



# KAIA Förar- och fordonskompatibel alkoholsensor med inbyggd absolutmätning

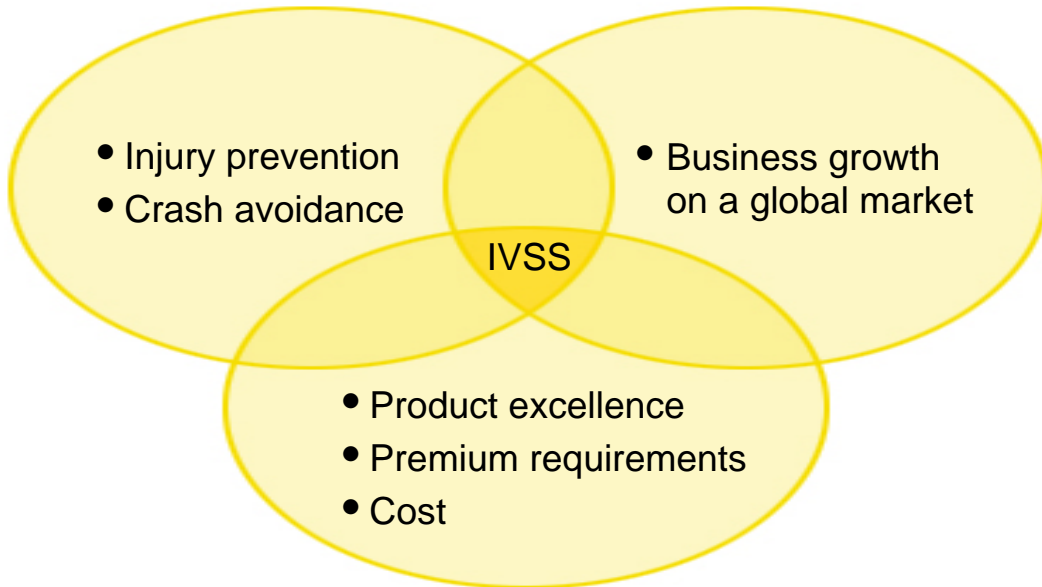
IVSS Project Report

2010-02-04

# The IVSS Programme

The IVSS programme was set up to stimulate research and development for the road safety of the future. The end result will probably be new, smart technologies and new IT systems that will help reduce the number of traffic-related fatalities and serious injuries.

IVSS projects shall meet the following three criteria: road safety, economic growth and commercially marketable technical systems.



**Three interacting components** - for better safety, growth and competitiveness:

## **The human being**

Preventive solutions based on the vehicle's most important component.

## **The road**

Intelligent systems designed to increase security for all road users.

## **The vehicle**

Active safety through pro-active technology.

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# Executive Summary

Alcohol related traffic accidents and fatalities account for about 25% of the total number according to statistics from Europe, the US and the rest of the world. At the same time, the alcohol interlocks used today are expensive, take a long time to warm up, require an exchangeable mouth piece and a yearly calibration. This was the background when we started the KAIA-project in 2005 with the final objective to design a user friendly alcohol interlock. However, such a project was regarded as rather risky associated with high costs. There were several reasons behind these arguments. The acceptance of alcohol sensors and interlocks by users and society was much less in 2005. In addition, the KAIA-concept was not proven and engineers and researchers with competences from various fields should be involved resulting in external costs. The support from IVSS was therefore a prerequisite for the start of the project!

The KAIA-idea which is based on simultaneous measurements of alcohol and CO<sub>2</sub> by the use of IR (InfraRed) technology results in a calibration free interlock not requiring a mouthpiece. This concept has been successfully implemented, evaluated and verified. As a result Autoliv have continued with further development and industrialization together with Hök Instrument AB and SenseAir AB. A pre-qualification of a generic prototype will be carried out during February and March 2010, with introduction in vehicles from 2013.

The KAIA-project has also resulted in further projects and funding. One example is the funding from the DADSS Program (Driver Alcohol Detection System for Safety), a partnership between NHTSA (the National Highway Traffic Safety Administration) and ACTS (the Automotive Coalition for Traffic Safety), in the US. This is a project aiming for the next generation of unobtrusive alcohol interlocks. Seventeen technology providers from around the world submitted proposals for developing a working prototype based on their DADSS technology concepts. Autoliv, with partners Hök Instrument and SenseAir, was one of three awardees receiving a fund of \$400,000 for the first twelve month phase. A second spin off project is related to medicine for emergency care where Hök Instrument has received funding from Vinnova for a future product which can be used also for unconscious persons to discriminate alcohol intoxication from other causes.

The KAIA-project has also contributed to Swedish research. First, an industry-based doctoral student was recruited to the project contributing to the small but very important group of Swedish researchers with good understanding of the conditions in industry. Further, Imego have started to cooperate with Göteborg International Bioscience Business School (GIBBS) for the development of products, with applications outside automotive, based on the KAIA concept.

We were invited to participate in the development of a new CENELEC standard and as a result the Swedish representatives managed to propose and establish a new standard for alcohol interlocks without having a mouth piece.

A massive introduction of alcohol interlocks world wide will considerably reduce the number of alcohol related accidents, injuries and fatalities. As an example, if alcohol interlocks were installed in all vehicles in the US it is estimated that 10,000 lives could be saved annually. Further, it is reasonable to assume that KAIA-based units and systems will take a considerable market share!

Sales of alcohol sensing devices based on the KAIA-principles will contribute to economic growth primarily for Autoliv and SenseAir. In addition, Hök Instrument has recruited three professionals and the company now foresee further economic growth as a direct consequence from the results of the KAIA-project.

# Projektsammanfattning

Alkoholrelaterade trafikolyckor står för ungefär 25% av det totala antalet enligt statistik från Europa, USA och resten av världen. Samtidigt är de alkolås som användes idag dyra, tar lång tid att värma upp, kräver utbytbara munstycken och behöver kalibreras om en gång per år. Med detta som bakgrund startade vi KAIA-projektet 2005 med målet att konstruera ett användarvänligt alkolås. Ett sådant projekt ansågs emellertid som ganska riskfyllt och förenat med stora kostnader. Det fanns flera skäl bakom det resonemanget. Acceptansen hos användare och samhället för alkoholsensorer och alkolås var inte lika stor 2005 som den är nu. Dessutom var KAIA-konceptet oprövat och forskare och ingenjörer med kompetenser inom skilda områden måste involveras i projektet, vilket i sin tur skulle leda till stora kostnader. Stödet från IVSS var därför en förutsättning för att projektet överhuvudtaget skulle starta!

Idén bakom KAIA är att samtidigt mäta alkohol och CO<sub>2</sub> med hjälp av IR-teknik (Infra Röd), vilket resulterar i ett kalibreringsfritt alkolås som inte kräver något munstycke. Konceptet har nu utvärderats och verifierats med gott resultat. Som en följd av detta har Autoliv gått vidare med den fortsatta utvecklingen och industrialiseringen tillsammans med Hök Instrument AB och SenseAir AB. En generisk prototyp kommer att förkvalificeras under februari och mars 2010, och produkten kan introduceras i fordon från och med 2013.

KAIA-projektet har också resulterat i följdprojekt med extern finansiering. Ett exempel är stödet från DADSS-programmet (Driver Alcohol Detection System for Safety), vilket är ett samarbete mellan NHTSA (the National Highway Traffic Safety Administration) och ACTS (the Automotive Coalition for Traffic Safety) i USA. Det här programmet har som mål att utveckla nästa generations alkolås där det inte behövs någon aktiv medverkan från föraren. Sjutton företag från hela världen kom in med förslag på att utveckla demonstrationsprototyper baserade på sina respektive "DADSS-teknologier". Autoliv, med sina samarbetspartners Hök Instrument och SenseAir, var ett av tre konsortier som valdes ut, vilket resulterade i ett bidrag på 400 000 USD för den första tolv månadersperioden. Ett annat spin off-projekt handlar om diagnos och medicinering inom akutsjukvården där Hök Instrument fått finansiering från Vinnova för en framtida produkt, (vilken också kan användas på medvetslösa personer), avsedd att särskilja kraftig alkoholberusning från andra orsaker.

KAIA-projektet har också bidragit till svensk forskning. För det första, en industridoktorand rekryterades till projektet och hon kommer att bli en del av din lilla men mycket viktiga grupp av svenska forskare med en bra förståelse för industrins förutsättningar och villkor. Dessutom har Imego startat ett samarbete med GIBBS (Göteborg International Bioscience Business School) för att utveckla produkter, som ej ligger inom området fordonssäkerhet, baserade på KAIA-konceptet.

Vi blev också inbjudna att medverka vid framtagningen av en ny CENELEC-standard, och som ett resultat lyckades den svenska delegationen att föreslå och genomdriva en ny standard för munstyckslösa alkolås.

Ett massivt införande av alkolås över hela världen kommer att avsevärt minska antalet alkoholrelaterade trafikolyckor, skador och dödsfall. Som ett exempel har det uppskattats

att omkring 10000 liv skulle kunna räddas om alkolås installerades i samtliga fordon i USA. Det är dessutom rimligt att förmoda att produkter baserade på KAIA-teknologi skulle ta en stor marknadsandel av dessa.

Försäljningen av alkoholsensorer och alkolås baserade på principerna bakom KAIA kommer att bidra till ekonomisk tillväxt hos Autoliv och SenseAir i första hand. Dessutom har Hög Instrument anställt tre ingenjörer och forskare med hög kompetens och företaget förväntar sig nu ytterligare ekonomisk tillväxt som en direkt följd av resultaten från KAIA-projektet.

# **1. Introduction and background**

## **1.1 Fatalities in alcohol related traffic accidents**

Driving under the influence of alcohol is one of the major reasons for a large number of fatal traffic accidents each year. For instance alcohol is a contributing factor in about 25% of the fatal accidents which occur on European roads. In the US there were about 13 000 fatalities in crashes 2005 with drivers having a BAC (Blood Alcohol Content) of 0.08% or higher.

## **1.2 Political initiatives and market development**

At present, alcohol interlocks are used mainly for repeat drink-drive offenders, but also in quality assurance programs for taxis and school buses. Over 60 000 interlocks for commercial applications have been installed in Sweden alone. Interlocks will soon be installed in school buses in France and Denmark, Belgium and Norway have initiated programs related to commercial and public transport. Another example is the DADSS (Driver Alcohol Detection Systems for Safety) initiative in the US aiming for a massive introduction of unobtrusive alcohol sensing systems also in private vehicles.

At the moment, about 12,000 alcohol interlocks are sold annually in Sweden for the quality of assurance of transports. Although Sweden is in front when it comes to using alcohol interlocks within public transport, also other countries will contribute significantly in the coming years. In addition, the use in private vehicles is expected to grow significantly.

## **1.3 Current alcohol interlocks and the KAIA-technology**

Today's alcohol interlocks use fuel-cell or semiconductor technologies. However, products based on these technologies have some shortcomings in cost and/or reliability. The objective with the KAIA project was to verify our ideas aiming at a future product which could overcome these shortcomings.

# **2. The KAIA concept in summary**

The alcohol sensor project (KAIA) started 2005 as part of the Swedish Intelligent Vehicle Safety Systems program (IVSS). The objectives of KAIA-project were to demonstrate and validate alcohol sensing solutions meeting the demands of large user groups. Some specific goals were established for this project:

- Contact free without mouthpiece
- Completely maintenance free
- Reliable

- Hard to manipulate
- Hygienic
- Cost-effective
- Fast response time

A more detailed technical description is provided in the enclosed manuscript, in Appendix A. B. Hök, H. Pettersson, A. Jonsson, S. Haasl, P. Åkerlund: “Breath Analyzer for Alcolocks and Screening Devices”. IEEE Sensors Journal. In press.

Eight patent applications have been filed within the KAIA-project.

## 2.1 Contact free without mouthpiece, selective

Within the KAIA concept, the concentrations of alcohol and CO<sub>2</sub> in the open airflow from the test person are measured, i.e. it is contact free without a mouthpiece. The equation below describes the patented principle, and it is based on the fact that the CO<sub>2</sub> concentration from the lungs is fairly constant and/or can be calculated. It illustrates the relationship between the externally measured CO<sub>2</sub> and alcohol (EtOH) concentrations and their respective values in the body:

$$C_{EtOH} = C_{extEtOH} \cdot \frac{C_{CO2}}{C_{extCO2}}$$

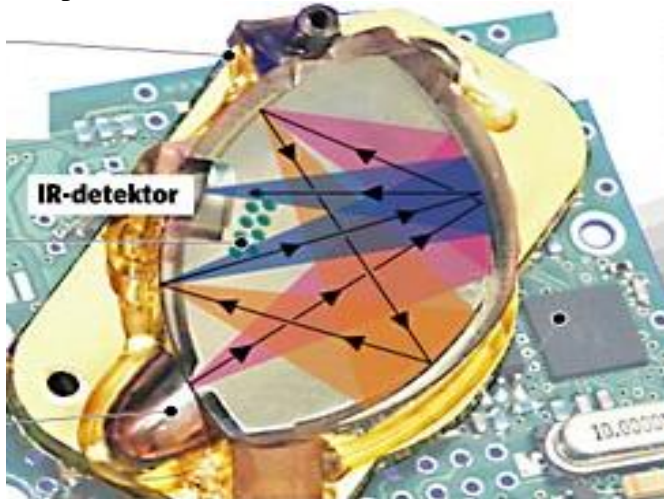
The validity of the basic relation has been the subject of extensive studies within the project. In one investigation, the variability of end-expiratory CO<sub>2</sub> concentration between healthy subjects and patients suffering from obstructive lung disease was studied. The results from this study indicate that the influence on the estimated alcohol level will be comparable to those from other physiological effects when using conventional alcohol interlocks with a mouthpiece. Furthermore, it was found from the expirograms (exhaled concentration vs time during a breath) that the ratio EtOH/CO<sub>2</sub> ratio can be reliably predicted after 2 seconds, thus allowing the process of breath sampling to be shortened in time and easier for the subject. Breath analyzers according to the state of the art require 5 seconds of continuous exhalation, and a minimum volume of more than 1 litre, which can be difficult for many persons.

The selectivity of alcohol detection is an important issue, both with respect to endogenic substances which may be present in the breath air, e.g. acetone, and exogenic substances which may be present in the ambient air. In principle, IR spectroscopy provides almost limitless possibilities to identify the “finger print” of organic molecules, including EtOH. The requirements listed in the CENELEC standard EN50436-1 include 13 substances that were uncritically adopted from an earlier standard for evidential instruments.

## 2.2 Maintenance free, reliable and fast response time

The measurement principle used in the KAIA project is non-dispersive Infra-Red technology. This measurement principle is the same as the one used in the advanced measurement instruments used for evidencing and has a higher accuracy and specificity (ability to discern alcohol from other substances) than e.g. the fuel cell technology used in most alcohol interlocks. As opposed to fuel cells, IR-based sensors can be stable over the full product lifetime, eliminating the need for recurrent calibrations.

A patented optical device using multiple reflections, see figure below, makes it possible to calculate the level of alcohol with high resolution. The time to warm it up is fast compared to a fuel based alcohol sensor due to its small thermal mass.

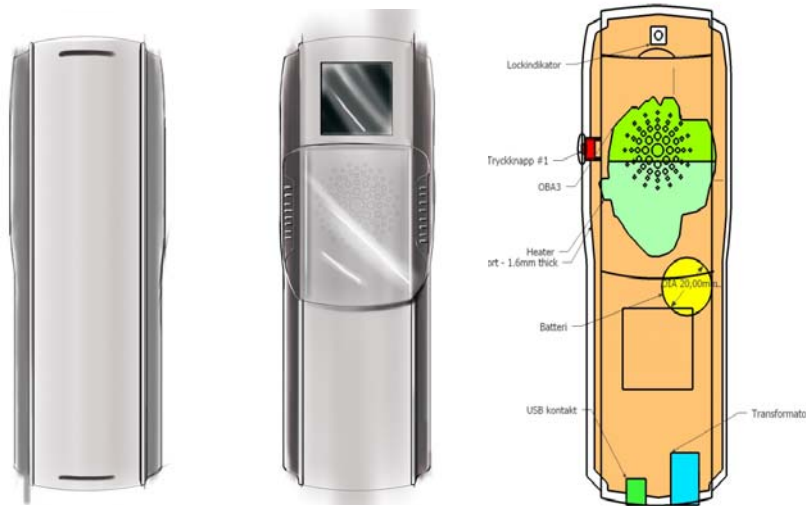


## 2.3 User acceptance and HMI

The issues of user acceptance and HMI have been addressed during the project. Several studies in different vehicles have been performed.

## 2.4 Prototypes

The figures below show handheld prototypes. First, an initial reference measurement is done and then the driver opens the cover and blows towards the alcohol sensor at a distance of 10-30 cm. The whole sequence takes a couple of seconds and the result can be shown as OK or not OK or alternatively, the result can be displayed as the registered alcohol level.



## 3. The next KAIA-phases. Product development, industrialization, HMI

### 3.1 Product development and industrialization

Autoliv started the next phase of the project, the development phase, in 2008 in cooperation with Hök Instrument AB and SenseAir AB, a work financed by Autoliv. The main focus in this project is to develop and qualify a generic optical assembly which can be the basis in hand held products.

Compared to the first prototypes discussed in the previous paragraph, several characteristics have been improved for instance the measurement resolution which is now better than the requirements listed in the CENELEC-standard. In addition real tests have been performed with the most important, and difficult, interfering substances in the CENELEC-standard with good results. We have also a good understanding of the influence from other interfering effects and countermeasures have been implemented and their positive effects have been verified.

We are now, in January 2010, in the process to initiate an "automotive qualification" not only comprising standard automotive requirements but also including other phenomena and environments essential for the chosen technology. The work is planned for Q2 2010, A- B and C-samples will follow 2010-2012, and introduction in vehicles are planned from 2013.

In addition, SenseAir have carried out a detailed industrialization investigation comprising aspects such as; methods for calibration including cost issues and material considerations.

### 3.2 HMI-clinics

One important aspect is related to HMI. Several “HMI-clinics” were performed during the IVSS-funded part of the project. That approach has been revised and further evaluated and improved after the IVSS part of the project. In particular, the project partners, in this case Autoliv, Hög Instrument, SenseAir, Volvo and Volvo Cars, have performed two “HMI-clinics” funded by SRA (The Swedish Road Administration). More than 150 persons participated and made their evaluation of four different opening covers. They also rated the easiness to blow. The four different prototypes and their characteristic opening covers are shown below.



The results from this clinic have been fundamental when it comes to the development of the final generic prototype and it will have great impact on the first hand held product.

## 4. Further work made possible by the KAIA-project

### 4.1 Alcometer for emergency care

Approximately every fifth patient admitted to emergency care is intoxicated by alcohol. Serious conditions, like stroke, coma and epileptic seizure may be mistakenly taken for drunkenness. Deaths occurring in police custody are tragic demonstrations of such mistakes. There is a need for a quick and yet reliable test of breath alcohol concentration which could be used both by paramedics and at emergency care units. At present, adequate action is delayed by several hours due to the dependence on blood analysis. State-of-the-art alcometers are not useful in these patients, since they require active participation and forced expiration.

Hök Instrument AB is developing a new alcometer for use even in unconscious patients. The project is a direct spin-off from the KAIA project. A significant part of the system solutions are common, e.g. simultaneous measurement of CO<sub>2</sub> concentration, which in the clinical context can provide valuable additional information about the patient condition. The project has received Swedish governmental support from VINNOVAs Forska & Vax program. During 2010 prototypes will be developed and evaluated in cooperation with clinical partners at the Academic Hospital, Uppsala, and Falck Ambulans AB, Stockholm.

For more information, please contact Bertil Hök, [bertil@hokinstrument.se](mailto:bertil@hokinstrument.se) or Annika Kaisdotter-Andersson, [annika@hokinstrument.se](mailto:annika@hokinstrument.se).

### 4.2 DADSS (Driver Alcohol Detection Systems for Safety)

The DADSS Program, a partnership between the National Highway Traffic Safety Administration and the Automotive Coalition for Traffic Safety in the US, is exploring new advanced alcohol detection technologies that one day could be developed for widespread use. The program is aiming for a non-obtrusive alcohol detection system for the sober driver with a tentative introduction on the market from 2016?

Seventeen technology providers from around the world submitted proposals for developing a working prototype of their DADSS technology concepts. Autoliv, with partners Hök Instrument AB and SenseAir AB, was one of three awardees receiving a fund of \$400,000 for the first twelve month phase. The aim is to develop a POP (Proof of Principle) prototype. In the second phase one or possibly two concepts will be selected for prototype development with integration into a vehicle.

Our approach is to develop the KAIA-concept one step further and identify small variations in the air composition with an arm-length distance to the driver's mouth and nose. The intention is to use Infrared (IR) Spectroscopy as the sensing principle for both alcohol and CO<sub>2</sub>, with the unique prospect of this technology to provide high sensitivity, specificity and system reliability. By measuring the correlating signal variation between alcohol and CO<sub>2</sub>, the detection of the presence of alcohol within an arm-length of the driver can be accomplished.

### **4.3 GIBSS (Göteborg International Bioscience Business School)**

Imego have started to cooperate with Göteborg International Bioscience Business School (GIBBS) for the development of products, with applications outside automotive, based on the KAIA concept.

## **5. Project participants and consortium**

The project consortium and its partners were specifically chosen for this particular project. It was essential to include relevant competences covering research (Imego), innovators (Hök Instrument AB), final producer (Autoliv) and system user (VCC and Volvo) already from the early phases of the project. In addition SenseAir AB joined the consortium for the final KAIA-phase, adding competence in optical gas measurement and experience from industrialization and high volume production of products based on a similar measurement principle.

In addition experts from other parts of the Swedish society, e. g. SRA (The Swedish Road Administration) and MHF (The Swedish Motorists Abstaining Organization) were invited to participate in the reference group.

Experts within medicine and forensic sciences did also participate on a regular basis in the project.

All in all some 40 people have contributed to the project from 2005 to 2008.

## **6. Impact on economic growth**

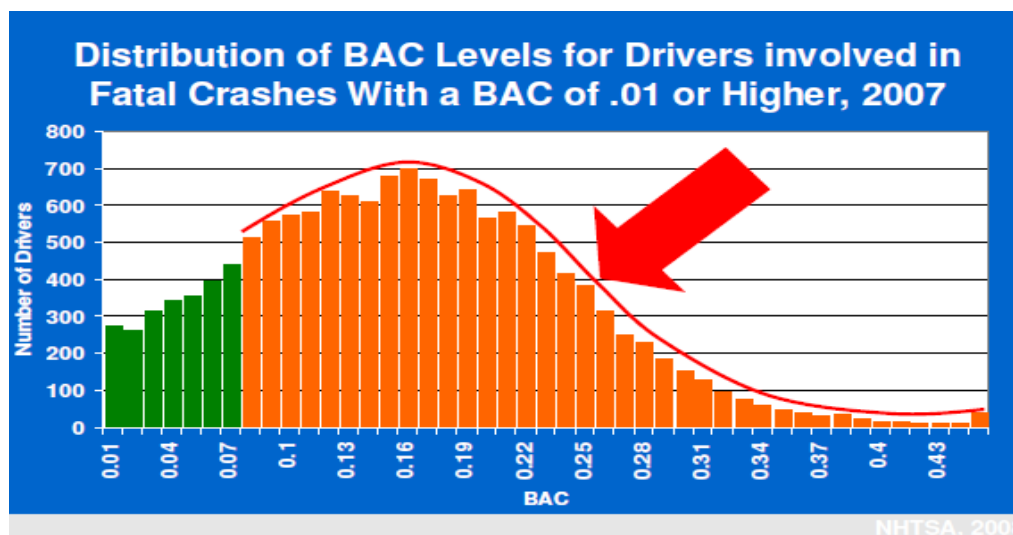
Based on the discussions about the number of alcohol related fatalities, it is obvious that there is a need for reliable, user friendly and cost effective alcohol sensors. This has been recognized by several organizations and initiatives such as DADSS (Driver Alcohol Detection System for Safety). The market for alcohol sensors and interlocks is therefore expected to grow first within quality assurance of transports and then for private vehicles. Autoliv have therefore identified alcohol sensing as one strategic future business area. Further, it is reasonable to assume that KAIA-based units and systems will take a considerable market share. Therefore, sales of alcohol sensing devices based on the KAIA-principles will contribute to economic growth primarily for Autoliv and SenseAir.

The KAIA project has had great impact on the development of Hök Instrument AB. The staff has grown from three to six employees, all highly skilled with respect to engineering competence. The basic KAIA concept is potentially useful in a medtech application which Hök Instrument has chosen to exploit on its own after approval from Autoliv, which is discussed in paragraph 4.1

The KAIA-project has also resulted in other spin off effects; we got an award from the DADSS program and Imego could start their cooperation with GIBBS. This might result in future products contributing to further economic growth.

## 7. Impact on traffic safety

Driving under the influence of alcohol is one of the major reasons for a large number of fatal traffic accidents each year. For instance alcohol is a contributing factor in about 25% of the fatal accidents which occur on European roads. In the US there were about 13 000 fatalities in crashes, in 2005, with drivers having a BAC (Blood Alcohol Content) of 0.08% or higher. In fact, most of these drivers had a BAC much higher than the legal limit which is seen in the figure below (From “Star Wars meets drunk driving; A technological solution to eliminate drunk driving” a presentation by Susan Ferguson August 2009 at the New Mexico DOT Traffic Safety Summit). Further, if alcohol interlocks were installed in all vehicles in the US it is estimated that 9,000 lives could be saved annually.



The statistics for the rest of the world is not documented in such detail but it is reasonable to assume similar figures. We can therefore assume that alcohol related fatalities in the traffic accounts for at least 25% of the total number.

## 8. Impact on research. Industry-based doctoral student.

Technical Licentiate Annika Kaisdotter Andersson (née Jonsson) was employed at Hök Instrument AB in September 2007. She has been responsible for the methodology evaluations of the measurement method. The method has been evaluated with respect to the assumptions on which it relies; similarities in the characteristics of the expiration profiles (expirograms) of ethanol and carbon dioxide (CO<sub>2</sub>), and small intra- and interindividual variations in the partial pressure of CO<sub>2</sub> after a complete expiration. The measurement method has been evaluated both with respect to breath test of small and larger volume, and provocative breathing pattern e.g. hyperventilation and breath holding.

These clinical studies has been done in collaboration with Göran Hedenstierna, Prof. in Clinical Physiology at Uppsala University hospital, and has resulted in two academic papers, see reference list.

Further, in May 2008 she participated as the representative from the KAIA project at “The Robert F. Borkenstein Course on Alcohol and Highway Safety: Testing, Research and Litigation”. Indiana University, USA.

She will defend her doctoral thesis in September 2010. The scope of the thesis is improved breath alcohol analysis with respect to user-friendliness and quality check of the breath sample, in the applications of alcohol ignition interlock, and breath alcohol analysis in emergency care.

Annika Kaisdotter Andersson has also been responsible for activities related to human-machine interface within the project. With a contact-free measuring alcohol ignition interlock the breath test technique is different compared to state-of-the-art devices, and the use is un-supervised. For these reasons resources has been assigned to study how future user’s experience to perform contact-free breath tests, their interaction with the device, and their need of visual and acoustic feedback.

## **9. Conclusions and recommendations**

The support from IVSS was a prerequisite for the start of the project.

The KAIA-concept has been implemented, evaluated and successfully verified in this three-phase project funded by IVSS, contributing to:

-The ongoing development and industrialization project of a hand held alcolock unit with tentative introduction in vehicles from 2013.

-A spin off project related to an alcometer for emergency care. This project has received funding from Vinnova

-A project aiming for the next generation of unobtrusive alcohol interlocks based on KAIA-principles. This project has received funding from the DADSS-programme.

Sales of alcohol sensing devices based on the KAIA-project and its spin off results will contribute to economic growth on a global market.

A massive introduction of alcohol interlocks world wide will considerably reduce the high number of alcohol related accidents, injuries and fatalities. It is reasonable to assume that KAIA-based units and systems will take a considerable market share!

An industry-based doctoral student was recruited to the project in 2007 contributing to the small but very important group of Swedish researchers with good understanding of the conditions in industry.

We were invited to participate in the development of a new CENELEC standard and as a result the Swedish representatives managed to propose and establish a new standard for alcohol interlocks without having a mouth piece.

Eight patent applications have been filed.

If we should start a similar project now, we would of course treat a lot of subjects differently, but there are certain things we can recommend:

-It was clearly defined from the beginning that the final goal was a product and not academic papers! Hence, all research was motivated by the final product.

-Volvo Cars and Volvo accepted to be involved very early in the project. This had at least two effects. First, the Volvo companies provided specifications and performed HMI clinics together with the rest of the consortium which was invaluable for the project. Second, a better mutual understanding of the conditions for the various partners was created; of value also in future projects.

-In addition to regular project meetings with the KAIA-partners, we also established a reference group with experts from MHF (The Swedish Motorists Abstaining Organization) and SRA (Swedish Road Administration). This cooperation gave us valuable knowledge related to the conditions for the use of alcohol interlocks in the area of quality assurance of transports but also insights in possible tampering attempts. Even more important is the network which was established and further collaboration which might influence the introduction of alcohol interlocks.

## 10. Publications and presentations

B. Hök. ”Morgondagens alkolås”.Electronix Scandinavia 2006, Sensorteknologi, mikro- och nanoteknologi, Göteborg, 7 september 2006

B. Hök, H. Pettersson, A. Jonsson, S. Haasl, P. Åkerlund: “Breath Analyzer for Alcolocks and Screening Devices”. IEEE Sensors Journal. In press.

A. Jonsson, B. Hök, L. Andersson and G. Hedenstierna: “*Methodology investigation of expirograms for enabling contact free breath alcohol analysis*”, J. Breath Res. **3** (2009)

Bertil Hök, Håkan Pettersson.” Infrared Technology for Alcolocks”. 9<sup>th</sup> Annual Interlock Interlock Symposium. August 24-26, 2008 Tällberg Sweden

Håkan Pettersson, Bertil Hök. “Alcohol Sensors for Automotive – Overview and a New Approach to Breath Alcohol Measurements” Sensor4car, 14-15 October, 2008 Kempten Germany

Bertil Hök, Annika Jonsson, Hök Instrument AB, ” Nästa generation av alkosensor – ett teknikskifte”, Transportforum 8-9 januari 2009.

H. Pettersson, B. Hök. Intelligent Vehicle Safety Systems (IVSS) in daily life. Presentation at ITS World Congress, Stockholm 23 September, 2009.

Project: Alcometer for emergency use”

A. Jonsson, B. Hök, M. Ekström "Development of a breath alcohol analyzer for use on patients in emergency care", World congress 2009 in Medical Physics and Biomedical Engineering, München, 7-12 September 2009.

A. Kaisdotter Andersson, B. Hök. "Improved breath alcohol analysis in patients with depressed consiousness", Medicinteknikdagarna 2009, Västerås, 28-29 september 2009.

## Appendix.

B. Hök, H. Pettersson, A. Jonsson, S. Haasl, P. Åkerlund: “Breath Analyzer for Alcolocks and Screening Devices”. IEEE Sensors Journal. In press.

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