

# EVALUATION OF DRIVING ASSISTANCE SYSTEMS EXEMPLIFIED BY THE AUSTRIAN PROJECT RONCALL\_I2

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## Abstract

The object of the research has been created due to the fact that road safety information is highly dynamic but traffic signs, which display such information, are definitely not. For the development of dynamic road safety information content providers and service providers always faced the problem that there are no standardised interfaces or billing procedures for the input they have to offer. So those simple services which are offered to customers at the moment are not very useful due to the lack of interfaces.

To solve these problems the two projects RONCALLI and RONCALL\_I2 have been carried out. RONCALLI dealt with the development of the structural and technical basis for the creation and display of road safety information services and in RONCALL\_I2 the aim was to conduct a neutral marketplace for transport telematic information, to demonstrate it by several services and evaluate the services afterwards.

Now the two projects are finished. Based on the system architecture the hardware and software components were adapted respectively developed, an electronic platform as market place including billing functionalities was set up and the evaluation of the demonstrated services was completed.

All in all the projects have been a very good and successful attempt to develop the basis for dynamic road safety information services and their commercialisation. But as the developed services were only tested in a pilot trial they are of course not completely ready for the market, and further improvements towards perfection are necessary.

## Introduction

### Well-known Problems

Road related information is highly dynamic. Traffic signs cannot reflect these high dynamics and so do not gain full acceptance by the driver. Additionally the validity of many traffic signs is limited by time (e.g. Monday to Friday) or specific road conditions (snowfall or rain). So the driver has to spend a lot of his concentration to properly react on traffic signs. Moreover most of today's in-car-clients provide only routing information and not road safety information to support the driver. On this account RONCALLI is a new attempt to bring road safety relevant information directly to the driver and so to act as driving assistant system. But to achieve high user acceptance the correctness and accuracy of road safety information is a critical issue and one of the most challenging as well.

## Aim of the RONCALLI Projects

In the projects RONCALLI and RONCALL\_I2 the aim was to prototypically demonstrate how this highly dynamic information can be handled and to show the benefits of dynamic road safety information for the user.

The road safety information should be presented 0

- where it is exactly needed,
- only if it is relevant,
- with content that is precise and that really matters and
- in a way which does not distract the driver.

Moreover a neutral market place for transport telematic information should be developed and its functionalities should be tested through several services by a driving school. Finally an evaluation of the services concerning the acceptance of the test users and concerning marketability was planned.

This paper includes an overview about the system architecture of this driving assistance system and about the system communication and end device as technical basis for the development and implementation of the RONCALL\_I2 services. A short introduction of the marketplace will be given and finally the evaluation results of the test drivers and the market survey will be shown.

## RONCALLI – The Technical Basis

### System Architecture

The system architecture 0consists of two main parts:

- the server framework and
- the in-car client

The server framework consists of the main database, holding the road network and road safety relevant information (speed limits, traffic signs, road surface characteristics, etc.), and the service database which handles the communication with the client and transforms the raw content of the main database into services for the in-car client.

The in-car client is a PDA (Personal Digital Assistant) equipped with GPS (position update rate 1 second) or differential GPS (dGPS) if available. The aim was to set up the system architecture for commercially available products, maybe products that the drivers already possess (like PDA and mobile phone), to enable all interested customers to use RONCALLI. In this regard no modification of the car is needed. For example, additional sensors (e.g. rain sensor) can be connected via Bluetooth interface to the PDA. A GSM/GPRS connection is also established via a Bluetooth connected mobile phone.

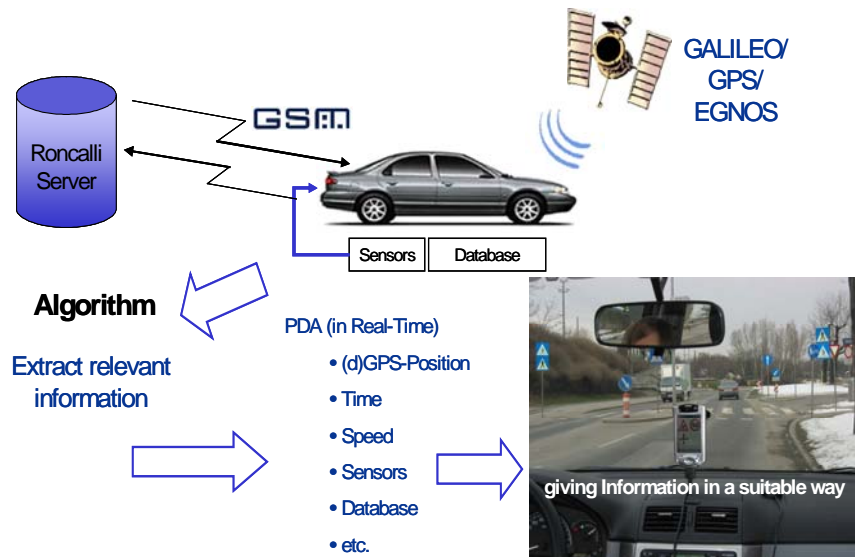


Fig. 1: System Architecture

### Server and Client Server Communication

All raw content is stored in the main database and refers to the reference road network. Because of its limited memory capacity, the client is not able to store the complete road network. So the reference road network is split in tiles and stored in the service database. Depending on road density, the tiles cover square areas ranging from 2 x 2 km to 10 x 10 km approximately. On every modification of the road network (such as changes in speed limits), new versions of the affected tiles are created. The same tiling and versioning is made for the attributes. The client holds in its memory only the "home tile", which it is currently in and the surrounding tiles. Road network tiles and attribute tiles are dynamically downloaded by the client on every change of the current tile via GPRS.

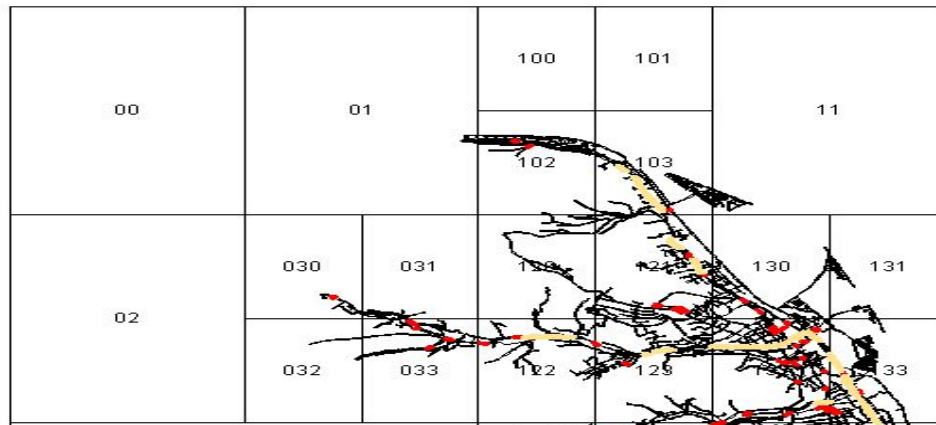


Fig. 2: Tiling of road network

All data is stored in XML-structures in the service database. Client and server communicate via SOAP (simple object access protocol), the transferred content is compressed via zlib (a very common library used to compress data efficiently) to reduce communication costs.

## Client

The in-vehicle client is a standard PDA with a memory extension via SD Card. It receives the current position, speed, heading and time from an attached GPS receiver via serial port or Bluetooth. The road safety services are presented to the user via a simple graphical user interface. Each service is presented at a fixed location on the display with intrinsic icons (mostly regular traffic signs) in order to minimise distraction of the driver. All information and warnings are only presented if necessary, i.e. dependent on position, speed and time. For example, a warning about bad skid resistance is only presented at road sections with the attribute "bad skid resistance", at a certain speed and only in case of rainfall. But to ensure that the client is working, a small watchdog icon is displayed in the lower left corner of the display that is changing periodically.

A multi-threaded software design is used to execute the main routine and the parallel downloads. The basic RONCALLI services require no user interaction. Everything is done by the client "automatically".

## RONCALL\_I2 – The Market Place

During the project RONCALL\_I2, the focus was on establishing a market place for transport telematic information. Until now, traffic information was a business-to-business market, mostly from one content provider to one service provider. The aim of RONCALL\_I2 was to spread the business wider and to enable new telematic services depending on different sources of content. Standardised interfaces enable various content providers to offer their content to various service providers. So, content providers and service providers are both customers of the market place. The service of the market place is, on the one hand the provision of a standardised digital road network as reference system, and on the other hand the clearing and billing of the data traded via the market place.

The screenshot shows the RONCALLI DataMarket homepage. The browser window title is 'Roncalli - Microsoft Internet Explorer provided by Oesterreichische Kontrollbank AG'. The address bar shows 'http://roncalli.oeb.at/roncalli/portal/home.jsf'. The page layout includes a top navigation bar with tabs for 'Traffic', 'Non Traffic', 'Business', and 'Freizeit'. A search bar is located below the navigation. The main content area features a central graphic with the text 'Ein Marktplatz für Verkehrsdaten' and a description of the market place. Below this is a 'Straßenverlauf' section with a map and a table of 'Aktuelle Produkte und Angebote'. The right sidebar contains a 'Mein DataMarket' section with a login form and a 'Newsletter' section.

Bezeichnung	Anbieter	
Verkehrszählstation Wien West		» mehr
Referenzsystem Wien-Umgebung		» mehr
Unfallhäufungsstellen Ö		» mehr
Akustikdaten von Fahrbelägen		» mehr
Straßenverlauf WU, BN, MD		» mehr

Fig. 3: Homepage of the market place

## RONCALL\_I2 – The Services

To demonstrate the functionalities of the market place several services were developed. To test and survey the developed services, a driving school agreed to implement the necessary hardware in three of their driving school cars.

### Road Safety Services

The first developed service is called “Road Safety” and dealt with the transfer of road safety relevant information to the single road user. This information was:

#### ISA – Intelligent Speed Adaptation

Intelligent Speed Adaptation (ISA) is a driver assistance system where the current speed limit is displayed all the times. Large scaled experiments concerning ISA were carried out in various countries (Sweden, the Netherlands, United Kingdom) with remarkable good feedback from the test persons. If the driver exceeds the speed limit, the displayed speed icon begins to blink, changes color and, dependent on the amount of violation, a sound is played. So the intensity of the warning is increased step by step. Prerequisite for this service is the availability of the current speed limits of the whole road network.

#### Warnings of Accident Black Spots or Dangerous Road Sections

Prior a car reaches a dangerous road section or an accident black spot this fact is communicated to the driver and he can react according to the circumstances.

A warning of a dangerous road section is created in case of poor skid resistance or in case of deep ruts. The warning considers the actual velocity (no warning under 50 km/h) and the actual road conditions (dry or wet), derived from the rain sensor.

Road condition data for the test site were collected by RoadSTAR (Road Surface Tester of arsenal research). Skid resistance and ruts were measured on the high-level road network, and road sections with constantly poor skid resistance and deep ruts were identified. These data can also be derived from existing pavement management systems.

The warning of accident black spots is meant to increase the attention of the driver on sections or points (mostly crossings) of the road network with high accident risk.

The data for this service is derived from the accident statistics maintained by Statistik Austria and was corrected for precise location by the Austrian Road Safety Board – KfV – Kuratorium für Verkehrssicherheit). Every accident involving injury in Austria is recorded by the police. The accidents are centrally aggregated to “Unfallhäufungsstellen” (sections where more than three injury accidents have occurred in one year, more than three accidents of the same kind in three years, etc).

For the test site, the collected accident data was analysed in detail. To give only relevant information, the accident circumstances (weather, time of day, driving direction) were analysed to avoid unnecessary warnings.

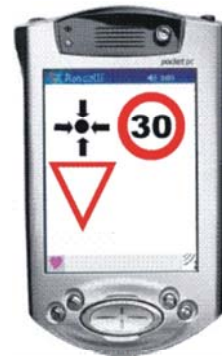


Fig. 4: In-car client displaying road safety services

## Priority Information

For this service, well-known symbols displayed at the PDA are, as far as possible, describing the current priority situation for selected crossings. When getting closer to such a complex crossing a hint concerning the current priority situation is given. For sure the priority situation can not be described in detail, as it is unknown in which direction the ride will be continued and is therefore constricted to basic behaviour recommendations. The necessary information has to be provided by the content provider based on the traffic logic.

## ECO-Driving

The second service concerned the topic "eco-driving". Eco-driving is an accepted measure for reducing fuel consumption and thus CO<sub>2</sub> production (estimated 10 percent). But economical driving is first of all a matter of driving behaviour. To quantitate the driving behaviour numerous vehicle-sided parameters were necessary. Actually the service should teach and judge eco-driving solely from GPS data.

To calibrate the system, GPS data (position, speed) and data from the car's CAN-bus (fuel consumption) were recorded and analysed. Two types of parameters were developed to characterise the driving style: The first contains the intenseness of acceleration and deceleration and the second takes the closeness between accelerations and decelerations into account (so called "look ahead"). These parameters are derived from GPS data collected every second. All values were defined as penalties, i.e. the lower, the better, the more economic. The results of the automated evaluation could then be listed in a score balance to enable competition and comparison and in this way foster the individual ambition to drive most economically.

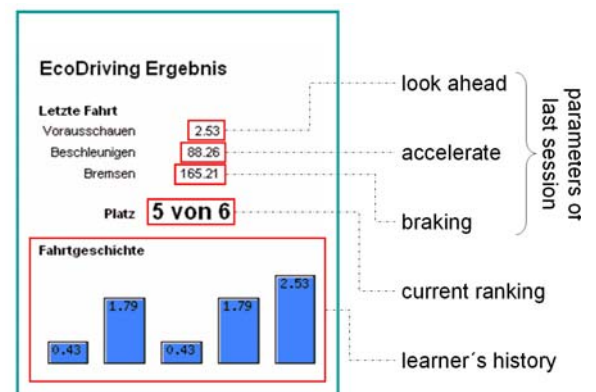


Fig. 5: Visualisation of a driving lesson result including learners' history and ranking

## Extended Floating Car Data (xFCD)

Extended floating car data is additional data generated in the car offering additional information concerning the route. The content can be related to the vehicle itself or to its environment. The ambition was to develop a service enabling an interactive data input for the driver. To transfer subjective noticed road safety information the concept of manual input was developed. The driver should be able to initiate an action by touching the display. To keep the distraction as small as possible the maximum display split for input fields was 2 x 2. Each field was related to a function either to open the next layer or to trigger an action.

For demonstration of the xFCD service a site-related trigger for the function was implemented to generate data automatically. When driving with the PDA in or out of a defined area the function was activated. This was used to indicate the utilisation degree of the exercise area for the driving school.

## RONCALL\_I2 – The Evaluation of the Services

To evaluate the services as basis for business planning and development of a strategy the Institute of Transportation of the University of Natural Resources and Applied Life Sciences of Vienna as project partner did a survey at the driving school as well as a market analysis based on telephonic and personal interviews.

### Survey in Driving School

The evaluation of the services by the learners was done depending on their course as one- or two-staged pre- and post-survey. Additionally, the driving instructors had to record the responses of the learners to the services during the driving lessons. Finally a moderated group discussion with the driving instructors was done to exchange experiences and to work through the driving lessons' protocols.

### Evaluation of the Services by the Learners

During a period of three month the services had been tested by 37 learners of whom 60 % had been women and 85 % had been 19 years old or younger. Even though all of the learners used mobile phones only 8 % had experiences with a PDA.

The questionnaires included the four topics ISA, warning of dangerous road sections, priority information and eco-driving. Unfortunately because of organisational and technical problems the eco-driving service could not be tested often enough to derive objective results from the evaluation.

For the other three tested services the results were very similar (see Fig. 6):

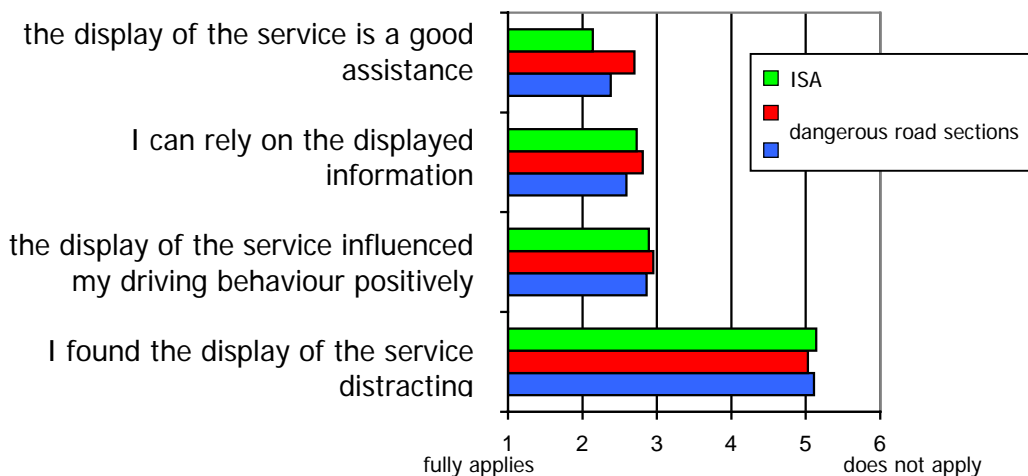


Fig. 6: Evaluation of the services by the learners

For the first question concerning the services' degree of assistance the display of the maximum speed (ISA) was rated best. All services were rated nearly equally good concerning the reliability of the services and the positive influence of the driving behaviour. Moreover none of the services was evaluated as distracting or interfering. The indication of dangerous road sections was, in comparison to the other services, all in all rated worst but the gap averages only 0.2 points.

For the two-staged survey the second questionnaire was supplemented by a question concerning the willingness to use and buy the tested services after the driving education. In fact only eight persons filled out the second questionnaire. Half of them would definitely use the services in their private cars and they would be willing to purchase the necessary hardware for EUR 100,-- to EUR 300,-- at a maximum. But as the sample was pretty small

the information is not very representative but the market survey offers more detailed results.

### Evaluation of the driving instructors' protocols

The driving instructors had to document the learners' reactions on the RONCALLI services each lesson. The display of the maximum speed limit (ISA) had the widest influence on the driving behaviour of the learners as shows. Nearly 90 % of the learners showed a significant reaction on ISA. Especially in areas with a speed limit of 30 km/h ISA had a positive impact on the drivers.

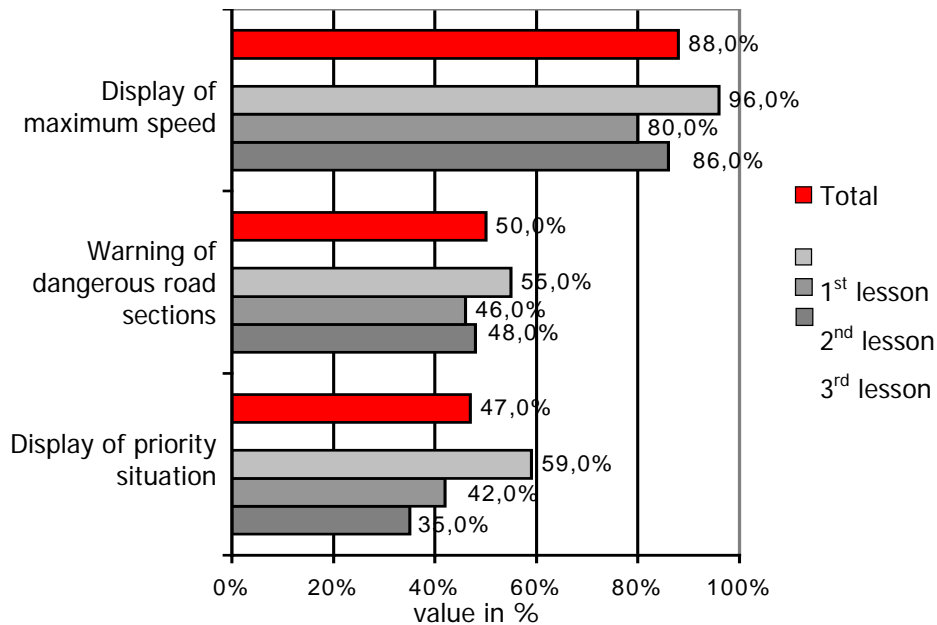


Fig. 7: Percentage of learners influenced by RONCALLI services

For all the other speed limits (e.g. 50 km/h, 70 km/h) it was not possible to notice a special effect on the speed of the learners. That is due to the fact that higher speed is not reached very often during driving school rides because the test persons (learners) are unexperienced and influenced in their speed choice.

The proportion of those learners who reacted on warnings of dangerous road sections respectively on the display of the priority information is 50 % and so noticeably smaller than the one on ISA. Moreover Fig. 7 shows that all three services attracted the learners' best attention in the first lesson.

### Group discussion with the driving instructors

At the end of the three-month test run a group discussion with the three driving instructors and the owner of the driving school was organised. The instructors' opinions were in all points nearly the same and can be summarised as follows:

The service ISA and the service priority information were rated as very helpful. The display of dangerous road sections and accident black spots was evaluated as not that important and useful. A combination of the RONCALLI services with congestion information was named as possible further application. Additionally they were astonished that the display of the services turned out to be non-distractive even though they expected it to be an additional problematical strain for the learners.

Of course it was criticised that the services did not work all the time and that they were not available area-wide but only within the testing area – but as it was only a pilot trial these were preconditions. Moreover it was mentioned, that the reliability of the services has to be granted to ensure a positive effect on road safety. If the service offers wrong information fatal consequences can arise.

### Market Survey

The aim of the market survey was to analyse the customer's view of the services' market acceptance, the potential target groups as well as ideal features and ways of utilisation.

The market survey was done in two stages. First of all a relatively large sample (1.345 addresses of Vienna and Lower Austria were drawn) was contacted via telephone and asked concerning objective personal features. Out of the sample those with driving licence and regular car usage were chosen, and 200 people agreed to take part in the interactive stated-response interviews.

### RONCALLI services

The estimation of the potential personal benefit of the services is shown in Fig. 8. The highest potential benefit (82 %) is seen in the service Extended Floating Car Data, indicating accidents, road works, congestions and offering the possibility to transfer messages concerning dangerous situations to a central office. Only 51 % consider the service eco-driving as helpful, which evaluates the driving behaviour concerning economy and pollution control.

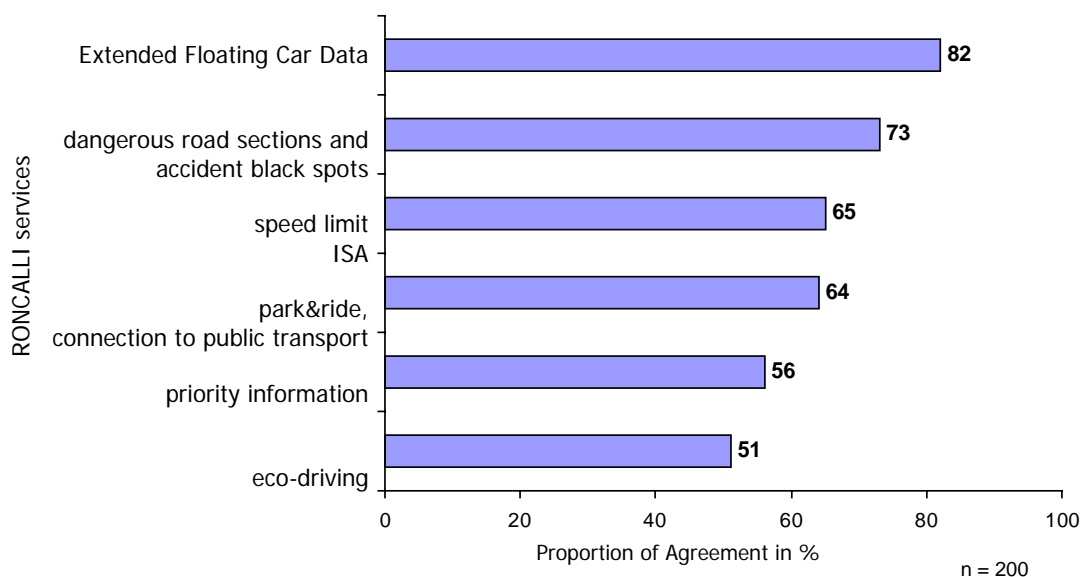


Fig. 8: Estimation of potential personal benefit of RONCALLI services

### Additional services

Beyond the RONCALLI services the following additional services, which might be interesting for drivers, had been asked:

- Information concerning road surface condition
- Possibility of cashless payment for tolls or parking fees
- Information concerning petrol stations or shopping centres along the route
- Current check on vehicle condition (e.g. oil-check, service, ...)
- Possibility to get news (daily news, weather, sports, ...)
- Information about sights (museums, ...) along the route
- Information concerning restaurants and hotels along the route
- Administration of appointments and personal correspondence (scheduler, sms, e-mail, ...)

Generally the approval for these additional services was lower than that for the RONCALLI services (see Fig. 9). The highest benefits for the additional services was seen in the services road surface condition information (64 %), cashless payment of tolls and parking fees (61 %) and information about petrol stations and shopping centres (60 %).

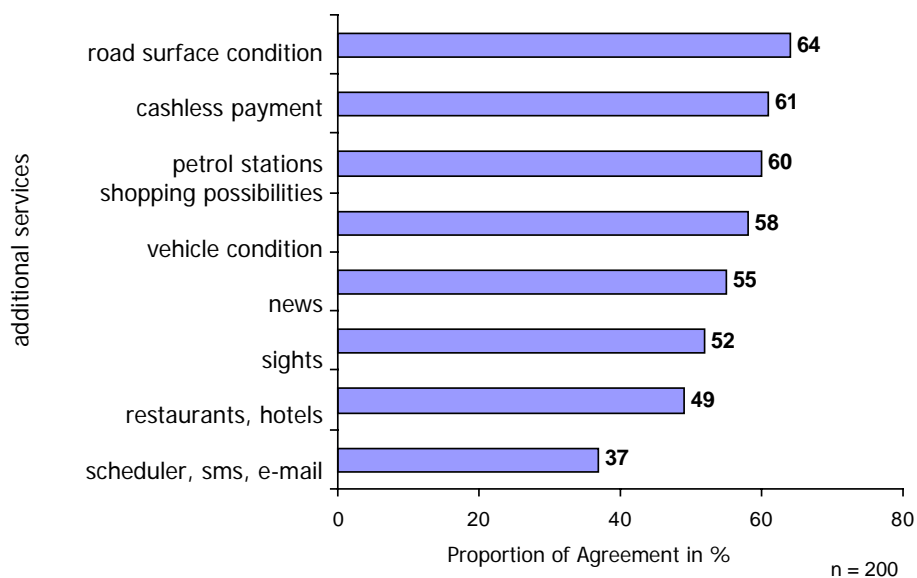


Fig. 9: Estimation of potential personal benefit of additional services

### Type of Settlement

Concerning the settlement for the transfer of transport telematic services three different types were offered:

- fixed, monthly flat rate
- daily rate, when the device is on
- rate per kilometre, when the device is on

Nearly half of the interviewees (47 %) preferred a billing per kilometre, 28 % appreciated a monthly flat rate and only a quarter chose the daily rate.

A concluding discrete-choice-analysis brought the types of settlement into relation to find out their impact on purchase decision.

Monthly flat rate in relation to daily rate:

The interviewees would be willing to pay as much for a monthly flat rate as for 17 days service usage within one month. That means the customers would only choose a monthly flat rate when the costs are below the costs for 17 days service usage and vice versa. The respondents used their cars averaged at 21 days a month.

Monthly flat rate in relation to rate per kilometre:

The interviewees would be willing to pay as much for a monthly flat rate as for 525 kilometres service usage per month. That means the customers would only choose a monthly flat rate if the costs are below 5.25 times the rate for 100 kilometres a month and vice versa. The respondents drove 1451 km per month as an average.

Daily rate in relation to rate per kilometre:

The daily rate was evaluated as if it would be the same as for 31.3 kilometres a day. That means the customers would only choose a daily rate if the costs are below 0.313 times the rate for 100 kilometres and vice versa.

### **“Value” of a service**

Within this context the question concerning the “value” of single services occurred. When correlating the service extended floating car data (having highest purchase priority) with the service eco-driving (having least purchase priority) the value of a service gets obvious. Is the service xFCD included in a service package people are potentially willing to pay EUR 45.89 more than for the monthly flat rate for a service package including eco-driving. For the daily rate this would correspond to EUR 2.73 and for the kilometre rate it would be EUR 8.74 per 100 kilometres.

## **Conclusion**

RONCALLI and RONCALL\_I2 were both projects dealing with driving assistance systems. In the first project “RONCALLI” transport telematic related information was gathered, transferred, analysed and processed as basis for the development of road safety relevant services. A coherent system architecture consisting of a server framework and a client was set up successfully and it was prototypically shown how relevant road safety information can be delivered to customers.

Within RONCALL\_I2 an electronic market place for selling, buying, billing and administer transport telematic content and services was developed. Only if content and services are traded out of competition everybody can benefit. Standardised interfaces for content and service providers were generated and theoretically trade could start on the market place. The market place could be a big step towards the increase of road safety but as long as the general framework (e.g. governments publishing road related data) is missing it is not possible to start up the market place successfully.

For the demonstration of the market place several services were developed and evaluated by test persons of a driving school and in a market survey. All in all, ISA (Intelligent Speed Adaptation) and xFCD (Extended Floating Car Data) were rated as the most interesting and road safety contributing services. But also the other offered services, like warnings of bad road condition or accident black spots were rated pretty good by the interviewees. Surprisingly the service eco-driving was rated least by the respondents of the market survey even though the savings in fuel consumption through eco-driving are evidenced.

Hence, the demonstrated services arouse interest in the target groups and they were a very good and successful attempt to show how a driving assistance system can work. Of course, as it was a pilot trial, there are many features which have to be improved and preconditions (e.g. area-wide data) have to be established. But the two projects RONCALLI and RONCALL\_I2 contributed a lot to set up a basis which will be very helpful for further driving assistance systems in Austria and perhaps in a few years, government and economy will be ready for the market place and the RONCALLI services will be the first to be offered.

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