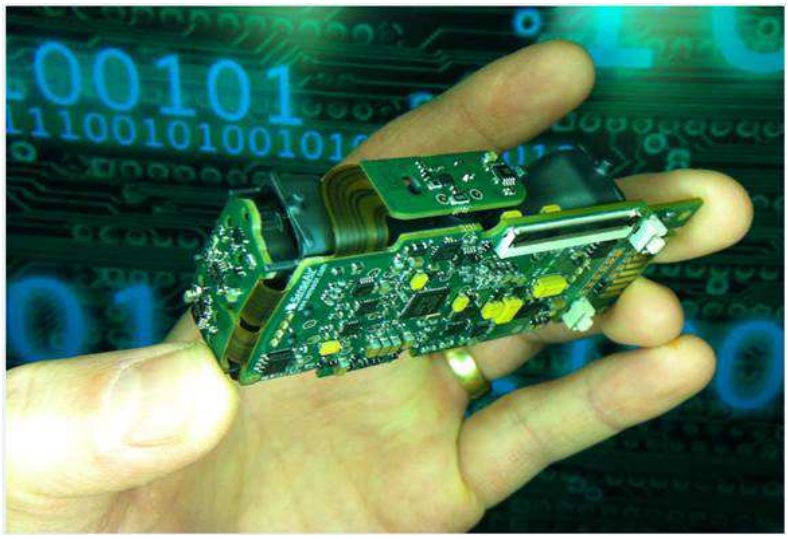
iBASS. (integrated Breath Alcohol Sensor System). Final report.



Project within: Traffic Safety and Automated Vehicles

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Content

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

The project was mainly carried out in accordance with the original plan. The initial field operational test by VCC was slightly shorter than planned. On the other hand, the total project costs for the other partners became higher than planned.

A field operational test performed by personnel from VCC was done between February 2014 and August 2014 with totally more than 4000 tests. No degradation in performance could be observed afterwards. In addition, the driver acceptance was generally high. These results therefore formed the fundamental basis for the further iBASS-work.

Future requirements concerning the dimensions of handheld and integrated alcohol sensors are very challenging. In this project we have shown that a product could be of similar size as a small modern mobile phone.

We performed several studies related to possible interfering and disturbing factors and substances inside the vehicle. As a result from one of these investigations we observed that there is no influence on the alcohol sensor performance from intoxicated passengers

A user interface was developed where the instructions and information to the driver was done by LEDs (Light Emitting Diodes).

The algorithms have been further developed resulting in shorter warm up times especially from very low temperatures.

After discussions between VCC and Autoliv, we abandoned the idea to utilize integrated alcohol sensors in the next field test. Instead, hand held prototypes will be used which will result in a more flexible approach.

Scientific investigations were carried out in order to find out the fundamental technical limitations of the iBASS-concept. These results have been published at international conferences and in peer-reviewed journals

2. Background

In 2005, Autoliv started the KAIA project (acronym based on “förar- och fordons-kompatibel alkoholsensor med inbyggd absolutmätning”) with Imego and Hök Instrument as partners, with the objective of developing new solutions for breath alcohol determination of vehicle drivers. The work was motivated by the high mortality of alcohol related traffic injuries. In most countries 20-30% of traffic accidents with lethal

outcome are related to driver alcohol intoxication, although, in a country like Sweden, an overwhelming majority (>99%) of all drivers are sober.

Basic concept analysis was performed in the next KAIA phase under the leadership of Autoliv, with Imego, Hök Instrument and the additional partners Volvo Cars, AB Volvo, and SenseAir. A new concept was introduced based on using CO2 as a tracer gas and identifier of breath in a diluted breath sample. Hence, there is no longer a need for a mouthpiece. Infrared spectroscopy was selected as the basic sensor solution, which means that it is not necessary to perform recalibration of the alcohol sensor. Such services must generally be performed annually on conventional sensors.

The concept, to measure without mouth piece and with no requirements to make annual recalibrations, was evaluated and finally qualified by the DADSS-initiative (Driver Alcohol Detection System for Safety). A cooperation with DADSS, ACTS (Automotive Coalition for Traffic Safety) and NHTSA (National Highway Traffic Safety Administration) was then initiated in 2011.

Over the years our efforts to develop user friendly alcohol sensors have been supported and partially financed by IVSS (Intelligent Vehicle Safety Systems), Vinnova (Sweden's innovation agency), the Swedish Transport Administration, FFI-Strategic Vehicle Research and Innovation, and ACTS/NHTSA. However, the project partners and especially Autoliv has been the main financier.

Our work with prototypes in laboratories and with vehicle drivers resulted in a proof of principle concept in 2013 which most likely would result in future user friendly alcohol sensors. Still, much work related to R&D, field tests and human subjects testing remained before the industrial development could start. The objective with the iBASS-project was to bridge the gap from proof of principle prototypes status to the start of proper development programs.

3. Objective

The main purpose with the iBASS project was to demonstrate that it will be possible to develop and manufacture new and user friendly alcohol sensors. The acceptance from drivers must be investigated and the principles for a new and smaller design must be established in order to develop future products which can be integrated in vehicles. In addition, human subjects tests to investigate the variation in sensor response for different dilutions when the test person blows towards the sensor from various distances must be carried out. Finally, possible influence from foreign substances such as washer fluid but also from intoxicated passengers should be studied.

4. Project realization

WP1. Initial laboratory and field tests with existing handheld units

The initial tests performed within this WP addressed previous experience with earlier developed devices, and had the objective of clarifying issues with usability. The tests were divided into one part performed within the project group at Autoliv, SenseAir and Hök Instrument, involving a total number of ten test drivers and ten devices. The tests were performed during the Swedish winter season between December 2013 and February 2014, to provide experience from cold ambient conditions.

The second phase was performed by staff at Volvo Cars from February 2014 to August 2014, involving 12 drivers and devices. The drivers were instructed to perform tests at various circumstances, including unsober tests. They were also encouraged to try to "fool the system". Fig 1 shows a typical setting from a vehicle interior.

Fig 1. Vehicle interior from field test performed on devices developed before the start of the iBASS-project.

The results of the field tests can be summarized as follows:

- More than 4000 breath tests were performed, the majority of them inside vehicles
- No device failures were noted
- No false “red” indications were noted
- No false “green” indications were noted
- Some uninstructed users had difficulties to obtain an approved breath sample. However, after 3-4 attempts most users learned how to provide an accepted sample
- False tampering indication remains to be an issue.

WP2. Research, pre-studies, simulations and design modifications

In this work package air flow simulations were performed intended to improve the air passage and purging times in the measurement cavity. A number of possible geometries were tested, and the implementation of the CO2-channel could be optimized.

As a result from the work the dimensions of the new sensor cavity could be decreased to approximately 64 x 40 x 18 mm and the optical path of the EtOH channel was still close to one metre. The smaller dimensions facilitate integration in the vehicle while the long optical path length is a condition for a high measurement resolution! Figure 2 shows a photograph of the assembled sensor cavity and its electronics and a complete model of the entire system is shown in figure 3.

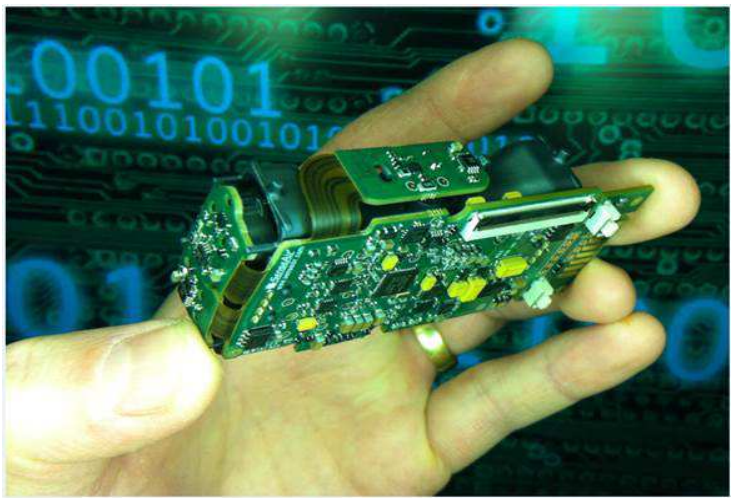

Fig 2. Photograph of the assembled sensor cavity and its electronics.

Fig 3. Transparent model av the complete system..

WP3. Laboratory and human study test results

This work package is addressing the problems related to the performance and the influence of environmental factors on the iBASS system.

The cross sensitivity to other substances, including acetone, diethyl ether, ethyl acetate and methanol were investigated. Methanol exhibits the largest cross sensitivity, but the requirements of EN50436-1 are fulfilled with good margin.

The initial tests with intoxicated passengers in vehicles have shown that they have a negligible influence, if any, on the measurement performance of the sensor system. However, washer fluid will have a significant impact but the sensor signals are bigger and different than those from a very intoxicated driver. Thus, by using intelligent signal processing the washer fluid case can be identified as a false positive signal.

The signal resolution is illustrated in fig 4 showing an Allan plot, in which the rms (root mean square) noise is plotted against the duration of a time window. Using an integration time of 1 second the resolution is approximately 0.0013 mg/l, which is more than an order of magnitude better than the allowed error, 0.02 mg/l, according to the industrial standard for alcohol interlocks EN50436-1.

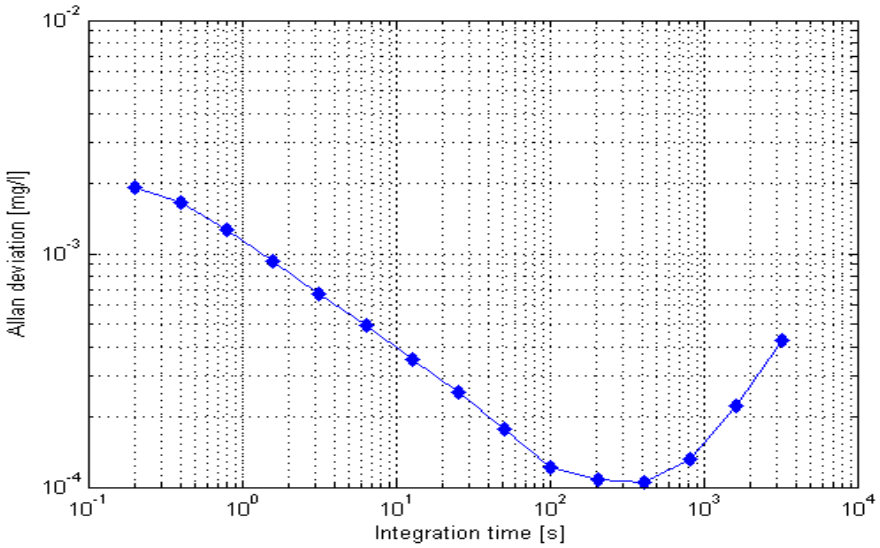

Fig 4. Allan plot characterizing the signal behavior over time (see text).

WP4. HMI and user interface

Several user interfaces have been developed and evaluated. They can be based on sound and/or LEDs (Light Emitting Diodes). One example which was implemented in the prototype which was demonstrated at the ESV-conference in Gothenburg in June 2015 is shown in figure 5. In this prototype light emitting diodes which could twinkle or alternatively shine with a fixed light were used to instruct and inform the driver.

Fig 5. Example of user interface based LEDs

WP5. Algorithms

Various sensor algorithms have been further developed and modified for the iBASS application.

The measurement algorithm has been optimized and the stochastic noise was reduced after the introduction of a new sampling technique. The final result is an improved measurement accuracy!

The algorithm controlling the startup time of the sensor has been further improved and the warm up time especially from very low temperatures can be reduced.

WP6. Tests in vehicles

The work carried out in this work package was done in cooperation with the DADSS-project

One goal is to find the best possible sensor position when the driver exhales towards the sensor from a long distance, but also for an entirely passive sniffer system. A test setup when the exhaled air comes from an artificial model is shown in Figure 6.

Fig 6. Vehicle compartment flow experiments were conducted using a model of a breathing human being.

Test have also been done when intoxicated drivers enter a vehicle. The sensor signals, with the unit positioned close to the seat belt, from such an experiment are illustrated by the graphs in Figure 7.

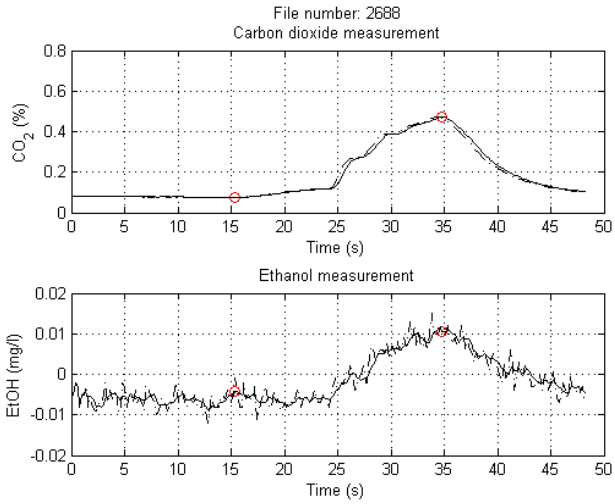

Fig 7. Passive sensor signal response to an intoxicated driver upon entrance into the vehicle. Sensor position: Seat belt.

WP7. Scientific investigations, publications, and patent applications

Parts of the technical results have been published and presented at conferences, workshops and other public or non-public events. See paragraph 6.2 “Publications”.

Four patent applications have been submitted, see table 1,

Patent application number	Title	Applicant
GB1420647.8	Alco sensor heater	Autoliv
GB1500640.6	Alco sensor microphone	Autoliv
EP15172431.7	Breath analyzer with tampering detection based on image processing	Autoliv
US62/171,566	Integrated breath alcohol sensor system	SenseAir

Table 1. Patent applications

5. Results and deliverables

5.1 Delivery to FFI-goals

The results from the iBASS-project are in many cases directly related to the objectives in the FFI-initiative. The main objectives in the project have been reached which have resulted in new projects, which will contribute to the long term goals; to introduce new innovative products on the global market, which will strengthen Swedish industry, but also to decrease the number of alcohol related fatalities on the roads.

The cooperation with DADSS, ACTS and NHTSA has been extended during the iBASS-project. The final goals for DADSS are entirely passive alcohol sensors which can be introduced worldwide in personal vehicles with the potential to significantly reduce the number of deaths caused by alcohol.

Further the results from iBASS was a prerequisite for the Vinnova project ´Facilitating sustainable production of alcohol sensors targeting global reduction of alcohol related fatalities´. This project is targeting very high volumes. However, we plan to start the production of alcohol interlocks, in very low volumes, for the aftermarket already in 2017. This product has a mouthpiece but in all other aspects it will be very similar to the iBASSS concept.

A new product, based on ideas from the iBASS-concept, related to passage system has already been introduced.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The results from the iBASS-project have been disseminated at universities by visiting lecturers.

6.2 Publications

The results have been published at international conferences and in peer-reviewed journals.

J Ljungblad, B Hök, M Ekström, Critical Performance of a New Breath Analyzer for Screening Applications, 9th International Conference on Intelligent Sensors, Sensor Networks and Information Processing, ISSNIP 2014.

B Hök, J Ljungblad, A Kaisdotter Andersson, M Enlund, Unobtrusive and Highly Accurate Breath Alcohol Analysis Enabled by Improved Methodology and Technology, J Forensic Investigation Vol 2 (Issue 4) (2014) 8-15.

B Hök, H Pettersson, J Ljungblad Unobtrusive Breath Alcohol Sensor System, 24th International Conference on Enhanced Safety for Vehicles, 24th ESV, Göteborg, June 8-11- 2015, Paper No 15-0458.

J Ljungblad, B Hök, M Ekström Development and Evaluation of Algorithms for Breath Alcohol Screening (submitted manuscript).

7. Conclusions and future research

We have shown that products based on the iBASS concept can be developed, manufactured and will be accepted by the general driver.

However, the final objective is to develop an entirely passive system where the driver does not need to perform a directed breath towards the sensor. Research aiming for this application is currently partly financed by the DADSS consortium. But the challenges are great and additional investments are therefore necessary.

8. Participating parties and contact person

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