Journal of Agromedicine
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t792303961

Child Safety Driver Assistant System and its Acceptance

Elisabeth Quendler[a]; Christian Diskus[b]; Alfred Pohl[c]; Thomas Buchegger[d]; Ernst Beranek[e]; Josef Boxberger[a]
[a] University of Natural Resources and Applied Life Sciences, Vienna, Austria [b] Johannes Kepler University, Linz, Austria [c] Siemens AG Österreich, Vienna, Austria [d] Linz Center of Mechatronics GmbH, Linz, Austria [e] I.D. POOL, Vienna, Austria

To cite this Article Quendler, Elisabeth , Diskus, Christian , Pohl, Alfred , Buchegger, Thomas , Beranek, Ernst and Boxberger, Josef(2009) 'Child Safety Driver Assistant System and its Acceptance', Journal of Agromedicine, 14: 2, 82 — 89
To link to this Article: DOI: 10.1080/10599240902779394
URL: http://dx.doi.org/10.1080/10599240902779394

Journal of Agromedicine, 14:82–89, 2009

ISSN: 1059-924X print/1545-0813 online
DOI: 10.1080/10599240902779394

Taylor & Francis
Taylor & Francis Group

HOW WE LIVE

Child Safety Driver Assistant System and its Acceptance

Elisabeth Quendler, DI, MSc, PhD
Christian Diskus, DI, PhD, Prof.
Alfred Pohl, DI, PhD, Dozent
Thomas Buchegger, DI, PhD
Ernst Beranek, Mag., PhD
Josef Boxberger, DI, PhD, Prof.

ABSTRACT. Farming machinery incidents frequently cause the injury and death of children on farms worldwide. The two main causes of this problem are the driver's view being restricted by construction and/or environmental factors and insufficient risk awareness by children and parents. It is difficult to separate working and living areas on family farms, and the adult supervision necessary to avoid work accidents is often lacking. For this reason, additional preventive measures are required to reduce the number of crushings. Electronic tools that deliver information about the presence of children in the blind spots surrounding vehicles and their attached machines can be very effective. Such an electronic device must cover all security gaps around operating agricultural vehicles and their attached machines, ensure collision-free stopping in risk situations, and be inexpensive. Wireless sensor network and electrical near-field electronic components are suited to the development of low-cost wireless detection devices. For reliable detection in a versatile environment, it is necessary for children to continuously wear a slumbering transponder. This means that children and adults must have a high acceptance of the device, which can be improved by easy usability, design, and service quality. The developed demonstrator achieved detection distances of up to 40 m in the far field and 2.5 m in the near field. Recognized far-field sensor detection weaknesses, determined by user-friendliness tests, are false alarms in farmyards and around buildings.

Elisabeth Quendler and Josef Boxberger are affiliated with the University of Natural Resources and Applied Life Sciences, Vienna, Austria.

Christian Diskus is affiliated with Johannes Kepler University, Linz, Austria.

Alfred Pohl is affiliated with Siemens AG Österreich, Vienna, Austria.

Thomas Buchegger is affiliated with Linz Center of Mechatronics GmbH, Linz, Austria.

Ernst Beranek is affiliated with I.D. POOL, Vienna, Austria.

This project was funded by the Arbeitsgemeinschaft Zeno, supported by the Sicherheitsberatung der Sozialversicherungsanstalt der Bauern, Prävention der Berufsgenossenschaft Landshut and Bundesministerium für Verkehr, Innovation und Technology, and put in practice in collaboration with the Johannes Kepler University Linz, Siemens Austria AG, I. D. Pool Design, John Deere, Alois Pöttinger Maschinenfabrik GmbH, and Linz Center of Mechatronics GmbH und Raiffeisen Ware Austria.

Address correspondence to: Elisabeth Quendler, University of Natural Resources and Applied Life Sciences, Peter Jordan Straße 82, 1190 Vienna, Austria (E-mail: elisabeth.quendler@boku.ac.at).

The detection distance and reliability of the near-field sensor varied with the design of the attached machines' metallic components.

KEYWORDS. Children, driver assistant system, electrical near field, sensor network, tractors

INTRODUCTION

Worldwide, the injury of children on farms has long been recognized as a serious problem for rural societies. For example, up to 4000 children per year are injured on Austrian farms, and up to ten of these incidents are fatal.[1] Up to 10 children per year are killed by being run over by agricultural machines in European regions such as Austria, Germany, and the United Kingdom.[1–3] Children being crushed by agricultural machines has accounted for more than half of the incidents where children were seriously or fatally injured on farms in the past. Similar risks exist for adults involved in or not involved in work processes near and around agricultural and transport vehicles.[4,5]

Causes are the limited field of vision of the operator around large machines due to constructive and environmental factors, and the multi-tasking demands of continuously making steering adjustments while maintaining control.[6,7] Increased time pressure increases incident risk, especially during work peaks and at higher maximum driving speeds of tractors.[8] The majority of farmers have to supervise their children while working and most incidents occur while reversing or during careless maneuvers.[2,3,9] In these incidents, drivers were unable to detect children early enough to avoid collision.

Researchers have studied various sensory technologies for detecting obstacles in the vicinity of vehicles.[6] Even so, there is no reliable product available on the market that can detect objects in the vicinity of farming machines over 360 degrees with no gaps, and that do not cause too many false alarms. Based on these findings, the purpose of this study was the identification of user requirements and development of a fitting technical solution.

MATERIAL AND METHODS

Material was collected to identify incident causes and user requirements, and about technologies for prototype development. Accident reports were used for the identification of causes and event sequences. Accident reports from 1994 to 2007 were received from the prevention division of the Berufsgenossenschaft Landshut and the press service of the Austrian Press Agency. For analysis, incidents relating to the main scenarios were operationally defined in near-field (≤2 m initial distance between machinery and child during collision) and far-field (≥2 m) distance categories. Descriptive summaries were used to characterize the injury cases, endangered age groups, and main incident scenarios.

The user requirements were investigated by questioning randomly selected Austrian and Bavarian farmers and rural children in the endangered age groups. Via a standardized questionnaire, Austrian and Bavarian farm managers were first asked about the childcare situation on farms and usability aspects of a driver assistant system in development. Bavarian farmers were selected at random by the Prevention Service of the Berufsgenossenschaft Landshut, from a list of insured farm managers in Bavaria who live with children on farms. The questionnaire was distributed and collected by farm safety advisers. Austrian participants were drawn from a list of farm managers with an e-mail address provided by the Austrian Ministry of Agriculture. The questionnaire and an explanation of the questioning procedure was sent to Austrian farm managers via e-mail and filled out on an Internet page.

Additionally, rural children in the endangered age groups were questioned in kindergartens by trained students of a kindergarten college about the design aspects of the transponder. A questionnaire with simple questions and a picture of

an elastic band (wristband, hanging loop) with a disc-shaped transponder box was used to gather information. Based on these answers, students designed transponders and bands as part of their course work. The analysis of these data was done using descriptive and inferential statistics.

The technique chosen to develop a driver assistant system must guarantee child detection in worst-case scenarios and lead to a low-cost product with high affordability. A combination of an electrical near field and an ad hoc network sensor was identified as the most adequate technology for developing a product best fulfilling the user requirements.

The suitability, reliability, and user acceptance of these technologies were determined by user-friendliness tests. Two agricultural families who lived on their farms together with children in the jeopardized age group tested and evaluated the prototypes for 6 months on their farms. The tractors in use were medium and large sized with various attached machinery.

RESULTS

Detailed results were gathered regarding the circumstances of incidents involving children around agricultural machines, user requirements, and the usability of the system in development.

Incidents and User Requirements

According to accident reports, 101 kids were seriously or fatally injured by farming machines in Bavaria between 1994 and 2007. There were 62 serious farming machinery accidents involving children reported in Austrian newspapers during the same time period. Experts assume much higher numbers because in many cases other accident reasons were given to avoid legal problems. In both countries, more than half of injured children were run over by farming machinery caused in two circumstances (Table 1). In the far field, the child ran towards the moving vehicle and was knocked down by either the tractor or an attached machine. In the near field, children were either passengers who fell down or were hidden in, under, behind, or near the vehicle and were run over by the moving vehicle or attached machinery. More than 80% of crushing incidents involving agricultural machinery but not passengers occurred in the near field. In all cases, operator reaction was delayed due to a restricted field of vision and/or missing information.

In Austria, 6.2% of the registered farm managers with Internet access (10.4% of all Austrian farm managers [19,800/189,591]) responded online (1224/19,800). In Bavaria, 74% (892/1200) of the randomly selected farm

TABLE 1. Accidents Involving Children and Farming Machinery in Bavaria and Austria (1994–2007) (in percent)

Age of kids (years)	Bavaria[a]					Austria[b]				
	Near field	Far field			Passenger	Near field	Far field			Passenger
		Front	Rear	Side			Front	Rear	Side	
0–2	7.9	2.0	1.0		4.0	11.3				1.6
2–4	9.9	1.0		1.0	5.0	6.5	1.6	1.6	1.6	11.3
4–6	7.9				5.0	6.5	1.6	1.6		3.2
6–8	3.0		1.0		6.9	3.2				6.5
8–10	3.0		1.0		6.9	11.3				8.1
10–12	5.0			1.0	4.0	1.6				6.5
12–14	7.9				13.9	6.5	1.6			3.2
k. A.1					2.0					3.2
Sum (%)	42.3	3.1	3.1	2.1	49.4	46.8	4.8	3.2	1.6	43.6

Source: [a]Berufsgenossenschaft Landshut, 2007; [b]Austria Presse Agentur, 2007.

managers participated in the study, or 0.7% (892/136,386) of all Bavarian farmers. The distribution of questions was very similar in both countries, although different sample selection techniques were used.

Nearly two times more males than females responded, 71.7% (877/1224) of responders in Austria were male and 63.1% (563/892) in Bavaria. Two thousand six hundred thirty-nine children up to the age of 15 lived on the participating Austrian farms, an average of 1.54 children per farm. In Bavaria, there was a total of 1845 children on participating farms, or 1.48 children per household. The standard deviation for the Austrian sample was 3.1 children and much lower for Bavaria (1.57 children per farm). More than 60% of these children were under 10 years old (1825/2639; 1209/1845). Additionally, Austrian farms were visited by 13,434 children and Bavarian ones by 4802 children occasionally to daily per year.

Only 75.5% (924/1224) of the questioned persons on farms in Austria and 55.2% (492/892) in Bavaria had sufficient access to day-care services by nurseries, relatives, kindergartens, or day mothers. The questioned persons (Austria: 1224; Bavaria: 892) lived with their own children on farms and most were occasionally or frequently visited by other children (Austria: 1171/1224; Bavaria: 747/892). More than 60% of these families permanently supervised kids during work. On the majority of these farms, children (Austria: 827/1224; Bavaria: 553/892) could easily access the machinery area of the farm. Many of the farmers questioned (Austria: 771/1224; Bavaria: 556/892; a total of over 60%) were aware that they could not detect children in blind spots with available devices. The use of a technical device to detect children in the danger zones of agricultural machinery and informs the operator made sense for 89.2% (1092/1224) of the Austrians interviewed and 81.8% (730/892) of the Bavarians. Dressing a child with a garment equipped with a slumbering transponder was found to be feasible and acceptable by 81.8% (730/892) of Bavarian farmers and 81.1% (993/1224) of Austrians.

Neckband, bracelet, watch, and jacket were chosen as the best articles of apparel for carrying the transponder. Males rated the usability of the neckband as very good or good more often and females mainly chose the bracelet.

The majority of the interviewed persons recommended that a standard driver assistant system be equipped with two or more transponders (Austria: 804/1224; Bavaria: 573/892) with varying designs (Austria: 912/1224; Bavaria: 649/892). The possibility to purchase a separate additional transponder was important to over 75% of interviewees (Austria: 953/1224; Bavaria: 679/892) and significantly more important for young farmers, women, and persons with a higher education level. Over 70% (Austria: 976/1224; Bavaria: 628/892) of the questioned persons recommended sale prices of up to €300 for one system unit. Only 5.6% of farm managers in Austria and 7.6% in Bavaria said that they would pay more than €300 for a complete system. The sales price range was significantly influenced by gender, farm type, and farm size. The majority, more than 75% (Austria: 437/514; Bavaria: 355/438) of the questioned persons recommended single transponder prices of up to €20 each. As the number of tractors on a farm increased, the willingness to equip all motorized vehicles decreased.

To ensure that clear and realistic answers were obtained from the children in daycares (2 to 5 years old) and primary schools (6 to 10 years old) despite their limited literacy, interviewers with an established positive relationship were chosen. These were daycare and primary school teachers, teaching students in internship, and art teachers.

Of the 106 children interviewed, 54 boys and 52 girls, 48.1% (51/106) were in the 4- to 6-year age group, and 51.9% (55/106) in the 6- to 10-year age group. The children mentioned all body parts as adequate wearing positions for a wristband or hanging loop carrying the transponder. The odds ratio for choosing the hanging loop was 5.3 times greater for girls than boys, regardless of age. Girls and boys both suggested fantasy, comic, and magical figures as names for these objects. All fundamental colors were mentioned for the transponder box and

their fixation devices. Girls tended to prefer bright colors and boys cool ones. Similar gender and age differences were found for the recommended exterior designs such as comic and fantasy figures, animals, vehicles, hearts, plants, countryside motifs, sport symbols, and stars.

Developed Prototype and Usability

The prototype combines two detection technologies, a capacitive near-field sensor system operating on the frequency of 13.56 MHz and a radio sensor network operating on 433 MHz. The principle of electronic communication in the immediate vicinity of agricultural vehicles and their attached machinery is based upon the fact that all electricity conductors (metal) produce an electromagnetic field near the ground. The electric "aura" of the transmitter takes all parts of the tractor and possible attached machinery into account, leaving no "dead" areas. The "aura" of the human body is communicated via a slumbering transponder with the base sensor on the vehicle.[7] The second technology, the sensor network, detects at distances of up to 50 m. Multiple slumbering transponders could operate on separate vehicles simultaneously, each one using an unambiguous identification number and avoided continuous radiation for children. The first prototype hardware built with these technologies consisted of three modules: a base unit with information and alarm devices, a transponder module ($13 \times 6 \times 3$ cm large), and a capacitive near-field source (Figure 1).

During the test situations, the far-field sensor showed diffusion and shading characteristics common to radio detection and caused many false alarms within the farmyard. Detection distances of 40 to 50 m were achieved outdoors. Shorter distances were measured in farmyards and near buildings. Sufficient near-field distances

FIGURE 1. Base unit, near-field source, transponder.

were assessed near tractors and insufficient ones around attached machines with too little metal mass in the outer areas. The distances varied from a few centimeters up to 2.5 m, an insufficient stopping distance for driving situations, yet adequate for the gapless detection of children hidden in the immediate vicinity of active machinery. The optimum 360-degree detection radius around tractors and attached machines was obtained by a near-field source with a line section positioned in front of or behind the vehicle, in the center of the metal tractor frame. The detection distance could be expanded by up to 2.5 m by coupling into the board electrical system.

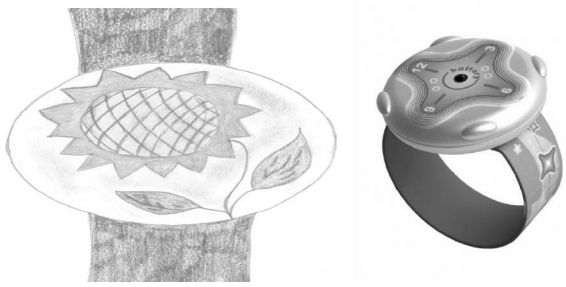
From the farmer's point of view, an acute warning at distances of 5 to 7 m for common speeds is needed in the farmyard in order to stop in time yet avoid too many false alarms.

A piezoelectric sound generator emitted acoustic alarm signals up to an intensity of 83 dB. The acoustic alarms were periodic beeping signals. The audio warning of the near field was changed during the testing phase to a higher repetition frequency and a louder tone, expressing acute danger.

Softer tones are now used for the far-field warning signal to help reduce the identified stress potential of false alarms in the far field. A complete elimination of false alarms caused by the far-field sensor's detection of children within safe areas (inside buildings, behind fences, etc.) could not be achieved at this development stage.

Despite this, the acoustic signals were identified by farmers as the most important warning mechanism. The visual indicator on the liquid crystal display was evaluated as being a redundant information channel. The size of the test transponder was inconvenient and the design did not encourage children to voluntarily wear it (Figure 2).

FIGURE 2. Transponder prototype, design example.



DISCUSSION

This study examined three aspects—incident causes and sequences, user requirements, and prototype development and test results, expressed by results.

Incidents and User Needs

Previous studies of pediatric farm injuries affirmed that the majority of fatalities occurred with tractors, half of them by being run over.[1,9] Zones with extreme visibility limitations were the areas closest to the rear tires and in front of the hood,[10] i.e., the near field and the area where the majority of run over incidents happened. Pryor and colleagues[11] and Morrongiello and colleagues[9] found that kids were injured significantly more when supervised at work than in living areas.[9–11] The reasons identified were the reduced level of attention and discontinuity of supervision. Restricted access to the work environment was not possible at the majority of the Austrian and Bavarian family farms surveyed due to the insufficient childcare opportunities in the countryside. These circumstances justify the importance of having such a detection device. The significant positive responses mentioned inability to see, insufficient child care service, supervision during work, and previous incidents.

Parents in the United Kingdom confirmed a similar willingness, with 75% of the questioned saying they would purchase an electronic device to trace kid's movements if they could. Parents feel that such devices improve child safety.[12] The risks of ignoring hazards because of using such a system do not exist, as confirmed by prototype testers. Parents are aware that technical devices can fail and cannot take over human responsibilities, but support safer handling processes during busy working periods.

To obtain a high safety standard, it is necessary that all motorized farming and logistics machinery is equipped with the system and that children continuously wear the transponder, especially in hazard zones. Old vehicles must be upgraded and the system should be mandatory for new machinery. A high application rate can be ensured by implementing easily mountable systems and financial incentives, e.g., subsidies by insurance companies or the state. The wearing frequency of the transponder is influenced by the decision-making ability of parents and children and also usability. Parents make decisions for children up to 3 years old; children from 4 to 5 years of age are influenced by trends and codecide with their parents. Older kids make decisions independently from adults and are strongly influenced by friends and the media.[13] Parents have to train their children to wear the transponder and subsequently monitor them. Due to the low energy consumption of the indirect recognition system and the use of a slumbering transponder, there is no risk of adverse health effects through continuous wear. The durability of the system can be ensured by having liquid, acid and impact proof components of the wristband. It can be checked by offering a functionality test to children and parents, e g., over a control lamp. Similar existing safety guidelines are, for example, riding a bicycle with a helmet or using a belt in the passenger seat of a tractor.

Special user-oriented design and quality support services, expressed by the survey results, increase usability and help achieve the continuous and voluntary wearing of the transponder device. It is important that the transponder device poses no danger to the child, e.g., strangulation by a loose necklace.

Developed Prototype and Usability

The combination of electrical near-field and sensor network technologies for the prototype development and their communication over a slumbering transponder should overcome the detection weaknesses of other existing technologies such as Doppler radar, video cameras, ultrasonic, infrared sensors, GPS, radiofrequency identification chips, and active radio frequency transponders. Their disadvantages lie in being limited to one direction, insufficient detection distances, detection gaps, and expense.[14,15] At field sites, the radio sensor network achieved the required detection distance for halting without collision. Shorter distances and too many false alarms were recorded in farmyards and near large objects like buildings and stone walls. These false alarms were triggered by the transponder being detected within a protected area, for example, inside a building or fence. The reasons for shorter detection distances and gaps immediately surrounding vehicles and nearby buildings were the shading and reflection effects of radio. Its environmental-related weaknesses were the directionality of the ultra-short-wave area and the shading and reflection effects negatively affecting detection range.[16] Similar results were cited by Ruff when using radar to detect pedestrian workers near mining equipment.[14]

Gaps in the immediate surrounding could be filled partially by the electrical near-field sensor. Gaps were identified around machinery parts with very little metal mass. In these cases, coupling into the electrical board system can extend the electrical aura. Electrical near-field technology was initially used as a means to interconnect body-borne information appliances and electric field sensors for position measurement over short distances.[17] In this study, an extension of the detection distance up to a maximum of 2.5 m was achieved. For these reasons, the electrical near-field sensor can only be used for the detection of hidden children or other objects under or around running vehicles or other machinery, or in extremely slow driving situations.

A highly reliable information system to overcome the false and too slow alarms would require improving existing sensors and an additional redundancy and fusing of information or outputs of the different sensors.[18] A similar method was proposed for the GPS-based systems of surface mining operations.[19] A more sophisticated warning system would be required to eliminate the existing weaknesses, meaning more warning levels according to determined risk ranges.[20]

The slumbering transponder that avoided continuous emission and operated with an identification number increased detection

reliability, information, and communication of process and data quality. Böse and colleagues identified similar results in a transport logistics benefit analysis.[21] Current size and shape inconveniences must be reduced and redesigned according to user requirements.

REFERENCES

1. Furian G, Gruber M, Spiess J. Kinderunfälle im bäuerlichen Bereich. Sozialversicherungsanstalt der Bauern. 2002;SVB Wien:6–7.

2. Austria Presse Argentur (APA). Unfallberichte der Presse, Datenbankausdruck 2007, Wien.

3. Berufsgenossenschaft Landshut. Unfallberichte 2006, Landshut.

4. Lundqvist P, Svennefelt CA. Work Science in European Agriculture—time for renewal? In: Proceedings of the 15th Arbeitswissenschaftliches Seminar, March 6–7, 2007. Vienna, Austria: Radinger; 2007: 89–92.

5. Lötjönen T, Mattila T, Mattila T, Rautiainen R. Injuries in potato and open field vegetable production. In: Proceedings of the XXXII CIOSTA-CIGR Section V Conference: Advances in Labour and Machinery Management for a Profitable Agriculture and Forestry, Nitra, Slovakia, September 17–19, 2007. Nitra, Slovakia: Slovak University of Agriculture; 2007:444–449.

6. Wei J, Rovira-Mas F, Reid JF, Han S. Obstacle detection using stereo vision to enhance safety of autonomous machines. In: Transactions of the ASAE, 2005. ASAE Annual International Meeting, Florida, July 17–20, 2005, pp. 1–25.

7. Quendler E, Niernsee S, Boxberger J. Systemanforderungen für ein Kindersicherheitssystem. *Landtechnik.* 2006;61:2–3.

8. Hoppe U, Meyer HJ. Ursachen von Traktorunfällen. *Landtechnik.* 2005;60:90–91.

9. Morrongiello BA, Pickett W, Berg RL, Linneman JG, Brison RJ, Marlenga B. Adult supervision and pediatric injuries in the agricultural worksite. *Accid Anal Prev.* 2008;40:1149–1156.

10. ISO. Tractors for agriculture—Operator´s field of vision. International Standards ISO 5721:1989(E);1–5.

11. Pryor SK, Caruth AK, McCoy CA. Children's injuries in agriculture related events: the effect of supervision on the injury experience. *Issues Compr Pediatr Nurs.* 2002;25:189–205.

12. Atkins L. 2005: Tracking by tagging our children. *The Guardian,* London. December 7, 2005, p. 9. Available at http://omega.twoday.net/stories/1240202/

13. Quendler E, Kristler I, Beranek EW, Boxberger J, Diskus C, Pohl A, Buchegger T. Acceptance and design aspects to a driver assistant system. In: Proceedings of the XXXII CIOSTA-CIGR Section V Conference: Advances in Labour and Machinery Management for a Profitable Agriculture and Forestry, Nitra, Slovakia, September 17–19, 2007. Nitra, Slovakia: Slovak University of Agriculture; 2007:562–569.

14. Ruff T. Application of radar to detect pedestrian workers near mining equipment. *Appl Occup Environ Hyg.* 2001;16:798–808.

15. Viel PE, Letellier L, Gavrila D, Marchal P, Meinecke MM, Töens M. 2002. Sensors and system architecture for vulnerable road users protection. Deliverable 2: Characteristics of the dressed human body versus the different sensing technologies. Project funded by the European Community under the "Information Society Technology" Programme (1998–2002); 2002:51.

16. Winner H. Mit aktiven Sensoren das Kfz-Umfeld erfassen—Funktion und Leistungsfähigkeit von Radar & Co. *it—Information Technology.* 2007;49:17–24.

17. Brown BH, Barber DC, Seagar AD. Applied potential tomography: possible clinical applications. *Clin Phys Physiol Meas.* 1985;6:109–121.

18. Niehsen W, Garnitz R, Weilkes M, Stämpfle M. Informationsfusion für Fahrerassistenzsysteme. In: Mauer M, Stiller Ch., eds. *Fahrerassistenzsysteme mit maschineller Wahrnehmung*. Berlin: Springer Heidelberg; 2005:43–57.

19. Holden T, Ruff T. GPS-based proximity warning systems for mining and construction equipment. In: Proceedings of the 14th International Technical Meeting of the Satellite Division of the Institute of Navigation, ION GPS/2001, Salt Lake City, UT; 2001:517–525.

20. Bekiaris E, Nikolaou S, Mousadakou A. Design guidelines for driver drowsiness detection and avoidance. Deliverable 9.1 of EU co-founded project AWAKE; 2004. Available at http://www.awake-eu.org/pdf/d9_1.pdf (accessed September 18, 2008).

21. Böse F, Lampe W. Transponder im Fahrzeugmanagement. *Industriemanagement.* 2005;20:29–32.