# Minutes meeting Special Knowledge Group ABvM

During this meeting TRL presented the preliminary results of the research project **"Accuracy and Reliability for distance measurement and determination of tariff for Kilometerpricing"**. The main part of this research work involved the trialling of vehicle borne On-Board Units (OBU) to evaluate the overall level of accuracy in calculated distance travelled using low cost GNSS technologies, associated sensors and other innovations.

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| Date | Wednesday 31 October 2007 14:00-17:30 |
| Location | Connekt, Kluyverweg 6, Delft |
| Attendees : | See annex |

**Agenda**

- Welcome and opening
- Introduction by Katya Ivanova co-ordinator of the research programme at the project team of the ministry of transport.
- Presentation by Peter Vermaat of TRL on the approach of the trial of vehicle borne On-Board Units (OBU) to evaluate the overall level of accuracy in calculated distance travelled using low cost GNSS technologies, associated sensors and other innovations.
- Introduction and routes
- Q&A
- Vehicle fitting and OBU selection
- Q&A
- Presentation of the preliminary results
- Q&A
- Discussion
- informal drinks

**1. Welcome**
Mr. Paul Potters, manager ITS Netherlands of Connekt, welcomes over sixty representatives (see annex) of national and international organisations present and gives a short introduction.

**2. Background of the research (see attached presentation)**
Mrs. Katya Ivanova, co-ordinator of the research programme at the project team of the ministry of transport gives a short presentation on the background and contents of the research programme.
Of the 6 questions mentioned for the GPS trial, only the first three will be addressed in this session. This are the questions useful for input for requirements for the ABvM system.
In December the final report will be made public.

**3. Presentation by TRL on research and results (see attached presentation)**
Mr Peter Vermaat of TRL gave a presentation on the research approach and results. The research was carried out by TRL, BDL and ARS T&TT. Only the first phase of this research will be presented. The requirements for the system are differentiated by time and by place. And external influence is also addressed in the research.

**Introduction and routes**
The method of the research is: OBU selection by an overview of the available systems in the market. 12 of these were selected with a cross section of all the different technologies available. The influence of extra sensors on the different parts of the system was addressed. Then the test routes were

selected. These test routes are not representative of the typical Dutch route distribution, but are worst case scenario's. In the example of a route presented the blue line states the position of the GPS receiver and the green line the actual route driven. A problem of the GPS receiver visualised in the picture is the vehicles movements while standing still. In the The Hague centre route also a part of non mapped roads were included.
After the selection of the routes the charge segments and charge areas were defined. In Amsterdam the ring road was defined as a charge area. In The Hague a tunnel was defined as charge area, with the route going twice through the tunnel by taking a u-turn at the end.

**Q&A (1)**
The target was to drive each route 10 times to make the outcomes statistically sound. But some routes vary per day and also some errors were made during driving the route. This had no influence on the results.

Furthermore the following answers are given to questions of the participants:

- only one type of vehicle was used, because connections differs between types of cars. The wiring was pre-done in the UK, because of the pressure of time.
- Different speeds are inevitable during driving the routes. Urban routes especially have natural speed variations. Differentiation of accuracy caused by speed alteration has not been researched.
- The Amsterdam ring has been placed outside of the charge area for no particular reason. Including the ring makes it a bit easier for the vendors and the distance calculation more difficult.
- 13 charged segments were defined, but not all driven. These were mainly defined on highways.

**Charge zones**
In the presented pictures the red line indicated the charged zone: entry/exit time, position en travelled distance through the zone were measured. Charge segment was about 600 m long.

**Vehicles fitting and OBU selection**:
The research used 3 identical Opel Astra, because of the square area to attach GPS and the wiring of this car was known by the constructors. Building capital made a strapped down, full inertial system, with high resolution. A wing to stop cyclist from knocking down the system was also installed.

Data: al vendors had to provide raw distance and position data, "raw" means data that hasn't been subsequently processed (not by a back office). Vendors had a week to post process the data. Minimum 10 times a route has been driven, except for one route.

OBU selection, 50 worldwide identified. 30 interested and received a vendor pack with information to be hand in. 11 of these were selected and covered all the technologies TRL wanted to evaluate. Vendors gave before and after data. The researchers were very pleased with the enthusiastic vendors.
11 vendors were installed, and also an ESA Galileo receiver because this was asked by the Ministry (this didn't play any role in the outcomes).

**Q&A (2)**
Were there any other means used to measure distance directly? An external wheel sensor was the primary distance tool. INS calibrated this, a gyroscope was used by INS for going around corners. Any additional sensors will not have added any extra data.
The wheel sensors weren't relying on any system of the car. It was a loaded and independent wheel.

How was the GPS data compared to the car meter? TRL has no confidence in the odometer in car for input. Not a real time monitor, but point to point measurement.

**Preliminary results**
Result on driven distances on the quite long route. 11 vendors, 21 result sets → 21 technologies. Distance accuracy goal is 1%: 9 technologies did manage this, 4 did this on every route, even in The Hague (the most difficult route). All used an odometer, GPS did not manage to reach the 1% accuracy.

The data was reanalysed on kilometre basis for the effect of short journeys. 6 technologies managed this. The accuracy was measured by the INS as truth data.

**Q&A(3)**
Charge zones were identified correctly most of the time, but the distance is tricky. Especially the tunnel was hard, GPS only device had problems on the exit.
Majority achieved time accuracy of sub 10 seconds.

EM radiation is not off any influence → position accuracy went down, but driven distance was unaffected.
Foliage: average 10% drop of 8-9 satellites in view. 1 had a bigger drop than that because of old chip technology.

In the routes were two areas of multi-path errors: ING Rotterdam and Herengracht Amsterdam.
This caused an increase in position error, but not significant on driven distance.

Tunnels: with external sensor (especially wheel speed sensors) limited effect on driving distance.

**Conclusions (see presentation)**
1% accuracy achievable but not easy, in NL for all routes an odometer input gave better results. GPS only device: the best was near 1%. 1% is achievable but not by GNSS only.

**Q&A(4)**
what was the standard deviation? Result in general quite well clustered, there were outlier result, but it was prototype technology. This was especially true on 'easy roads'.

Was a start up situations analysis carried out? Some, but not here presented yet. This was included in the results.

No outliers in results were removed. Outliers are given to the vendors, so they can identify them their selves.

Why 1% accuracy? These are the requirements handed out by V&W last year by cost monitor, but this is not yet definite. A tax system makes the needed accuracy higher. But this is not yet decided. The research presented will also be used to adjust the requirements and certification.

Was the deviation positive? This was mainly negative, TRL suspects the systems were tuned to that: The deviation was -1% but not +1%.

Correlation accuracy and the consolation of the satellites: that analysis has not been carried out. This could be significant.

In London much of the accuracy depended on the post process. This can be analysed by comparing the raw data with the processed data, this was not done in every case, but can be analysed by extra research. Sufficient numbers of trials for GNSS exist, research wasn't aimed at finding the performance of GPS, but on sensors and software algorithms. The researchers did not mandate how vendors got their results, but enabled them to show their best technology to get the best system result.
Statistical results: data have been given to vendors to identify themselves which part of the system made the failure and which faults were systematic.

**4. informal drinks**
The participants were able to network during the remainder of the afternoon.

Participants:

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| F.E. (Ferry) Smith | ANWB B.V. |
| A.W. (Arjan) den Hollander | Arcadis Infra BV |
| J.H. (Jan) Linssen | ARS T&TT |
| R. (Roel) van Dijk | ARS T&TT |
| W. (Willem) Verbaan | BMC |
| D. (David) Rollafson | Building Capital Ltd |
| R.H. (Remi) Tops | Capgemini Nederland B.V. |
| M.P. (Marcel) de Jong | Centraal Justitieel Incassoburo |
| A. (Albert) Visser | Centraal Justitieel Incassoburo |
| P.T. (Paul) Potters | Connekt / ITS Netherlands |
| E.A. (Edwin) Roestenburg | CSC Computers Sciences B.V. |
| J. (Jörg) Schwieder | Daimler Services |
| P. (Pieter) Hilhorst | Deloitte Consultancy |
| W. (Wolfram) Tuchscheerer | EFKON mobility GmbH |
| G. (Guido) Peters | EFKON AG |
| T. (Thomas) Kallweit | FELA Management AG |
| M. (Miguel) Azaola Sáenz | GMV |
| J. (Joaquín) Cosmen-Schortmann | GMV |
| A.A.C. (Anne) Tip | LogicaCMG Nederland B.V. |
| H. (Harvey) Appelbe | Mapflow |
| A. (Aad) de Hoog | Ministerie van Verkeer en Waterstaat |
| M. (Max) van Heijst | Ministerie van Verkeer en Waterstaat |
| J. (Jan) Breeman | Ministerie van Verkeer en Waterstaat |
| E.M. (Katya) Ivanova | Ministerie van Verkeer en Waterstaat |
| B. (Bernd) Herrman | mm-lab GmbH |
| A.K. (Arnold-Kees) van Rongen | Mobi-Spot BV |
| P.J.B. (Peter) Brown | NedMobiel bv |
| J. (Jan) Taelman | NXP |
| T. (Torsten) Labuhn | OMP computer GmbH |
| M.F.L.A. (Mark) van Oosterhout | Oranjewoud B.V. |
| M. (Martin) de Vries | Peek Traffic bv |
| J. (Jaroslav) Altmann | PRINCIP a.s. |
| P.R. (Pål Rune) Johansen | Q-Free ASA |
| W. (Wim) Foederer | QUALCOMM Wireless Business Solutions BV |
| S. (Stefan) Eisses | Rapp Trans NL |
| R.H. (Russell) Smith | Richmond Management Group |
| M.A. (Mark-André) Funk | Satellic |
| W. (Wolfgang) Lohwasser | Siemens AG Österreich |
| Th. (Thomas) Wilhelm | Siemens AG Österreich |
| B. (Bart) Vuijk | Siemens Nederland N.V. |
| D. (Dragan) Kostevski | Siemens VDO Automotive |
| P. (Preet) Khalsa | Skymeter Corporation |
| H.C. (Henri) Engel | STOK |
| P.H. (Paul) van Koningsbruggen | Technolution B.V. |
| P. (Peter) van Haperen | Telematic Consultant Kapsch TrafficCom AG |
| () Tijink | Telematic Consultant Kapsch TrafficCom AG |
| G. (Guido) Sluijsmans | TNO Verkeer en Vervoer |
| B. (Bas) van der Moolen | TNO Verkeer en Vervoer |
| L.W. (Lucas) Wildervanck | TomTom International b.v. |
| Y. (Yoav) Megged | Traffilog |
| N. (Nicholas) Williams | Transport for London |
| T. (Tim) Strong | TRL Limited |

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| P. (Peter) Vermaat | TRL Limited |
| P. (Patric) Houben | Tsolve |
| J. (Joachim) Lanzen | T-Systems International Gmbh |
| J. (Johan) van Driel | T-Systems Nederland b.v. |
| R.F.G. (Rein) van Lansberge | Van Lansberge Public Affairs |
| W.P.B. (Wim) Broeders | Vialis Traffic bv |
| C. (Christian) Robl | Vodafone Group R&D GmbH |