of investigation as Hammond and Wellington (2013, 91) state:

[Interviews allow] the researcher to see an event or context from the point of view of the people he or she is researching; interviews are interactive allowing for clarification of questions and identification of unexpected themes. In contrast, surveys are better suited to getting the broad picture.

Broad questions prior to the meetings with the interviewees were set up; nonetheless, additional or modified questions were asked depending on the evolving conversation. This method of semi-structuring an interview grants a greater flexibility in terms of obtaining research material compared to fully structured interviews (Hammond–Wellington 2013, 92). The themes of the study's interview questions centered on:

- Frequency, type and nature of tourists' questions concerning driving on roads in the north
- Problems concerning weather and road conditions while driving in the north
- Interest in using a technical device/application providing real-time weather and road condition data
- Ways of displaying the road weather information to potential users

The interviewees were informed in the first contact email about the inquiry's scope and scale and during the actual meeting, the purpose of the research was mentioned again plus personal anonymity was granted. The recorded interviews, lasting both around 15 minutes, were transcribed verbatim after the meetings. The spoken language during the interviews was English. For the two interviews the abbreviations Car rental and Tourist info, as shown in Table 3 below, are used in the consecutive chapters.

Furthermore, an online poll (see Table 3) in a German language online forum was created, asking similar questions as in the interviews. Attention had to be paid to the legal regulations of online forums since those virtual environments are often only open to private and personal use while institutional or commercial utilization is prohibited. Hence, a forum without limitations in usage was chosen. Also in this stage of inquiry, the participants were informed about the purpose of the poll and the further use of their answers. The written conversation was later on translated by the main author from German into English.

Table 3. Interviewee and Online Poll Abbreviations

Car rental	Car rental company in Rovaniemi
Tourist info	Rovaniemi Tourist Information
Online poll	Poll in German language online forum (several different respondents)

The obtained qualitative data was analyzed in a qualitative content analysis, developed by Mayring (1983). Flick (2011, 136–137) summarizes this specific analyzing technique for qualitative textual material. After the familiarization and selection of the relevant text and the definition of unambiguous research questions, specifically the summarizing subcategory of qualitative content analysis was adopted in this study. Text passages with the same meaning were summarized under the relevant research questions while irrelevant material was skipped. Moreover, the significant transcript passages were reduced to their essential meaning. (Flick 2011, 137.) This method is suitable in the case of this study since its' primary interest is in making explicit 'what was said by the interviewees' and not in 'how a certain issue was addressed' or digging for a deeper meaning between the lines within the textual data (see Flick 2011, 139). Table 4 presents the categories of the qualitative, summary focused content analysis.

Table 4. Categories of Content Analysis

Analysis Categories	Responses of Interviewees & Online Poll Participants
Tourists' familiarity with northern road conditions	Not at all, often afraid to drive in the north, especially in winter. However, most tourists drive in Lapland during summertime (Car rental/Tourist info)
Frequency of customers' requests concerning northern road weather and driving conditions	Requests on a regular basis via email, face-to-face or by phone (Car rental/Tourist info)

Types of questions asked	Safety concerning driving in the dark, road maintenance in the winter, road conditions in general, deer crossing (Car rental/Tourist info)
Tourists' interest in real-time road weather information and road conditions	Especially during winter time questions concerning how to drive on icy roads and road maintenance, more concerned with general information of how to drive in the north (Car rental/Tourist info) It is somewhat important to be informed about current road weather, however, forecast is enough (Online poll)
Tourists' interest in using a technical device/application for displaying real-time road weather information	Maybe, if price is not too high (Car rental/tourist info) Not at all, disproportionate development, concordant call for reasonable and adapted driving behavior, devices might distract the driver and are therefore a danger to traffic safety (Online poll)
Company's incitements for providing technical devices for real-time weather data to their customers	If the costs are not too high (Car rental) No, rather a booklet entailing general road and weather information and how to drive in the north, especially during wintertime (Tourist info)
Ways of displaying the road weather data to the users	Smartphone app or special navigator (Car rental) Booklet or smartphone app (Tourist info) TV weather forecast/ newspaper/ digital road signs (Online poll)
Additional concerns and road or weather related issues that are significant while driving in the north	Emphasis on issues of deer crossing and collision with reindeer and moose (Car rental) Danger to road safety when watching a smartphone display, causing accidents by being distracted (Online poll)

4 FINDINGS: ROAD USERS' INTEREST IN REAL-TIME ROAD WEATHER INFORMATION

The research findings are presented in this chapter. First, the general interest of the study participants, local everyday road users, professional drivers and tourists, in receiving real-time road weather information is delineated plus their willingness to use technical solutions and applications, which displays such information while they are travelling on the roads in the north is revealed. Secondly, the study elaborates, which specific real-time information potential users would like to receive while driving. Thirdly, potential users' evaluations of suitable technical solutions displaying real-time road weather and driving conditions are examined.

Caution has to be given to comparing the responses of the three user groups because of the numerical imbalance in responses received, 217 everyday local road users answered the questionnaire while only 12 professional drivers responded, along with the difficulty to equate quantitative and qualitative data. Thus, no direct comparisons between the three road user groups can be drawn. The study's results, however, can be understood in terms of signifying trends among the research population, which can be employed to engineer the Intelligent Road System in a user-driven manner.

4.1 Receiving Real-Time Road Weather Information While Driving: Potential Users' Interest

Since it is the Intelligent Road project's goal, to develop a system, which informs drivers about real-time road conditions of the route ahead, the study focused first on illuminating potential users' interest in receiving this real-time road weather information plus their willingness to use a technical solution, which displays this data. The first survey question asked the respondents (n=229) to indicate if it is important for them to gain real-time information concerning road weather and road conditions. As the questionnaires' results show, everyday local road users as well as professional drivers consider it very significant to obtain real-time and accurate on-spot weather and road condition information while driving. The majority, 87% of the total amount of respondents, chose the 'yes' option for this particular question. Figure 2 displays the responses of the specific road user groups.

92% of the professional drivers in human and freight transportation and 87% of the local everyday road users rate it as important to receive real-time road weather information while driving.

Do you think that it is important to be informed in real-time about road and weather conditions while driving? (Answers in %)

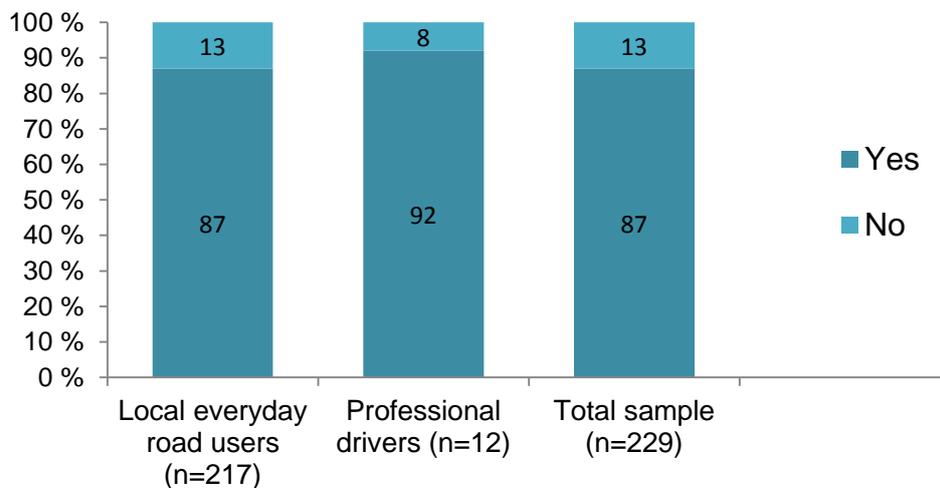


Figure 2. Rating Importance of Receiving Real-Time Information About Road and Weather Conditions

Regarding tourists driving in the north, a similar picture of a great interest in information about road weather and driving conditions occurred when analyzing the interviews. The interviewed representatives of the car rental and tourist info emphasized that tourists are often not familiar with the road and weather conditions in the north implying that there exists a great need for information:

[Question: Do you think that tourists are mostly familiar with the Nordic road conditions?] Not at all. Actually, they are afraid about the condition. [Afraid?] Yes. Many times they have been asking by email, how can they drive at the wintertime when the roads are icy. And they are concerned, and they are little bit afraid. They don't know that we are cleaning up the roads [referring to winter maintenance]. They don't understand that. (Car rental.)

Consequently, tourists habitually consult the car rental as well as the tourist information before driving in Lapland:

[Question: Do you often get questions about road conditions?] Yes, quite often. They ask the weather forecast for the next few days and they always worry about driving up to the north. (Tourist info.)

It seems that tourists are very concerned with the driving and road conditions in the north since they are not accustomed to arctic winter weather. Beside the general information need of how to drive in Lapland when the roads are icy, there persist also a clear necessity for receiving real-time road weather information among tourists as the representative from the car rental firm states since this specific data is not displayed by regular navigation systems:

But actually the weather details... they [tourists renting a car] are asking about that quite often... And that information not included in navigation systems (Car rental).

Thus, there exist great prospects for the Intelligent Road System among those three study sample populations. This high interest in real-time road weather information echoes also in the willingness of the targeted users to employ technical devices and/or applications which display accurate on-spot information. In total, 86% of all respondents (n=229) would use technical applications for being informed about real-time road weather and driving conditions and in particular 86% of the local everyday road users and 75% of the professional drivers, as shown in Figure 3, indicate to be keen in using a technical device to obtain real-time road weather information.

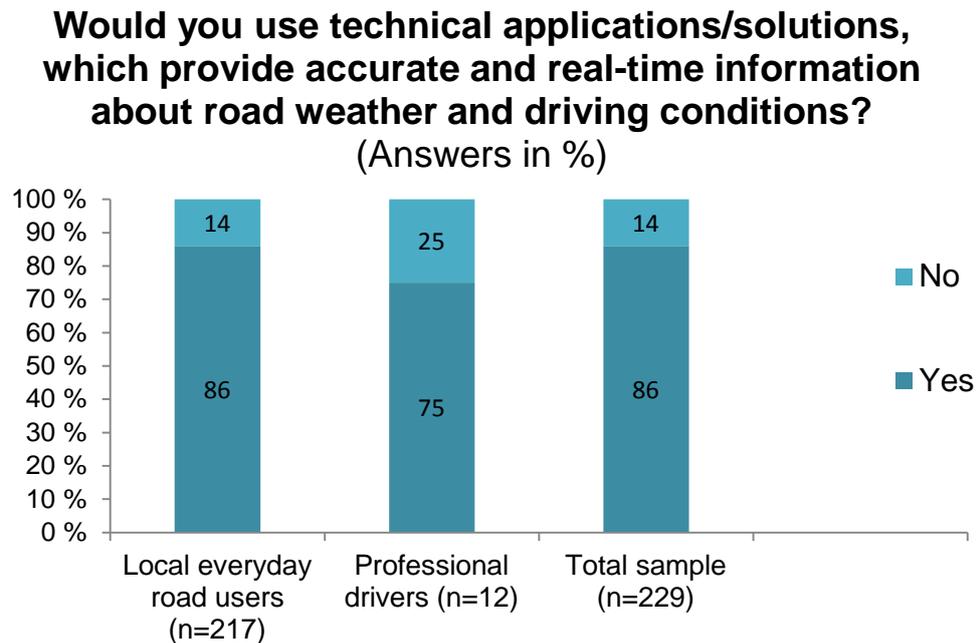


Figure 3. Willingness of Potential Users to Employ Technical Solutions/Applications for Receiving Real-Time Road Weather Information

The car rental company showed interest in providing a technical solution or application, which displays real-time road weather information for their customers if the price of the device would be not too high. Furthermore, the interviewed car rental's representative states that customers would be possibly interested in using such a road weather displaying technical solution.

It depends about the price. What is cost for us and how much we can ask from clients. [Would your customers rent such a device or application?] Good question. I guess yes, but depends about the price. (Car rental.)

When asked the tourist information if the organization would be willing to for example install a monitor in their office, which displays real-time road weather data or present this information on the homepage, the representative answered in a more contained manner and offered instead the idea to produce a brochure for tourists en route in the north. This printed leaflet would satisfy more the general information need of tourists relating to how to

drive in the north when the roads are covered with ice and snow, the speed limits in Finland and responding to matters of winter road maintenance.

[Question: Would you install here some kind of monitor or something, when people come in they can see right away what the actual weather and driving conditions are?] Maybe not but some kind of booklet maybe...that how to drive in Finland, how to drive in Lapland, the things like that. [Maybe you could provide some kind of real time information on your website?] Also yeah... we have like a basic information on our website that how to drive in Lapland. But of course not everybody find it from there. So, for example, some kind of little info booklet. Why not, that might be useful for tourists. (Tourist info.)

With respect to the poll launched in a German language online forum, the respondents showed no interest in a technical solution despite digital warning or speed limit road signs. A smartphone app was seen as a rather disproportionate development and problematic in its technical realization. The respondents opted more for an adapted winter weather driving style.

[Question: Would you use for example a smartphone app or an in the car integrated system which display road weather information?] That sounds rather like a horror vision, jarring with the worth to travel locale of the far north. (...) I would say that nothing replaces an appropriate and anticipatory driving behavior and permanent exposure to road information is rather distracting. (...) Overall, I would opt for the established LED road signs, which display information about the roads. I think a smartphone app is disproportionate, because ultimately there will not be so many weather stations on the roads that one could realize a real-time feedback with GPS positioning. Thus, if you know what comes ahead on the road displayed through LED road signs, then it is enough. (...) I would say it does not need anything like this [technical applications, smartphone etc.]. 90% of the people who drive there [in Lapland] know the conditions. The remaining 10% are tourists and they drive mostly on the main roads. In general, in the north does not, like in middle Europe, suddenly oodles of snow fall down. It is just important that the car is equipped according to the weather conditions and above all, the driving style is appropriate. That is my opinion and forty years of experience. (Online poll.)

Those findings are somewhat in opposition to the statements given by the representatives of the car rental firm and the tourist information. This deviation might be explained first by the limited amount of responses received in the online poll compared to the great

experience of the two representatives, who deal on a daily basis with tourists respectively their concerns of driving in the north and secondly, the car rental and tourist information employees meet the tourists when they actually face the situation of driving in Lapland during adverse weather conditions. Hence, the online poll respondents are not confronted directly with the actual weather and road conditions. This difference in actual versus probable situation might affect the opinion of the respondents leading to altered answers. Moreover, especially the first sentence of the above cited online poll excerpt shows that travelling (in the north) has a romantic touch. Particularly Lappish tourism is equaled with being a nature experience; consequently tourists seek to roam independently and autonomously in the wilderness. This romanticism of exploratory travelling is in opposition to relying on technical appliances and technical progress per se. Instead, the poll respondents trust in their driving experience and rational capability to evaluate weather and road conditions. This exploratory idea of tourism offers a further possible explanation for the poll participants' reluctant attitude.

However, given the findings of the two survey questions plus the interview responses, obtaining real-time road weather information is very significant for different groups of road users. The survey results show that the same proportion of respondents who rate it as important to receive real-time road weather information would also use technical appliances, which display this data. Thus, there exists a great interest among local everyday road users and professional drivers in real-time road weather information and there is a considerable potential that the Intelligent Road System would find a ready market.

4.2 Real-Time Road Weather Information: Potential Users' Needs

Besides uncovering the general interest among different road user groups in real-time road weather information, the study illuminates also as how significant potential users assess different types of data for safely driving on roads in the north. The respondents were asked

to evaluate the importance of receiving real-time information concerning road conditions, air temperature, road temperature, state of winter maintenance, slipperiness warnings, sight and warnings of traffic slowdowns. Three optional categories were offered: irrelevant, important and very important.

Figure 4 below depicts the responses of the local everyday road users. Real-time information regarding road conditions, winter maintenance and slipperiness warnings received the most 'very important' ratings while local everyday drivers judge the actual air and road temperatures as the least significant.

How important do you rate to receive the following weather and road condition information in real-time?
 (Answers of local everyday road users; multiple answers possible)

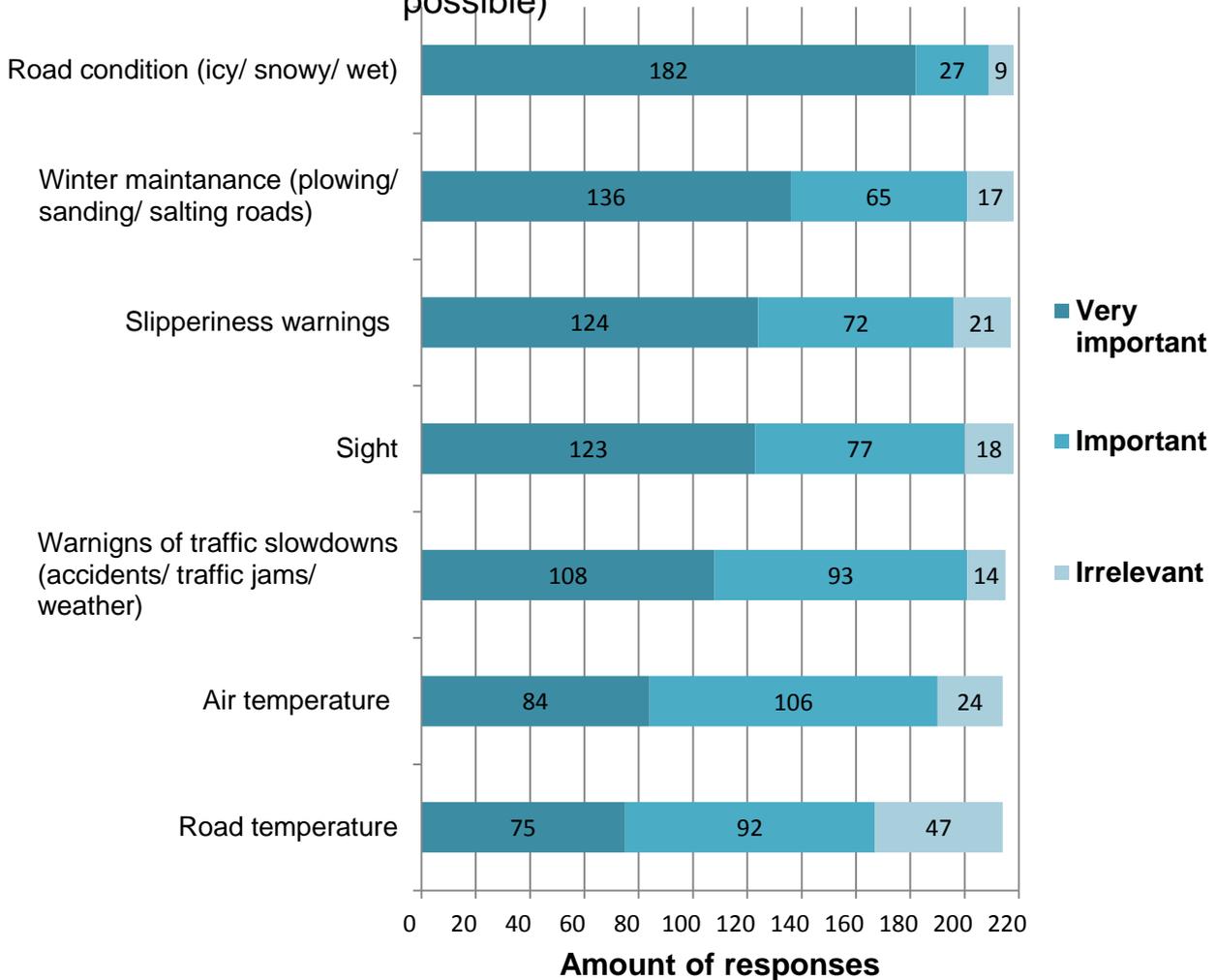


Figure 4. Rating of Specific Road Weather Information (Local everyday road users)

Figure 5 illustrates how the sample of professional drivers rates certain types of road weather related data. Information concerning current road conditions, location specific slipperiness warnings and the actual road temperature gained the most 'very important' evaluations. Professional drivers judge receiving real-time information of the air temperature and sight as the least significant.

How important do you rate to receive the following weather and road condition information in real-time?

(Answers of professional drivers; multiple answers possible)

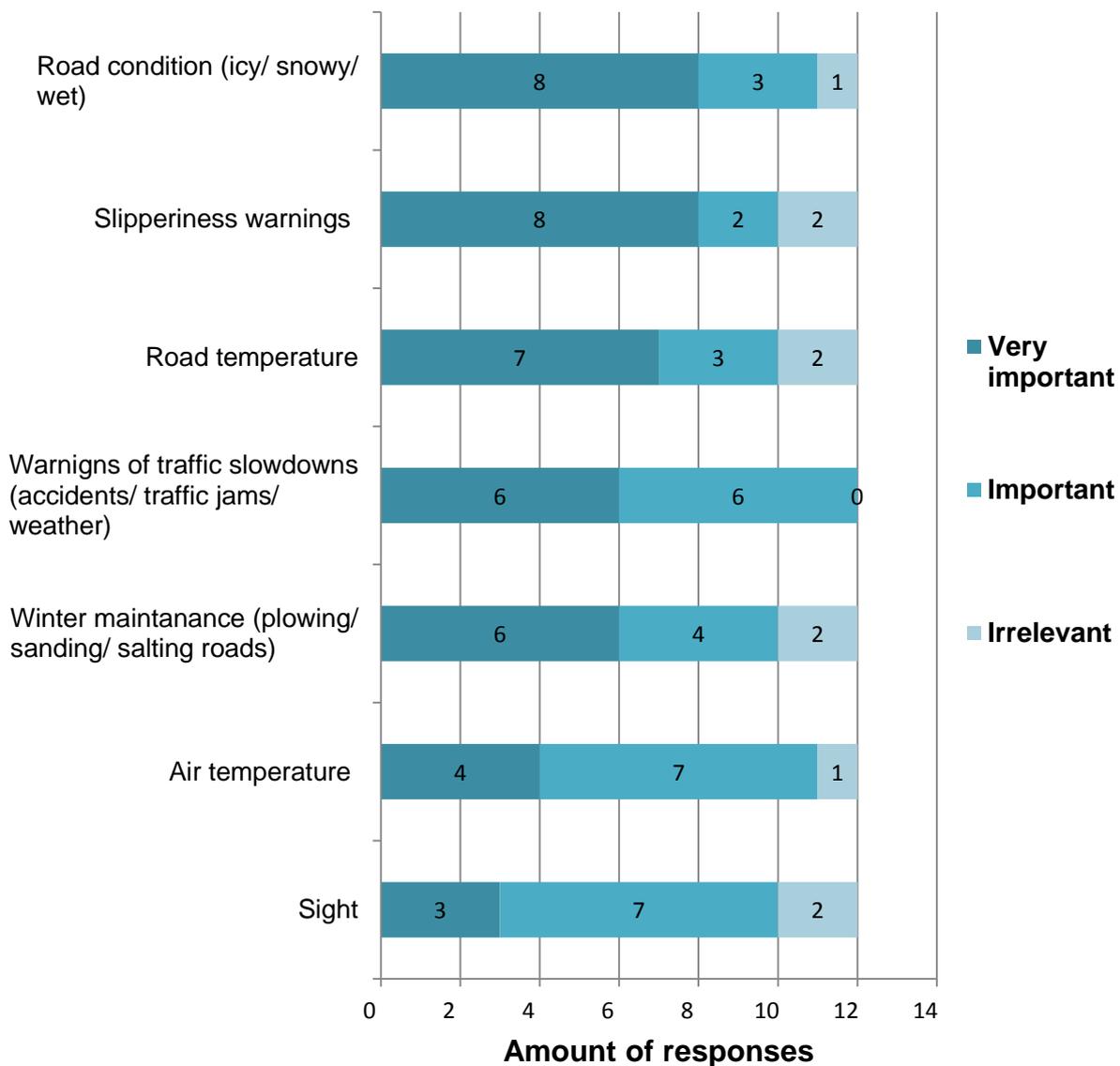


Figure 5. Rating of Specific Road Weather Information (Professional drivers)

In order to understand the specific need of potential users concerning real-time road weather information profoundly, an open-ended question amended the online survey. In total 61 responses were received, often entailing several suggestions for additional real-time information. Table 5 summarizes the themes of those responses numerically descendent. A considerable amount of road users is very interested in real-time information of deer crossing, followed by wind speed and storm warnings, current snow and rainfall, the actual plowing and winter maintenance condition of a particular road section, heavy load transports interfering in the regular traffic's flow and lane grooves.

Furthermore, selected direct quotations from the open-ended question are cited, which provide evidence that especially local everyday drivers necessitate *road weather information* instead of *road weather data*. As already seen in Figure 4, they do often not know how the road temperature relates to the actual driving conditions. Those extracts portray additionally the reasons for drivers' reluctance of using a real-time RWIS as they contrast a technical device with their own driving experience and capability of judging road conditions. Those respondents mistrust a reliance on technical road weather appliances and emphasize instead their rational competence as a driver.

Table 5. Potential Users' Suggestions of Additional Real-Time Information

What kind of additional information concerning road weather and driving conditions would you like to receive while being on the road?	
Response themes of open-ended question	Number of responses citing the theme
Reindeer/ moose on the road (deer crossing)	19
Wind, wind speed and storm warnings	9
Plowing and winter maintenance situation of specific road sections	7
Snow and rainfall	6
Weather prognosis/ forecast for the following day(s)	6
Heavy load transports and other abnormal road incidents (schedules)	4
Lane grooves	4
Sudden changes in weather conditions	3
Road works	2
Polanne (no translation found)	2
Alternative routes with better conditions	1
Sunrise, sunset and twilight	1
Road weather for pedestrians	1
Dangerous area	1
Road side erosion	1
Quotations from the open-ended question	
<ul style="list-style-type: none"> 'Kuuluvuusalueet mm. navigoinnin takia (esim 3G). Voisi varautua karttojen offline lataukseen. Huom. käytän paljon IPadia työvälineenä.' 	

- 'Hmm, it would be already beneficial to know e.g. why I should know the temperature of the road? What does it tell to me as a driver? What is the temperature of the air is +2 but temperature of the road [sic] remains -5 - how does that affect [sic] the safety of my driving? how do all these measures affect the safety of my driving? How should I adjust my behavior on road if the above measures change, what's the safe correlation [sic] between them? Lots of questions ... but I believe lots of knowledge would be beneficial to increase for example safe driving.'
- 'Ei mikään. Ajoneuvon kuljettajan on ajettava olosuhteiden mukaan, ja olosuhteet pitää kuljettajan itse tutkia jokaisella kilometrillä, suoralla ja mutkalla.'
- 'Ei ole, tie on muuttava itse pitää osata kuskina arvioida auton ominaisuudet ja tien pinta'

The interviews with the representatives from the car rental firm and the tourist information revealed that tourists are foremost concerned with the slipperiness of roads during wintertime and the road winter maintenance in Lapland.

[Question: Which information do tourists need when they drive in Lapland?]

Is it safe to drive at the dark time, is there a lot of snow on the roads or are they cleaning up (Car rental).

Ice, the slippery and the ice...condition of the roads...how to drive in the winter... is this snowing. But basically the ice on the road. (Tourist info.)

Likewise to the results of the open-ended question (see Table 5), especially reindeer on the roads are a problem for driving in Lapland and related real-time information would be of assistance for road users. The car rental's representative mentioned that deer crossing causes the most accidents and should consequently be included in the Intelligent Road System.

[Question: Do you think that the Intelligent Road System could prevent accidents and help people to travel safer?] I guess yeah... But maybe the biggest problem is the animals. (...) If this [the Intelligent Road System] is working so that you are driving and its telling about the next 50 km all the time, could be... And if you could somehow get the animals...that is the most common reason for the accidents, the reindeers. (Car rental.)

The poll respondents were mainly interested in receiving information about closed roads and roads without winter maintenance. They took also here a rather reluctant position towards real-time road weather information and stated that weather forecasts obtainable in the internet or in print media are sufficient.

But even with an own car I would be only interested if a closed road is announced in time (but for that, regular road signs are sufficient). Or if a road is not maintained during winter at all or things like that. Weather forecasts are, especially when you are travelling on the roads and therefore all the time “in the civilization” [emphasis in the original], available beforehand in the newspaper or if necessary in the internet or in the radio. (Online poll.)

In order for the Intelligent Road System to become a user-friendly, yet helpful tool enhancing the road safety in the north, *road weather data* needs to be transformed into *information*, which is understandable and meaningful for road users. The findings from the survey, the interviews and the poll suggest that people are cognizant of the danger of slipperiness, which is arguably the biggest risk factor of weather related accidents (see Kilpeläinen–Summala 2007), however, especially local everyday drivers do not know how the actual road’s temperature relates to this issue. Moreover, it shone through that road users are not fully aware of the difference between real-time road weather information and forecast information. This crucial difference has to be clarified for potential users in order that they can make use of the Intelligent Road System in a correct and effective manner.

Potential users were strongly interested in an extension of the Intelligent Road System, covering specifically deer crossing warnings since traffic accidents with reindeer and moose occur quite frequently in Lapland. Additionally, wind speed and storm forecasts were recurrently mentioned along with the current plowing and winter maintenance situation of particular road sections as being significant for road users.

4.3 Technical Solutions for Receiving Real-Time Road Weather Information: Potential Users' Suggestions

The third focal point of this study deals with how potential users want to receive real-time road weather information, providing the project with information of how the Intelligent Road System could be developed for its end-users. Different technical solutions, covering smartphone and navigator applications, digital warning and speed limit road signs, radio announcements and on-board computer displays were proposed in the online questionnaire and respondents could choose among those options. This question was also amended by an open-ended question to obtain additional user input. Figure 6 represents the answers of the local everyday road users. The smartphone application and digital warning and speed limit road signs gained the majority of responses while radio announcements and on-board computer displays received the least reception.

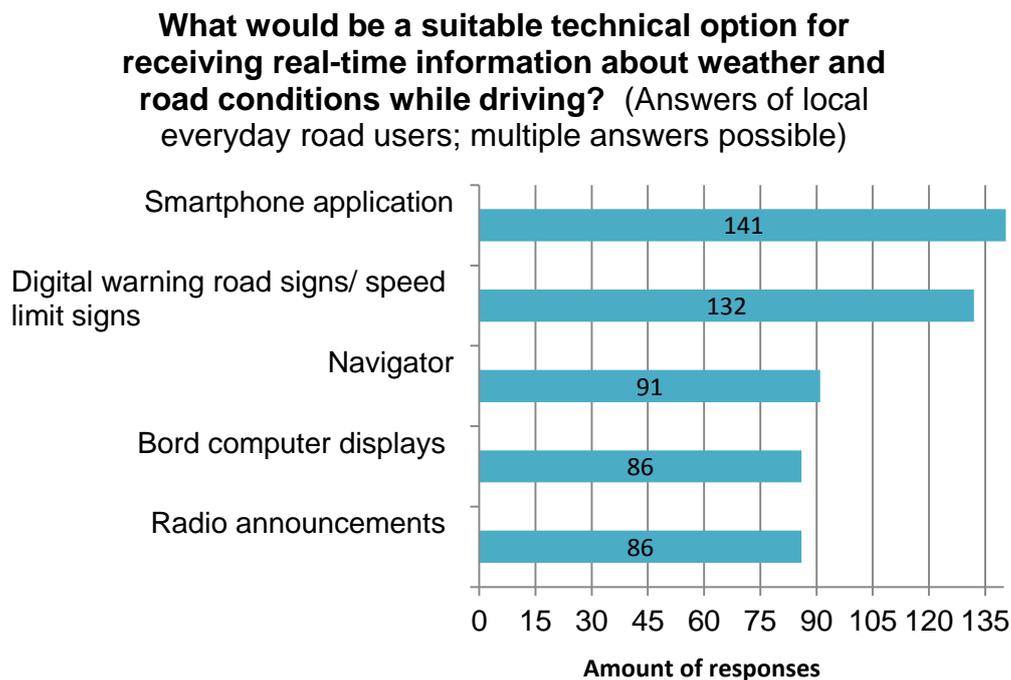


Figure 6. Users' Options for a Technical Solution (local everyday road users)

Professional drivers argue also for a smartphone application in addition to on-board computer displays. Car radio plus navigator announcements were judges as least suitable alternatives for receiving real-time road weather information as depicted in Figure 7.

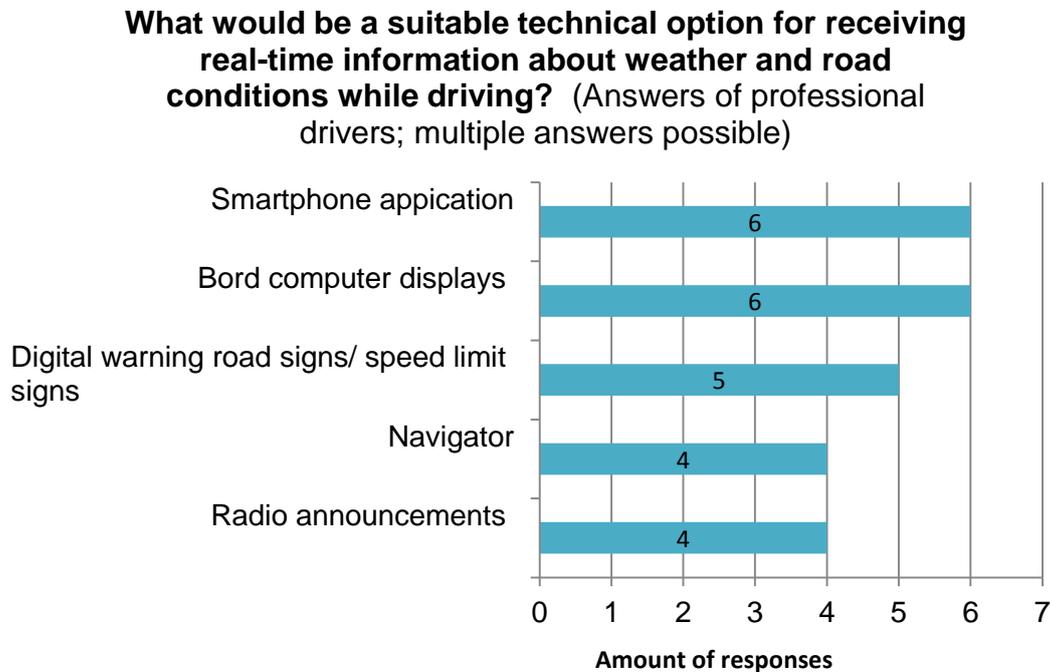


Figure 7. Users' Options for a Technical Solution (Professional drivers)

Table 6 below represents the response themes of the supplementing open-ended survey question, inviting the respondents to suggest additional solutions for informing drivers about real-time road and weather conditions. In sum, 40 answers were received, frequently entailing more than one suggestion for technical solutions of how drivers could be informed about real-time road weather conditions. The majority of responses focused on a homepage, where drivers can find information on their particular route before starting a trip. Direct quotations from the open-ended question illustrate the opinions and concerns of the study participants more detailed. Also here, respondents accentuated the contrast between relying on a technical solution and the capability of determining road and weather conditions and adjust the driving behavior accordingly (see also Table 5).

Table 6. Potential Users' Suggestion for Technical Solution

What could be another solution for informing drivers about real-time weather and road conditions?	
Response themes of open-ended question	Number of responses citing the theme
Homepage with real-time road weather information, which drivers can consult before starting a trip	22
Short message	3
Map program for tablets (Ipad)	3
Warnings for the driver through signal sounds	3
E-mail	1
Social media	1
TV	1
Quotations from the open-ended question	
<ul style="list-style-type: none"> • 'Ilmainen TMC palvelu myös Suomeen, tällähetkellä saan mm. Ruotsin TMC palvelun tiedotteet suoraan ajoneuvon omaan navigaattoriin näytölle mutta Suomessa palvelu on lyöty maksulliseksi.' • 'Omaa koemusta ja asennetta noudattaa olosuhteiden edellyttämää varovaisuutta. Tämä höpötys menee jo liian pitkälle heittäkää jo pois hyvän "sään" aikana. Tekniikka ei korvaa ajoneuvonkuljettana asennetta ja kokemusta tiellä liikkumisesta. Pitää muistaa aina mitä tieliikennelaissa kirjoitetaan, maalaisjärjen käyttö olisi myös suotavaa liikenteessä, eiköhän olisi viisainta sovittaa oma ajonopeus keliolosuhteiden ja oman ajotaidon mukaan sopivaksi...' • 'Ei ainakaan nuita rajoituksia. Niistä ole ko harmia. Saattaa pirun liukkaalla kelillä osottaa vaikka satasta (kokemusta Kemi-Tornio -moottoritietä) ja sitten hyvissä olosuhteissa rajoitukset saattaa olla jonkun teoreettisen sumun vuoksi asetettu 80 KM/H vaikka mitään näkyvää estettä ajaa vaikka 160 KM/H ei ole. Ja silloin sakotetaan, jos ei typerää rajoitusta noudata prikulleen. Ja kuten sanoin, on tien pinnan kitka kuljettajan itse havainnoitava joka laaksossa, vaarojen päällä, kurvissa, peltoaukeilla ja metsäisillä osuuksilla ihan itse. Siihen ei pidä sekoittaa teknologioita. Autovero pois -> ajovakaudenhallintajärjestelmä yleistyy, se pelastaa monta vahinkoa.' 	

- 'Mielestäni kaikki ne keinot, jotka eivät vaikuta liiaksi ajamiseen/ huomion herpaantumiseen. Eli juuri nuo edellä mainitut: radio, autoradion näyttö ja opasteet ovat ne ykkösvaihtoehdot.'
- 'Älypuhelinsovellus on hyvä, koska sillä voi tarkistaa säätiedot ennen matkaan lähtemistä. Radaioilmoitus on hyvä jo liikeenteessä olevalle saada tietoa esim. määrällisiin säätiedoista. Reaaliaikaiset opasteet eivät välttämättä "toimi", koska jos niihin ei saa tarpeeksi tärkeää informaatioita. Ajaessa kuljettaja ei voi lukea kovin pitkää tekstiä. Pelkkä nopusrajoitusten reaaliaikainen muuttuminen ei riitä informaatioksi huonosta ilmasta.'
- 'Yksin ajon aikana ei varmaan oikein tulisi katsottua älylaitteita, eli ne muuttuvat opasteet kuulostaa hyviltä!'

As cited elsewhere, the representative from the tourist information opts from a company's point of view for a booklet providing general information of how to drive in the north. However, the employee considered also digital road signs plus a smartphone application as beneficial technical solutions for tourists travelling by car in Lapland.

[Question: What kind of technical solutions would be good for informing drivers about real-time weather and road conditions?] This kind of digital road symbols that say ice, slow...Yeah... why not... And especially in English because Finnish people they know well how to drive in winter but especially in English guides and things like that. Also applications to the phone which are like providing real-time information, showing the weather so that they can plan...ok, now the weather is getting worse, maybe they can think that we can stop and continue later. I think it is a good idea. (Tourist info.)

Also the poll respondents, as previously mentioned, go for digital road signs while they point out the possibility of a smartphone application as a potential drivers' distraction, thus representing a danger to traffic safety. This opinion of technical applications distracting the drivers echoes also in the above-quoted responses from the online survey's open-ended question concerning suggestions for technical solutions of the Intelligent Road System.

I would say that nothing replaces an appropriate and anticipatory driving behavior and permanent exposure to road information is rather distracting. (...) Overall, I would opt for the established LED road signs, which display information about the roads. I think a smartphone app is disproportionate, because ultimately there will not be so many weather stations on the roads that one could realize a real-time feedback with GPS positioning. Thus, if you know what comes ahead on the road displayed through LED road signs, then it is enough. (...) For the security while driving: The best is to switch off mobile phone & co and watch to road. The less of technical falderals, the better the chances for adequate concentration and a recreational trip. (Online poll.)

Those opinions of online poll participants and the survey respondents are in line with research results in the field. Indeed, related studies point out the positive effect of adaptive digital speed limit and warning signs in the sense that drivers recall them better than stationary ones and reduce their mean speed more frequently (e.g. Rämä–Loma 1997; Rämä 2001). Even though, mobile in-vehicle information technology is now seen as a means for increasingly providing locational specific real-time road information (Kilpeläinen–Summala 2007), road safety research addresses visual-manual distraction of drivers as a major cause for serious casualty crashes (Beanlanda et al. 2013). Beanlanda, Fitzharris, Younga and Lennéa (2013) find in their in-depth study analyzing Australian road crashes that driver inattention and driver distraction contribute to a substantial number of serious traffic accidents beside intoxication and fatigue. They report that most drivers' distraction includes visual-manual tasks and conclude that policy interventions should aim at discouraging drivers in engaging in distractions such as 'making telephone calls, entering destination details into a navigation device, or scrolling through music lists' (Beanlanda et al. 2013, 105). Clearly, a smartphone application informing drivers about real-time weather and road conditions entails visual-manual distracting potential as stated by several study participants.

5 IMPLICATIONS FOR DEVELOPPING THE INTELLIGENT ROAD SYSTEM

Drawing upon the research findings plus the body of related road weather literature, this chapter provides suggestions for developing the Intelligent Road System. Overall, the study indicates a great interest of different road users in receiving real-time weather and road condition information along with an ostensive readiness for using technical solutions and/or applications to obtain such information. Conversely, the research among different road user groups uncovered also several challenges as well as opportunities for developing the Intelligent Road System, entailing issues of a need for educating especially local everyday road users in the value and the meaning of real-time road weather data, along with the demand of designing the system in a way that it is not endangering drivers' safety. Thus, the Intelligent Road System application has to convert road weather data into easily comprehensible information and offer possibilities for different road user groups to customize the application according to their particular needs. A further opportunity for user-oriented development and a contribution to the traffic safety in the north is the compatibility with other road condition information systems, such as the planned application, which informs drivers about deer crossing.

5.1 User-Oriented Development: Information Instead of Data

In order for the Intelligent Road System to be a safety enhancing tool for different groups of drivers, road weather data has to be not only accurate and locational specific but requires to be converted into tangible yet accessible user-friendly information. Notwithstanding the great interest of road users in utilizing a technical application, which informs them about real-time road weather and driving conditions, especially the open-ended survey questions revealed that drivers often do not know what plain road weather data means and how it correlates to their actual driving. The prime example is the low evaluation of the importance of road temperature by particularly local everyday drivers (see Figure 4), which represents mere data for them in the first place instead of concrete information. Besides, the survey shows that the value of locational specific real-time road weather information is not fully understood, especially with regard to its key difference to conventional weather forecasts. Schirokoff and Tuominen mention in their analysis of road

weather services that more than a half (62%) of the peak day accidents in Finland happened as weather forecasts' predictions of adverse road conditions were valid. They raise the questions of whether the information did not reach the drivers and/or did it not affect the drivers' behavior. Kilpeläinen and Summala (2007) examine the effects of weather forecasts on driver behavior and report that even though people acquired road weather related information, no direct alterations of their driving performance, such as target speed, headway or overtaking frequency were discernible. Moreover, drivers' own road condition ratings were found to not correspond very well to the traffic weather forecasts as road users generally tended to deem the conditions better than the forecast.

Hence, real-time weather information systems offer a great potential to improve the traffic safety if the users comprehend the difference to forecast information and adjust their driving behavior in accordance to the information given. For this to happen, potential users need additional information and education about the functions and the benefits of the Intelligent Road System so that the system becomes an integral part of their everyday driving. Kilpeläinen and Summa (2007, 296) summarize the purpose of RWIS for drivers in the following way:

To have an effect on traffic safety, a traffic weather information system should be easily accessible to drivers, used by a considerable proportion of them, appear reliable and, finally, contribute to pre-trip decisions and on-road driving. (...) An example of local and temporally accurate warnings is a precise and standardized variable message system that displays concrete driving behaviour instructions for example current speed limit or overtaking restrictions.

Moreover, the study results show that potential users are somewhat concerned with the possibility of the Intelligent Road System to distract the drivers leading overall to negative effects on traffic safety. This relates especially to the favored solution of a smartphone application (see Figures 6 and 7), which might distract drivers visually and manually. The system requires therefore to be designed in a way that the technical solution is not only easy to operate but information is also intuitive and comprehensible for its end-users, particularly when they are driving. The research respondents suggested voice warnings and in the future, the application could be developed so that the information is received by

an intelligent car, which adjusts the driving mode automatically according to the location specific road condition.

In general, the research results represent also the discussion of the increasing reliance of modern human kind on technical appliances versus human rationality and capability to assess situations and act accordingly. Some study participants uttered their skepticism towards relying on RWIS when travelling on the roads in the north and emphasized instead human sagacity as decisive for evaluating adverse driving conditions. Undeniably, the biggest risk factor for the overall traffic safety is the human encompassing misjudgments, inattention and imprudent driving behavior. The Intelligent Road System offers the possibility to assist drivers in particularly those issues if the road weather data is processed into concrete information and/or even recommendations for adjusting the driving behavior.

5.2 User-Oriented Development: Compatibility and Customizability

A reoccurring theme in the survey as well in the interview results was the issue of deer crossing, referring here in the north especially to reindeer and moose on the roads. There are over one thousand elk collisions per year in Finland (Liikenneturva 2013) and approximately four thousand reindeer are annually run over by cars in Finnish Lapland (Reindeer in Traffic). Thus, deer crossing is a major issue regarding traffic safety in the north and the study participants were very interested in receiving related real-time information while driving. From the point of view of user-friendliness and applicability it would be a great development if this particular information could be integrated into the Intelligent Road System's technical end-user solution. There is currently another project going on, which deals with the realization of a deer crossing driver information system. However, both projects should collaborate in making their systems compatible for enhancing the overall traffic safety in the north. For potential users it is crucial to obtain road weather and driving condition information in an easy manner so that they are not forced to integrate information from many sources in the same time or make even

decisions, which application to use while driving. For a profound user-friendliness, the Intelligent Road System necessitates to be compatible with other road information systems in order to increase the value of the application as such along with the potential to contribute in the most effective way to traffic safety.

In addition, the study stresses that there are differences concerning the information need between road user groups. For tourists driving in the north during winter, especially general information of how to drive on icy roads plus answering questions relating to winter maintenance of roads was most significant. Beside the provision of a technical solution informing them about real-time road weather conditions, the representative of the tourist information suggested to produce a booklet featuring this general information. Local everyday road users require mostly information instead of plain road weather data while professional drivers are more familiar with the meaning of road weather data. Hence, a favorable technical solution of the Intelligent Road System would offer customizability options for potential users so that they can choose what kind of information they would like to receive while driving and how this particular information is presented to them, as data or in form of concrete advice for driving behavior adjustment. By those means, a great variety of different road users might be attracted to employ the Intelligent Road System as an integral and effective tool supporting road trips, whether for leisure or work related, in the north.

The goal of the Intelligent Road project should be the development of a compact user-friendly RWIS application, which is easily comprehensible and customizable for attracting a great variety of users. Moreover, potential users favor the idea that the technical solution displays not only road weather related info but covers also deer crossing and incidents influencing regular traffic.

6 CONCLUSIONS

The findings of the study indicate that local everyday road users and professional drivers rate it as very important to receive accurate real-time road weather information along with a great interest among those groups to make use of technical solutions informing them while driving about the current situation of the road ahead. Approximately the same proportion of respondents who consider real-time road weather information as significant for driving in the north would also employ a technical solution displaying this information. Specific information favored by potential Intelligent Road System users encompasses generally the current state of the road, the winter maintenance situation of a particular road section and slipperiness warnings. However, information needs vary among different road user groups due to their familiarity of the roads in the north, the state of a driver's training and professional background. With regard to the technical realization of the Intelligent Road System, a smartphone application followed by digital road signs and navigator system add ons were chosen to be the most suitable by potential users.

Given the research results, several opportunities as well as challenges for the development of the Intelligent Road System were revealed. Foremost, plain road weather data is neither sufficient nor meaningful for particularly local everyday road users and the Intelligent Road System is required to transform this data into comprehensive information. The open-ended survey questions revealed that the crucial difference between forecast and real-time road weather information is not thoroughly understood and the system necessitates also educating drivers about the correct integration of the technical solution into everyday driving habits. Thus, the Intelligent Road System should provide customization options for being adaptable to different road users' information needs, leading to a greater attractiveness of the system as such. Besides, potential users were very interested in a road information system, disseminating not only road weather but also real-time deer crossing and irregular incidents interfering into the traffic flow, such as road constructions or heavy load transports. The Intelligent Road System should therefore be designed to being either fully compatible with other driver information systems or include aforesaid information.

The main challenge in the development of the Intelligent Road System the study participants touched on concerned the distractive potential of a technical solution, which is

used while driving. Road safety related research emphasizes especially visual-manual distraction of drivers as a major accident causing factor. For the Intelligent Road System to become a safety enhancing tool, its technical solution has to display information in a cognitively easy absorbable manner so that drivers' attention on the road traffic is not drawn off. Respondents proposed voice alerts as an alternative to visual presentation of weather and road condition information.

In conclusion, there exist great prospects for a commercial development of the Intelligent Road System as the majority of the study participants showed interest to make use of such an application. However, its technical implementation requires for being truly user-friendly not only the conversion of weather data into intuitive information but also options for customizability plus compatibility with other road information systems.

7 LITERATURE COLLECTION

Besides illuminating the interest among local, touristic and professional road users in using technology for being informed about real-time weather information, thematically relevant literature, which is indented to serve as a basis for a scientific publication, was collected. A folder with pdf documents was created and sent to the project manager Heikki Konttaniemi as the amount of articles was too large to attach to this report. In this section however, significant references, which were not directly accessible as pdf downloads, are listed.

First of all, the TRID database is an excellent source of information for all road weather, safety and technical development related scientific research documents. This integrated database combines the records from TRB's Transportation Research Information Services (TRIS) Database and the OECD's Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database. Address: <http://trid.trb.org/>

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APPENDICES

Appendix A: Survey for Transportation Companies



Intelligent Road

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Tiesäainformaation kysely

1. Onko teistä tärkeää saada reaaliaikaisia tiesää- ja olosuhdetietoja kuljettajille tielläolon aikana?

- Kyllä
 Ei

2. Minkälaista tietoa tarvitsette kun olette liikenteessä? Miten arvioitte seuraavien tietojen tärkeyden?

	Erittäin tärkeä	Kohtalaisen tärkeä	Ei merkitystä
Ilman lämpötila	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien lämpötila	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien pinnantila (luminen, jäinen, märkä)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien hoitotoimenpiteet ja tien hoitoluokitukset (hiekotus, suolaus, auraus, aikataulut ja reaaliaikainen edistyminen)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kitkatiedot ja liukkausvaroitukset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Näkyvyys	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eri syistä johtuvat liikennehidasteet (ruuhkat, onnettomuudet, sää)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Mikä muu tiesää- ja olosuhdetieto olisi teidän mielestänne kuljettajille tarpeellinen edellisessä kysymyksessä mainittujen tietojen lisäksi?

4. Millä tavoin tiedot voidaan välittää kuljettajalle parhaiten?

- Älypuhelinsovellus
- Navigaattori
- Muuttuvat digitaaliset opasteet ja nopeusrajoitusmerkit
- Radioilmoitukset
- Autoradion tai ajotietokoneen näyttö

5. Tiedättekö muita ratkaisuja tietojen välittämiseen kuljettajalle?

6. Käyttäisittekö laitetta ja sovellusta, mikä antaa tarkat ja reaaliaikaiset tiesää- ja olosuhdetiedot?

- Kyllä
- Ei

Appendix B: Survey for Local Road Users in Finnish



Intelligent Road

safety by arctic know-how

Tiesääinformaatio kysely

1. Ovatko reaaliaikaiset tiedot tien kunnosta tärkeitä sinulle kun käytät teitä pohjoisessa?

- Kyllä
 Ei

2. Minkälaista tietoa tarvitsette kun olette liikenteessä? Miten arvioitte seuraavien tietojen tärkeyden?

	Erittäin tärkeä	Kohtalaisen tärkeä	Ei merkitystä
Ilman lämpötila	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien lämpötila	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien pinnantila (luminen, jäinen, märkä)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tien hoitotoimenpiteet ja tien hoitoluokitukset (hiekotus, suolaus, auraus, aikataulut ja reaaliaikainen edistyminen)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kitkatiedot ja liukkausvaroitukset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Näkyvyys	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eri syistä johtuvat liikennehidasteet (ruuhkat, onnettomuudet, sää)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Mikä muu tiesää- ja olosuhdetieto olisi teidän mielestänne tarpeellinen edellisessä

kysymyksessä mainittujen tietojen lisäksi?

4. Mikä olisi mielestänne hyvä keino välittää tarvitsemanne tiedot teille tai kuljettajallenne?

- Älypuhelinsovellus
- Navigaattori
- Muuttuvat digitaaliset opasteet ja nopeusrajoitusmerkit
- Radioilmoitukset
- Autoradion tai ajotietokoneen näyttö

5. Mitä muita keinoja suosittelisitte tietojen välittämiseen?

6. Käyttäisittekö laitetta ja sovellusta, mikä antaa tarkat ja reaaliaikaiset tiesää- ja olosuhdetiedot?

- Kyllä
- Ei

Appendix C: Survey for Local Road Users in English



Intelligent Road

safety by arctic know-how

Road Weather Survey

1. Do you think it is important to be informed in real-time about weather and road conditions while driving? *

- Yes
 No

2. How important do you rate to receive the following information about weather and road conditions in real-time?

	Very important	Important	Irrelevant
Road temperature	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Air temperature	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Road conditions (icy, snowy, wet)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Winter maintenance (real-time information about plowing/ sanding/ salting roads)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Slipperiness warnings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sight	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Warnings of traffic slowdowns (accidents, traffic jams, weather)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. What kind of additional information concerning road weather and driving conditions would

you like to receive while being on the road?

4. What would be a suitable technical option for receiving real-time information about weather and road conditions while driving?

- Smartphone application
- Navigator
- Digital road signs/speed limit signs
- Radio announcements
- Car radio or bord computer display

5. What could be another solution for informing drivers about real-time weather and road conditions?

6. Would you use technical applications/solutions, which provide accurate and real-time information about road weather and driving conditions?

- Yes
- No

Appendix D: Survey for Partner Organizations



Intelligent Road

safety by arctic know-how

Road weather survey

1. You are on the roads in the north as...

- Professional (road freight)
- Professional (taxi/ bus transportation)
- Other professional driver
- Local road user
- Tourist
- Other

2. Do you think it is important to be informed in real-time about weather and road conditions while driving?

- Yes
- No

3. How important do you rate to receive the following information about weather and road conditions in real-time?

	Very important	Important	Irrelevant
Road temperature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Air temperature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Road conditions (icy, snowy, wet)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Winter maintenance (plowing/sanding/salting roads)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Slipperiness warnings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Warnings of traffic slowdowns (accidents, traffic jams, weather)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. What kind of additional information concerning road weather and driving conditions would you like to receive while being on the road?

5. What would be a suitable technical option for receiving real-time information about weather and road conditions while driving?

- Smartphone application
- Navigator
- Digital road signs/ speed limit signs
- Radio announcements
- Car radio or bord computer displays

6. What could be another solution for informing drivers about real-time weather and road conditions?

7. Would you use technical applications/solutions, which provide accurate and real-time information about road weather and driving conditions?

- Yes
- No

