A co-operative road solution based on EGNOS to improve road mobility
Even using today's best on-board navigation systems for cars, drivers can still get confused when trying to choose the most appropriate road lane, when preparing to exit a motorway, for example, or to turn right or left in a multi-lane road.

To solve this problem, to enhance road safety and traffic efficiency and enable the deployment of new mobility systems and services, the next generation of navigation systems will have to be capable of lane-level vehicle positioning.

Today's GNSS is the backbone of almost every type of physical positioning system, but GPS alone cannot meet the requirements of lane-level precision and reliability.

The CoVeL solution
CoVeL is a European project co-funded in the 7th Framework Programme by the European GNSS Agency. CoVeL is coordinated by Italy's Centro Ricerche FIAT and its consortium includes Magneti Marelli (Italy), Hitachi Europe (France), Technische Universitaet Chemnitz (Germany), Centre d'Etudes Techniques de l'Equipement du Sud Ouest (France), Navteq Europe (the Netherlands).

The concept developed under the CoVeL project involves the exchange of raw satellite data between vehicles using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies. The resulting relative positioning of the vehicles is more accurate than these two stand-alone positioning techniques, thanks to co-operative map matching, relative positioning, and, in particular, data provided by the EGNOS augmentation system and by EDAS (EGNOS Data Access System).

CoVeL's new 'Lane Position Assistant' (LPA), demonstrated at the 2011 Infrastructures, Telematics and Navigation (ITN) Conference in Turin, Italy, is based on low-cost mass market receivers and can be used in different kinds of applications: for example it can feed into a vehicle navigation device or a more advanced vehicle safety system.

A connected mobility network for Europe
Smart, green and safe mobility is an important target, as today traffic congestion still represents a yearly loss of 1% GDP and 10% of the European road network is congested every day. Furthermore, in 2009, more than 35 000 people died on European Union roads and no fewer than 1.5 million were injured.

The mobility paradigm of the future, for passenger traffic and freight, will link vehicles, service providers, road infrastructure and traffic control centres in a single network, where the basic requirement for information exchange is localisation and geo-referencing.

A number of European research projects have demonstrated the benefits of co-operative systems in reducing the risk of accidents and in improving traffic flow. However, these projects have also tended to highlight a variety of technological challenges, including precise vehicle positioning at lane level. With the Galileo system now on the horizon, EGNOS and EDAS are already presenting significant market opportunities for vehicle manufacturers, suppliers, technology-oriented SMEs and map providers.

Combining GPS, EGNOS and Galileo
CoVeL project partners say their LPA opens a new era for navigation systems, especially in urban areas. Primary satellite positioning data provided by GPS are augmented and
corrected by EGNOS. EGNOS data are then obtained directly from EGNOS satellites or from EDAS and broadcast to vehicles using V2V and V2I communication systems.

EGNOS improves the accuracy and integrity of the vehicle positioning, creating a solid ground for a number of applications such as:
- Navigation at lane level
- Active ‘green driving’ based on navigation maps, including dynamic traffic data to optimise driving parameters and fuel consumption
- Safety-applications based on precise dynamic vehicle relative positioning and co-operative map matching.

EGNOS-corrected vehicle positioning is then further enhanced by the application of innovative algorithms for co-operative localisation and map matching, making it suitable even for urban driving scenarios. Once the Galileo system is operational, working in combination with GPS, the LPA system will be even more powerful, especially in the urban environment.

Higher accuracy through co-operative vehicle localisation
One of the core ideas of CoVeL is the exchange of satellite raw data among vehicles using V2V and V2I technologies. Relative positioning is a crucial problem in mobility applications and it is typically solved using proprietary ranging devices, such as radio sensors.

Direct access to EGNOS satellite data depends on the position of the user with respect to those satellites, which can be problematic in proximity to tall buildings. Therefore, CoVeL also uses V2I communications for EDAS data transmission, and it provides EGNOS access via Road-Side Units (RSUs).

Map matching of a single stand-alone vehicle will be extended groups of vehicles. As the relative positions of vehicles in a group are very accurate, the resulting shape of the vehicle group is also highly accurate. This shape is then matched to a digital map, with detailed information about the road area.

Figure 1 shows the CoVeL base algorithm.
- a) The car in the left lane cannot determine its lane position due to its position uncertainty (gray area); only the sidewalk areas can be excluded.
- b) Vehicle position is determined by GNSS receiver data, complemented with EDAS data and refined with other vehicle position information.

Figure 1 – From vehicle positioning to co-operative map matching
c) This method of vehicle localisation goes beyond the state-of-the-art of current systems, as it extends map matching of single vehicles to a co-operative approach using a group of vehicles. The performance indicator is a significantly reduced number of false road associations compared to a state-of-the-art (a) point map matching.

CoVeL has evaluated the co-operative map matching approach using traffic and GNSS simulations (fig 2). The simulation of the CoVeL system is based on data from a real test drive on a city ring road doing several loops, alternating the direction from time to time.

![Figure 2 – Screenshot of the CoVeL traffic simulator](image)

The performance of the co-operative localisation was evaluated assuming two different GNSS biases and two different noise values for the relative position measurements.

CoVeL outcomes show that 2 to 3 communication elements (or partners) are enough to improve the position estimation. Based on these simulations, a lateral position precision, which can be considered as lane-level accuracy, seems to be achievable.

These results show that the absolute accuracy of the CoVeL system depends heavily on the accuracy of the relative localisation approach, which in turn depends on the correction data provided by EGNOS. Thus, EGNOS and EDAS are important enablers of the CoVeL co-operative localisation approach. The CoVeL validation session took place in October 2011 in Bordeaux. The analysis of data collected at the validation session will consolidate the CoVeL results and will pave the way towards exploitation.

**Advantages of co-operative positioning**

CoVeL will provide highly precise position information to co-operative systems. For this purpose, CoVeL is investigating how precise positioning can be achieved with a combination of EGNOS and V2I networks, without introducing additional charges on the communication network. This study is also providing valuable inputs to V2I specification activities being carried out under other European co-funded projects, by ETSI and by the C2C-Communication Consortium.

CoVeL’s contribution to V2I technology combined with lane-level precision will allow a large number of new mobility applications for safety or traffic efficiency, such as lane merging, lane-level traffic information, etc. Up to now, this kind of application has been impossible due to the lack of precise positioning at affordable costs. The combination of
EGNOS and V2I systems is the key to fill this gap, both from a technical and cost-effectiveness viewpoint: delivery of the exchanged data among the vehicles with an high data rate, delivery of EDAS data to new application layers, feedback for advanced V2I applications (i.e. extended set of applications) are the criteria used in CoVeL to estimate the effectiveness of project outcomes.

In particular, in the framework of the CoVeL project, the following solutions have been investigated as applications for traffic management systems:

*Improved eCall vehicle localisation*
The CoVeL system will be used to improve the localisation of an accident. This application will enable a measurable reduction in time to intervention, thus saving lives and reducing the effects of accidents on the mobility network. For example, emergency vehicles will know in which direction to enter a motorway in order to reach the accident as quickly as possible.

*Detection of blocked exit ramps*
Current automatic traffic jam detectors have difficulties in determining whether a traffic jam is affecting a whole motorway or just an exit ramp. The CoVeL system will improve the ability to distinguish these two situations. By extension, information provided by variable message signs will be more reliable and will allow smarter route choices.

*Incident detection at motorway intersections*
As motorway intersections are a major source of traffic disturbance, the CoVeL system will be used to determine if certain lanes (e.g. the lanes leading to another motorway) are blocked. Detailed information will be provided to the driver about which lane he/she should use to avoid the traffic jam.

*Lane advice in urban areas*
The CoVeL system will be used to improve the efficiency of driving in urban areas by providing early information about blocked lanes after an intersection. As a consequence, smoother and earlier lane changes will be possible, resulting in less driver stress and increased traffic efficiency.

CoVeL will require lane information beyond that provided by current standard map databases, both in terms of geometry and attributes. Thus, CoVeL is investigating how lane-level information can be mapped to existing database definitions, or how those definitions could be extended to meet the application requirements. This work is being done on the basis of the Local Dynamic Map concept; that is, using open, non-proprietary interfaces.

Moreover, CoVeL will use accurate positioning information to develop a lane-level navigator module. This module will perform lane-level route calculation and guidance and is another key part of the CoVeL LNA.

The use of co-operative positioning developed under CoVeL to improve satellite and EGNOS data accuracy should drastically reduce localisation errors. Combined with co-operative map matching, this opens new opportunities for traffic management and for automotive stakeholders to create new applications and services or to improve existing ones.
More Information:
CoVeL project website [www.CoVeL-project.eu]