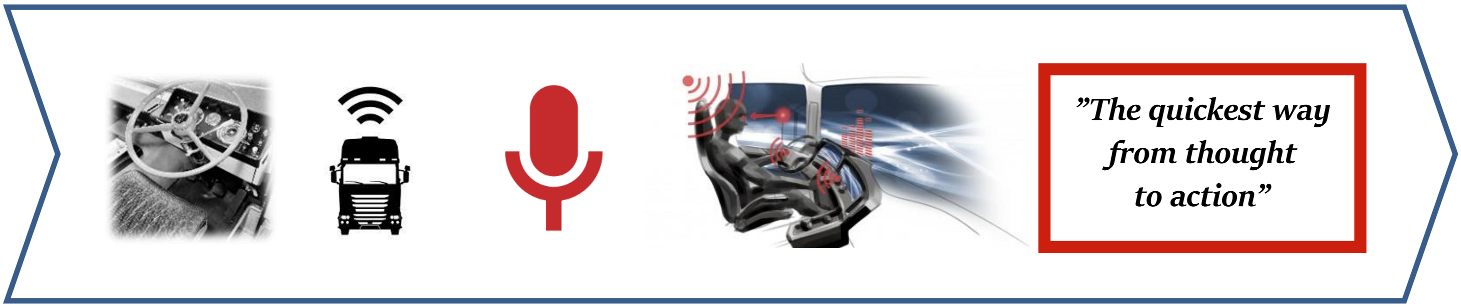
Pre-study and prototype development to investigate traffic safety aspect on completely novel speech- and language-based interfaces



Anders Lindström, Veridict AB

2015-11-12

Final report regarding pre-study No. 2014-05576 within the FFI sub-programme *Vehicle and Traffic Safety and Automated vehicles*

FFI Fordonsstrategisk Forskning och Innovation

Table of Contents

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1 Executive summary

"Pre-study and prototype development to investigate traffic safety aspect on completely novel speech- and language-based interfaces", reference № 2014-05576, was conducted from January through October 2015 by Veridict, a member of the Scandinavian Automotive Supplier Association (Fordonskomponentgruppen, FKG). The overall budget was 800 000 SEK, of which public funding through VINNOVA (Sweden's innovation agency) amounted to 520 000 (65%). The pre-study had three goals:

1. Investigate the potential for traffic safety improvements by using novel types of spoken language interfaces in connected heavy vehicles *(literature review)*
2. Develop a first technical prototype for demonstration purposes *(technical development)*
3. Establish collaboration with one of the vehicle manufacturers and develop a joint project proposal to develop and test the technology further *(consortium formation, proposal definition and preparation)*

The results of the pre-study are:

1. **A literature review** (Lindström 2015), providing deeper analysis and concluding that specific design criteria need to be developed in order to develop speech interfaces which draw directly upon the strengths of natural language communication. An initial set of such design recommendations are presented, motivated and discussed in the report.
2. **A speech-based prototype,** including a selection of service examples: traffic-relevant weather reports, traffic cameras, route planning and points of interest (POI), e.g. service areas, police incident reports, and toll stations (locations and current fees). The selection was made from a general traffic relevance perspective, rather than tailoring the services to any specific type of heavy vehicle (trucks, lorries, coaches or buses), or to any specific customer case or user category. The prototype was then used for demonstrations in a series of workshops to identify follow-up projects with potential stake-holders, including The Swedish Transport Administration (Trafikverket), The Swedish National Road and Transport Research Institute (VTI), and Scania (see below).
3. Knowledge dissemination, consortium formation and submitted project proposal. Individual workshops with potential stake-holders (Trafikverket, VTI and Scania) were held using the literature review and the demonstrator as tools. As a result, Scania and Veridict jointly formulated a bilateral collaborative project, with the objective to develop, demo and test a speech-enabled driver's HMI in vehicles connected to complex services. An initial interview survey (Krupenia 2015) among drivers at the Scania Transport Laboratory was carried out during preparation of the proposal, which has since been submitted to VINNOVA/FFI.

2 Background

Speech recognition and advanced spoken language understanding is expected to become key technologies in the driver's environment in heavy vehicles, as these form part of an increasingly complex, connected transport system for passengers as well as goods. In-vehicle use of such spoken language systems has vast potential of alleviating the communication between driver and vehicle, enabling new connected services for increased transport efficiency, as well as enhancing road traffic safety, but a major breakthrough is still pending. This is partly due to the fact that existing systems are cumbersome to use and error-prone, but can also be attributed to the fact that they often suffer from a design which fails to exploit and take advantage of the inherent strengths of language, leading to systems which and often tend to annoy rather than relieve drivers.

These assumptions served as a starting point for this pre-study, which also partially draws on results from "Snabb Säker Väg" ("A quick safe road"), a collaborative project carried out by VTI and Veridict and partially funded by Trafikverket, in which simulator studies compared speech-based traffic incident reporting to text-based interaction while driving. The results of those studies show that the speech-based solution is clearly preferred by the drivers, and showed no negative effects on traffic safety, while the text-based solution was deemed completely unacceptable by the majority of drivers, which was confirmed by quantitative results in the study, clearly showing significant negative effects on traffic safety, accessibility and transport efficiency (Kircher, Lindström och Seward 2014, Eriksson, o.a. 2014).

3 Objective, research questions and method

The pre-study had three main **objectives**:

1. **Analysis.** Acquire and disseminate a deeper understanding regarding spoken language interfaces as a tool for increased transport efficiency and improved traffic safety in connected heavy vehicles
2. **Prototyping.** Demonstrate a state-of-the-art solution and illustrate the technology potential related tdo AI-based speech control applied to vehicles and traffic
3. **Collaboration and exchange.** Form a consortium with at least one vehicle manufacturer (if possible extend with further stake-holders), and jointly formulate a collaborative project geared towards technical development, demonstration and testing of speech-based interaction with connected services in heavy vehicles on the road.

For each objective, a corresponding set of research questions and suggested methods were identified and proposed, as shown in summary in Table 1.

Table 1. Objectives, research questions and tentative methods used in the pre-study

Objective	Research questions	Method
1. Analysis	What is the potential for traffic safety improvements incurred by this technology? Which are the critical technical demands?	Literature survey and compilation of state-of-the-art research results, also using personal communication from individuals and groups within the areas of speech technology as well as traffic and vehicle safety.
2. Prototyping	How can the use and utility be visualized and demonstrated in practice?	Formulate requirements specification, based on analysis of vehicle industry's needs. Develop a speech-based prototype and use it for demonstration.
3. Collaboration and exchange	How can the pre-study contribute to national collaboration and knowledge exchange in the next step?	Formation of a boundary-crossing consortium with participants from the vehicle industry, vehicle and traffic safety research, traffic and transport authorities, and, if possible, also from insurance actors.

One comment regarding item 3 (Collaboration and exchange) above is that the consortium establishment task was deliberately initiated very early on during the pre-study, and targeted several potential stake-holders, with the explicit ambition of yielding a common proposal backed up by several stake-holders. Despite this head start and considerable effort being spent during on-site results dissemination, meetings and workshops, this turned out to be more labour-intensive and time-consuming than would have been desirable, or expected.

For this reason, it was chosen not to extend the efforts to also include representatives from the insurance side (as optionally listed under "Method" above). However, there is potential for doing so in suggested follow-up projects.

4 Goals

Each objective was further broken down into goals, deliverables and expected results, and activities were posited in order to achieve each of these, according to the summary in Table 2.

Table 2. Goals and activities of the pre-study

Objective	Activities	Goals, deliverables, expected results
1. Analysis	In-depth analysis of the current state of art in the area within the research community. Positing of an explanatory model, trying to reconcile what appears to be contradictory results regarding the traffic safety aspects relating to in-vehicle speech interfaces.	A deeper understanding of the causal relations behind the seemingly contradictory literature results. Charting of properties of relevance for speech-based interaction to reduce accident risks. Reporting and dissemination of results to vehicle industry and other stake-holders. Formulated hypotheses and proposals regarding testing methodology. Technical areas in need of development identified.
2. Prototyping	Develop demonstrator comprising one or more vehicle-related subsystem (e.g. position, range, temperature), and several traffic-related subsystems (e.g. traffic information, points of interest, i.a. filling and service stations, road surface data, and traffic cameras).	Prototype, which works in traffic under real conditions. Demonstration and dissemination aimed at vehicle industry representatives as well as other stake-holders.
3. Collaboration and exchange	Formation/extension of consortium and joint formulation of and application for a collaborative project.	Dissemination of knowledge and results, and widened support for the investigated technology with a focus on customer utility at a national level. Project proposal geared towards technical development, demonstrator, testing and user studies.

A few comments pertaining to item 2 (Prototyping) in the table above:

Veridict and Scania came to the joint conclusion that – for the purpose of the pre-study –demonstration in an office environment of the prototype and its functionality would be perfectly adequate, with an option for in-vehicle demonstration, rather than (for instance) carrying out demos in Scania's state-of-the-art vehicle simulator environment. The latter was initially investigated as an option, but was identified as better saved for purposes which are likely to need fulfillment at later stages, e.g. formal verification and controlled behavioral studies. In addition the technical integration, software development and resources required for such an effort were estimated to lie well beyond the scope of the present pre-study.

Most demonstrations and technical testing during the pre-study were therefore carried out in office or meeting room environments in conjunction with the series of workshops which was carried out, with a few specific tests being made in vehicles. The prototype was further tested under realistic (i.e. limited) connectivity conditions, with either low signal strength, drop-outs or geographical coverage issues, requiring hand-over between different types of mobile networks. Additional data was also collected from in-traffic use of the prototype. Time has not allowed analysis of this data within the framework of the pre-study, why it has been stored for possible further use in the proposed follow-up project.

5 Results and deliverables

The pre-study was coordinated by Veridict and carried out in three work packages (WP1 – WP3), corresponding to one objective each, and with individually assigned activity leaders. The results and deliverables of each work package is described below.

5.1 Analysis

A **report** was compiled, comprising a literature review and a deeper analysis of the research field. An overview of contemporary research sheds light on the apparent differences in the traffic safety literature as regards in-vehicle speech-based interaction. Clearly articulated and highly opposing view have been presented over the past several years – both in the research literature and in the current debate – regarding the appropriateness of using multi-modal and speech-based user interfaces in vehicles. On the one hand, such interfaces could be expected to lead to reduced visual and manual distraction in comparison with traditional vehicle instrumentation – on the other hand there are studies, seemingly indicating that several of the commercially available speech interfaces today cause considerable increases in cognitive work-load if used while driving. The report dissects this problem, and tries to identify the underlying causal connections between these apparently irreconcilable views. It is suggested that they are due to a mis-guided attempt at making direct comparisons possible, which has inadvertently led to speech-based interfaces with a design where speech is merely added “on top of” a pre-existing hierarchical, menu-based interface, originally designed for direct manipulation. This in turn leads to the systematic under-exploitation of the inherent strengths of communication by language. One conclusion, drawn in the report, is therefore that in-vehicle speech-based interfaces call for new design criteria to be devised, taking these strengths into account, in order to address, and potentially improve, traffic safety. One initial proposal for such design recommendations is given in the report, expressed in terms of several required properties of in-vehicle speech-based interaction, necessary for its contribution to traffic safety and eventually the lowering of the number of traffic casualties:

A. Ensure that the user is always in control, with the system non-obtrusively assisting and helping, without interfering with or negatively affecting traffic safety
B. Reduce the number of linguistic interaction steps by exploiting information-dense utterances
C. Strive for a state-less spoken language user interface, coupled to numerous system states, allowing for the co-existence of a large number of sub-services and data sources
D. Make the system receptive and responsive enough to be perceived as the “quickest way from thought to action”
E. Exploit contextualization regarding (at least) time, space, individual and situation
F. Exploit the specific power of language to directly select individuals from extremely large vocabularies

Verification of the validity of these recommendations still remains, and is one of the purposes of the proposed follow-up project (cf. section 5.2). The **primary hypotheses,** formulated in conjunction with this, is that the recommendations, provided they are followed, should lead to improved traffic safety in a series of three distinct steps (I – III below), and that this is achieved by

I. allowing for safer execution of functions or actions, hitherto performed in a more hazardous way (often involving eyes-off-the-road, sometimes for extensive time periods),
II. enabling traffic-safe execution of actions, hitherto impossible to carry out while driving, and by
III. enabling dedicated traffic-safety improving services which have been impossible to realize to date

In addition to this, related technical hypotheses have been formulated, and **identification of critical technical components** in need of development for the fulfillment of the design recommendations above has also been made. The latter was used directly in the formulation of the follow-up project proposal (cf. section 5.2).

5.2 Prototyping

A **speech-based prototype** was developed, including a limited selection of service examples, with intended in-traffic use, and which would be robust against limitations in connection coverage or speed.

Development work took its starting point in the technology base and service infrastructure, developed by Veridict in 2013 – 2014, as winners of the Innovation Contest "ITS Innovation Stockholm – Kista" [1]. However, the solution developed in said project was geared towards spoken language information services related to trains and underground and addressed public transport travelers as its general target group. Owing to the modular system architecture employed, several system components could be re-used in the prototype development in the pre-study, while novel technical development was necessary primarily to cover the service content. The pre-study prototype obviously differs considerably in this respect, since it targets professional drivers of heavy vehicles, which the pre-existing system did not.

The prototype consisted of three main components:

- client software, developed for a common mobile operating system (Android-app-based),
- a server solution implementing agent-based software for each individual service as well as for automatic speech recognition (ASR), natural language understanding (NLU) and generation (NLG), and,
- a scalable, connected cloud-based service architecture in which the entire solution is deployed, and which implements functionality for handling disrupted and degraded connectivity (this component benefitted the most from re-use of technology and prior component re-use)

Most of the service examples chosen relate to traffic, and to the intended use by drivers of heavy vehicles in commercial fleets but the prototype as a whole needed to be of general relevance so that it could suit the needs of different transport system actors. Because of this, the services were not designed to be specifically geared towards specific road traffic applications or any particular kind of heavy vehicle. The services included traffic situation, traffic surveillance cameras, toll stations (locations and current fees), navigation, police incident reports, points-of-interest (incl. ATMs, pharmacies and restaurants), traffic-related weather forecasts (by time and location) and a basic calculator.
The information used in the running prototype was acquired online from several different data sources, i.a. the national DATEX II system, hosted by Trafikverket, and open data sources, such as weather forecasts from YR. Having equipped the server side of the prototype with service-specific agent software, and having developed the client with multimodal interaction capabilities, as well as developing speech and language grammars for all data sources, the cloud-based service infrastructure could be re-used to deploy a version of the prototype in a connected, scalable service environment.

Following this technical development, the mobile prototype was submitted to a number of technical tests, where it was functionally tested under different mobile connectivity conditions. Subjective assessment

[1] Behind the contest, carried out in the form of a so-called pre-commercial innovation procurement, were: The City of Stockholm, the Stockholm County Council's Traffic Division (responsible for the Greater Stockholm Public Transport system), the ITS Council, Kista Science City and VINNOVA (as funding agency, project № 2012-03084).

showed no increase in latency nor any deterioration of other performance aspects, even at rather limited connection speeds (EDGE). Hand-over between different connectivity standards (EDGE, 3G, HSDPA, 4G) was also seamless, due to special technology and functions developed and integrated in the server solution for this very purpose. A considerable amount of further log data was also collected but has not been analysed within the framework of the pre-study.

After testing, the prototype was then used primarily for demonstrations and workshops with representatives from the vehicle industry and several relevant potential stake-holders, including or national transport and traffic bodies and authorities.

5.3 Collaboration and exchange

This goal was fulfilled through **knowledge dissemination and mutual development** of the interface concept, focusing on industrial customer utility. One means for this was the joint development of a **collaborative project,** geared towards the development, demo and testing of said concept in heavy vehicles in real traffic.

A series of some 10 individual workshops was carried out with pre-identified potential stake-holders, including The Swedish Transport Administration (Trafikverket), The Swedish National Road and Transport Research Institute (VTI), and Scania. The purpose of these workshops was to disseminate knowledge regarding the area and the concept, and to form as wide a consortium as possible to further develop the technology and demo and test services and the interface concept *per se* in a follow-up project. During all workshops, the prototype was used as a tool for brainstorming, to illustrate potential customer utility and to demonstrate the technology's properties and abilities, e.g. speed, precision and ease-of-use.

An equally important part of this is the converse knowledge transfer occurring in the line of this, where the coordinator, Veridict, gained a better understanding of the potential stake-holders activities, goals and strategies. This continuous process demanded numerous meetings and contacts with each actor, but was necessary to identify the needs and driving forces necessary to formulate common development goals, and subsequently, potential collaborative projects. In particular, a series of meetings took place between Veridict and Scania, who had not previously collaborated, in order to fully understand each other's needs and objectives and set up collaboration between the relevant individuals.

(Time and other resources did not permit to also include insurance agency representatives at this stage, but this should be considered in follow-up projects.) Several potential project ideas were identified through these meetings, one of which was then selected to be substantiated in the form of a bi-lateral technical collaborative project proposal involving Scania and Veridict. The objective of said project is the development, demo and testing of a speech-enabled driver's HMI in vehicles connected to complex services. An initial interview survey (Krupenia 2015) among drivers at the Scania Transport Laboratory was carried out during preparation of the proposal, which has since been submitted to VINNOVA/FFI.

The overall approach of developing ideas through brainstorming following hands-on technology demonstrations has generally worked very well, both in evoking interest and in generating project ideas. One of these led to a declaration of intent and the further development of a joint bilateral development project between Veridict and Scania. The proposed project is geared towards the demo and testing of speech-based interaction with complex data sources in connected heavy vehicles. During development of the project proposal, the Vehicle HMI group at Scania made an initial survey with drivers from the Scania Transport Laboratory (Krupenia 2015). A project description was detailed, and preliminary resources were allocated, prior to submission to VINNOVA/FFI, where the proposal is currently under processing.

5.4 Contribution towards the goals of FFI

The pre-study contributes to all primary objectives of the FFI programme in the following way.

Traffic safety objective

The pre-study contributes to lowering the number of traffic casualties (fatalities and severe casualties) by the planned introduction of vehicle driver interfaces of three distinct types (I – III on pg. 7).

Environmental objective

The pre-study enables the use of complex in-vehicle connected services, primarily of type I and II above, which are necessary to achieve increased transport efficiency, and which thereby contribute to reduced fuel consumption, and to the associated reduction, per transported unit, of environmentally adverse emissions.

Competition

The pre-study has developed and disseminated know-how and technology within a future area of development, where deep knowledge and technical advancement is required, but where there is large commercial potential. This provides the basis for Swedish vehicle industry to employ knowledge-based production in an internationally competitive way.

Relevance to the road map pertaining to "Traffic safety and automated vehicles"

Deliverables from the pre-study include new design guidelines, new technology and the dissemination of knowledge around the technology, the concept and its application. This has been done through a series of workshops with representatives from traffic authorities, the ICT industry, vehicle research and industry. The design recommendations were also used to identify and prioritize among areas in need of further technical development, in preparation for relevant industrial future development in a proposed follow-up project.

The project has further contributed to competence development within behavioural science, HMI and cognition, identified as areas in lack of competence at the national level in the area road map. The pre-study has also led to bi-directional competence exchange between the ICT and vehicle industry, and thereby between an SME and one of the national OEMs. For Veridict, the pre-study has given an opportunity to strengthen its R&D activities, and also to keep and develop unique competences within a key technology. For Scania, the pre-study has made it possible to gain quick access to competence and technology, locally, in a competitive area, where any alternative strategy is associated with considerable draw-backs, e.g. time-consuming, market competition or lack of resources or competence. This close collaboration also vastly improves the chances that the new know-how which is built up (and is expected to be further developed in follow-up projects), will actually be implemented in the next generation of vehicle product life-cycle, and thereby directly generate customer utility based on the R&D effort produced by this pre-study. A substantial step in this direction is the formulation of a joint follow-up project by Veridict and Scania.

All of the above serves to strengthen national vehicle industry and its suppliers (incl. Veridict) directly as well as indirectly. It may also in a slightly longer perspective contribute also to other ICT research in related areas, e.g. Big Data and Internet of Things. For instance, the connected data-center-based service infrastructure, developed by Veridict, which was used to deploy the prototype in the pre-study, should be of value also to these areas.

The pre-study should contribute to growth in the long run by virtue of the potential for increased transport efficiency (by some judged to be in the order of 50%), which stems from better use of road transport capacity regarding both passengers and goods. A key component in this is the co-ordination and complex information interchange (comprising extensive, and manually unmanageable data volumes, so-called "Big Data"), between vehicle, driver, transport system and traffic control or fleet management. By removing handling obstacles and providing speech-based interface which enables the full participation of commercial vehicle drivers in this information exchange in a way which is easy to use, and enhances traffic safety, the pre-study contributes to such a solution and thereby to the realization of this commercial and societal utility.

Relevant areas within the programme

In relation to the FFI road map for the area, the contribution of the pre-study lies primarily within two areas: The contribution to **programme area D, "Driver support and related vehicle-driver interfaces"** relates to

- Distraction-reducing HMI systems
- Safe interaction between driver, vehicle and external systems
- Intuitive, adaptive, multi-modal interfaces
- Demographically-adapted HMI solutions
- Connected, vehicle-portable interfaces
- Solutions for distraction-related accident prevention

Withing **programme area A, "Vehicle and traffic safety analysis including enabling technology and knowledge",** the contribution lies mainly in the literature review which was carried out and which involved the charting, analysis and compilation of the state-of-the-art in research. This in turn has created increased understanding of how the object of study – in-vehicle speech-based interaction – can best be exploited to enhance traffic and vehicle safety. Another important contribution is the formulation of initial design recommendations, which – if they are verified, developed and tested – may well in time become generally applicable design guidelines, or an industry standard "best practice":

Several results within the pre-study should also be generally applicable also outside the vehicle industry. However, the interaction situation faced by a driver in a modern connected transport situation is without question quite specific, and as such puts highly specialized demands on system and interface performance. Therefore, the design recommendations, should they be applied to another area and with a different purpose, may therefore need to be modified accordingly.

6 Dissemination and publications

6.1 Dissemination of knowledge and results

The technology investigated and developed in the pre-study has its direct application in the transport system and requires collaboration between national vehicle industry actors and suppliers for its realization.
The proposed follow-up project is a clear step towards such collaboration, provided it is funded and carried out.

The timeframe for introduction of the technology could furthermore be considerably improved by collaboration between traffic safety authorities and the vehicle industry at the national level, where there are several potentially traffic safety-enhancing and/or transport efficiency-improving services and functions that can be envisioned. Traffic incident reporting of the type investigated and simulated in "Snabb Säker Väg" is one clear such example, where an authority with special responsibility for traffic safety, e.g. Trafikverket, could play an important role as a neutral, societal part, in speeding up development.

How are project results being disseminated and taken up?	Mark using 'X'	Comment
Increase knowledge in the area	X	Literature review, knowledge transfer through workshops
Brought on to other advanced technical development projects	X	Follow-up project formulated and submitted
Brought on to product development projects		
Introduction to the market		
Used in investigations/legislation/regulations or political decision making	X	Pertains primarily to the design recommendations developed

6.2 Bibliography

Publikationer i förstudien är Lindström (2015) och Krupenia (2015).

Eriksson, Alexander, Anders Lindström, Albert Seward, Alexander Seward, och Katja Kircher. ”Can User-paced, Menu-free Spoken Language Interfaces Improve Dual Task Handling While Driving?” *Proc. of HCI 2014.* Heraklion, Crete: Springer International Publishing, 2014.

Kircher, Katja, Anders Lindström, och Alexander Seward. *Hinder- och incidentrapportering i trafiken med tal respektive text – en simulatorstudie.* Linköping: VTI, 2014.

Krupenia, Stas. *Behovsinventering av talstyrning i tunga fordon.* Intervjuundersökning med chaufförer från Scanias Transportlaboratorium, Scania/RCDI, Södertälje: Scania, 2015.

Lindström, Anders. *Tjänsteutformning med helt nya tal- & språkgränssnitt i uppkopplade tunga fordon.* Lägesrapport (projekt 2014-05576), Stockholm: Veridict & VINNOVA/FFI, 2015.

7 Conclusions and future research

7.1 Conclusions

In summary, the conclusions drawn in the pre-study are the following:

- Speech-based interaction in heavy vehicles have the potential for improving traffic safety n several distinct steps
- These steps are **I)** handling existing systems and services in a safer way, **II)** handling new and to date inaccessible functions in a safe way, and **III)** dedicated traffic-safety enhancing services such as incident and obstacle reporting
- To achieve this, in-vehicle speech-based systems must be designed drawing on the strengths of communication by language, not by adding speech to a pre-existing menu-based design
- An initial set of design recommendations to this effect was proposed
- These recommendations need to be technically implemented, demo:ed, tested and verified in heavy vehicles in real traffic
- Vehicle industry, traffic authorities and other actors regard speech interfaces as necessary for traffic safety and to achieve competitive and efficient transport systems, but remaining uncertainty regarding roles and responsibilities in the future connected transport system makes the road ahead more complicated.

7.2 Future research

Through the pre-study, the participants and other stake-holders who have contributed have gained further insight in the demands on in-vehicle speech-based interfaces and how these can be used for increased transport efficiency and improved traffic safety in heavy vehicles. Several project ideas were formulated in workshops, two of which were developed into actual proposal, and one of which was submitted to FFI. That proposal is based on the conclusion that the design recommendations developed in the pre-study now need to be verified through demo and testing in vehicles in real traffic. The follow-up project is therefore focused on improving technology in critical areas, and developing a solution where speech interaction is an integral part of a multimodal driver HMI which enables swift and effortless interaction with complex data sources.

In general the traffic safety-related application possibilities for speech technology are considerable in the future connected transport system, even if there is still some uncertainty regarding the make-up of the latter. The distribution of roles and responsibilities between vehicle manufacturers, traffic authorities and operators is also difficult to predict.

There are several ways to take the results of the pre-study further. One would be to look at the role of the driver under increasing degrees of automated driving, where there are likely legal reasons requiring a driver to still be present in stand-by mode, ready to take over the task of driving. In that situation, speech-based interaction may be the only feasible option to handle work-related tasks, compatibility with both traffic safety and the demands posed by possible hand-over of responsibility. Another line of development would be to investigate how language- and speech-based interaction can be used not only on the vehicle drive's side but also in other sectors of the transport system, e.g. for traffic control, "fleet management" or on the passenger side in public transport by bus. A third aspect would be to investigate what role traffic safety-related authorities such as Trafikverket may hold in relation to this new technology. This would be relevant since the technology in itself may support "Vision Zero", by enabling genuinely traffic-safety-enhancing services. It would also contribute to environmental goals by making transport-efficiency-improving services accessible in a traffic-safe way. All this would, however, require much more profound integration towards the traffic system infrastructure, and would also need to be supported by technology for such integration.

8 parties and contact person

Dr. Anders Lindström
Senior Speech Technology Specialist
Veridict AB
Sveavägen 166
113 46 Stockholm
Phone: +46 (0)8 21 44 10

Key personnel from Trafikverket, VTI and Scania have also participated, at their own expense.