15 August 2009

From: Michael L. Sena
To: Nick Bradley
Ref: Safe Operation of Large Vehicles through Map-based ADAS
Re: Proposed Article for Vision Zero

SAFE OPERATION OF LARGE VEHICLES THROUGH MAP-BASED ADAS

Everyone benefits from improved safety and fuel efficiency for large commercial vehicles. In Europe, Heavy Commercial Vehicles are classified as those over 16 tonnes. Over 40,000 people are killed on European roads each year, and around 10% of those deaths involve heavy truck accidents. In Sweden, heavy truck traffic has increased by 60% during the past 20 years, and now consists of 8% of road traffic, but trucks are involved in 22% of traffic-related deaths. According to a European Commission White Paper on Transport Policy, truck transport is expected to increase by 50% between 1998 and 2010, thereby increasing the risks for accidents and putting greater stress on the environment.

On average, a heavy truck travels approximately 120,000 kilometres per year. This number has been rising steadily for the past fifty years. So even though the average fuel consumption per truck has decreased from 50 litres per 100 kilometres in 1970 to 32 l/100 km in 2004, with a greater number of trucks and longer distances travelled by each truck, total fuel consumption has continued to rise. Further, increased traffic congestion caused, in part, by more trucks on the roads competing for space, multiplies the negative effects. A fully loaded 40 tonne truck that makes two stops per kilometre due to congestion has a fuel consumption that is four times higher than a truck that can move with no stops.

Addressing the safety and environmental effects of large trucks will take concerted efforts by government, industry and private individuals. On the government side, the European Union's focus on research and development in the transport sector is based on the multiple challenges transport faces in the coming years, including:

- The increasing need to conserve energy in order to fulfil its obligations to international agreements, especially the Kyoto Protocol;
- Threats to accessibility for people and goods caused by increasing traffic congestions on the Community's roadways;
- The competitive need to improve its transport industry's

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competitiveness; and,

- The desire to exploit new opportunities offered by enlargement of the Community.

Within this context, the two over-arching objectives for European transport research that are advanced by the various funding organisations are:

- To develop safer, greener and smarter transport systems for the benefit of Europe's citizens and out of respect for the environment and natural resources; and,

- To secure and develop the leading role of European industry in the global market.

These two objectives are addressed in a new class of in-vehicle applications, called Advanced Driver Assistance Systems (ADAS), that are beginning to make their way into vehicles. Most of the ADAS systems already developed use radar and motion sensors to deliver signals to the applications so that they can perform their specialised functions, such as stabilising the vehicle around turns (Electronic Stability Control), warning the driver not to change lanes if a car is approaching from behind in its blind spot (Lane Departure Warning), or keeping a safe and constant driving distance to the vehicle in front (Adaptive Cruise Control). The next generation of ADAS development will use map data as an additional sensor. Map data is an important—and in some cases vital—aid to providing the information for many safety and energy conserving driving applications, such as assisted braking on steeply sloping and curving roads, assisted acceleration and braking on hilly terrain, assisted steering and safe speed maintenance on winding roadways with many intersections.

Heavy Truck-specific ADAS

One application is a warning system for curves and speed control. With the help of stored information about upcoming radii, a truck driver can be warned if he or she is driving too fast into a curve. It is also possible to create an automatic cruise control device that can adapt the vehicle's speed so that the vehicle negotiates through a tight curve in a safe and energy efficient manner. The vehicle could automatically reduce acceleration before entering the curve in sufficient time, depending on both slope and curve severity, as well as accounting for the vehicle's own weight distribution characteristics.

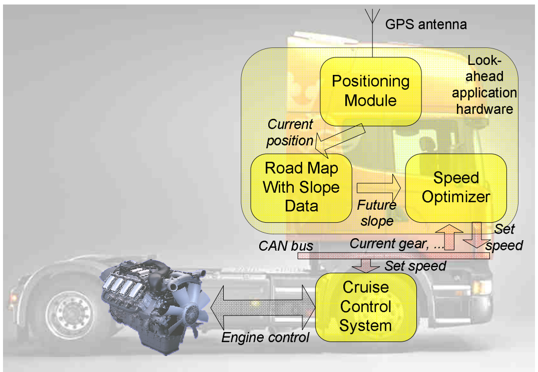
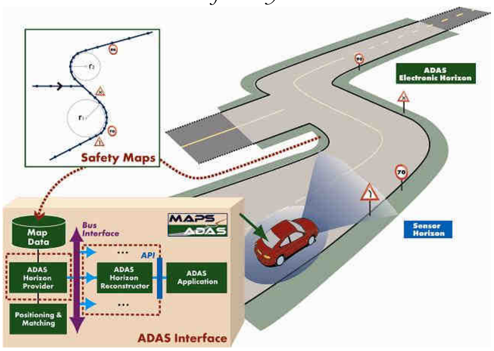


Illustration: Scania Trucks showing map-based ADAS architecture.

Another application is a gear box with a sixth sense. When a road is flat, it is possible to save fuel by changing to an extra high hear in order to achieve an optimal operating position for the engine. However, changing gears takes energy, so it only makes sense to do it if the road remains flat for a meaningful distance. This is where map data showing a so-called electronic horizon comes into play. When the motor's RPMs begin to slow down on the up side of a hill, it is good to know if the vehicle will soon reach the crown or if the hill will become even more steep so that the proper gear changing decision can be made. This decision includes both the number of changes and the ideal gear to choose. With the appropriate map data, there decisions can readily be supported in an automated system.

ADASIS Interface by ADASIS Forum



There are indications today that digital map data used for some in-vehicle ADAS applications will be supplied by current navigable map data providers (e.g., Navteq and Tele Atlas in Europe), and that the data will be delivered to system integrators in a form consistent with the structure of navigation systems. There is a geographic data model in wide use by the in-vehicle systems sector, the GDF specification, and it is according to this data model that system developers will most likely expect data to be delivered. The ***ADAS Interface Specification Forum***, an ERTICO-led industry group, is working on standardising the format of map data that will be delivered to applications requiring map data in an electronic horizon, as shown in the diagram above.

A major problem with introducing map-based ADAS is that the information contained in the current navigable map databases is not sufficient or not of a high enough level of quality to perform some of the required vehicle control and driver assistance functions. Slope is an example of data that is not currently included in the navigation data sets. Slope is the difference in height between two points, and the distance between these points. Slope, or even altitude, has not been needed for the turn-by-turn routing performed by the current generation of navigation systems, but it is essential for both safety and fuel economy applications in heavy vehicles. Methods currently used to record the altitude coordinate from which slope is derived are not sufficiently accurate for achieving the desired level of accuracy.

There are two problems with current altitude data collection methods methods: The resolution of the heights of points is too coarse; and, the distance between the collected points is too far apart. Using GPS and inertial measurement techniques it has been possible to achieve a slope accuracy—the difference between measured and actual—of up to 1%. However, tests have shown that for a fuel economy and brake management application for heavy trucks, 0.1% slope accuracy over a distance of ten metres is required on the portions of roads where slope begins to change, up or down. This is necessary in order to estimate the vehicle drag caused by gravity on small gradients.

The SOLVI (Safe Operation for Large Vehicles Initiative) Project within the Swedish IVSS (Intelligent Vehicle Safety Systems) Programme is performing extensive tests of map-based ADAS applications, particularly with slope and curve data, but also with truck-specific routing attributes and dynamic data. The ADASIS specification is being tested as well since all participants in SOLVI are also ADASIS Forum members. Swedish truck manufacturers Volvo Technology Corporation and Scania are responsible for developing the applications and testing the data. Navteq is supplying its standard navigable map data set along with specially compiled data for truck-specific ADAS applications. Navteq have begun to collect truck road attributes in Europe. They have a program for completing the countries in Western Europe by the end of 2009 to what they believe is an acceptable level of precision and attribute completeness. Most of this data is being collected by Navteq staff with tools that have been specially developed for the purpose.

Alternative Data Sources for ADAS

Highly accurate road data is being delivered by another SOLVI Project team member, the Swedish Road Administration (SRA). One objective of the SOLVI Project was to determine whether it is possible to incorporate data from the SRA dataset into the Navteq dataset in a way that would make it feasible to use the process in a production work flow. This data includes slope, curvature, banking, bridge heights, speed limits, vehicle type restrictions and much more. It has long been recognised that the national road authorities, like SRA, are one the best potential sources of high accuracy data in many countries around the world. There are over 100 countries represented in the World Road Association (PIARC). Most of these organisations have the responsibility for specifying and overseeing the building and maintenance of the national road network, and for establishing the standards for all roads that are built and maintained by the counties and or municipalities. The national road authorities' design engineering drawings and as-built drawings can be excellent sources of data for updating existing databases and for providing highly accurate curve and slope data.

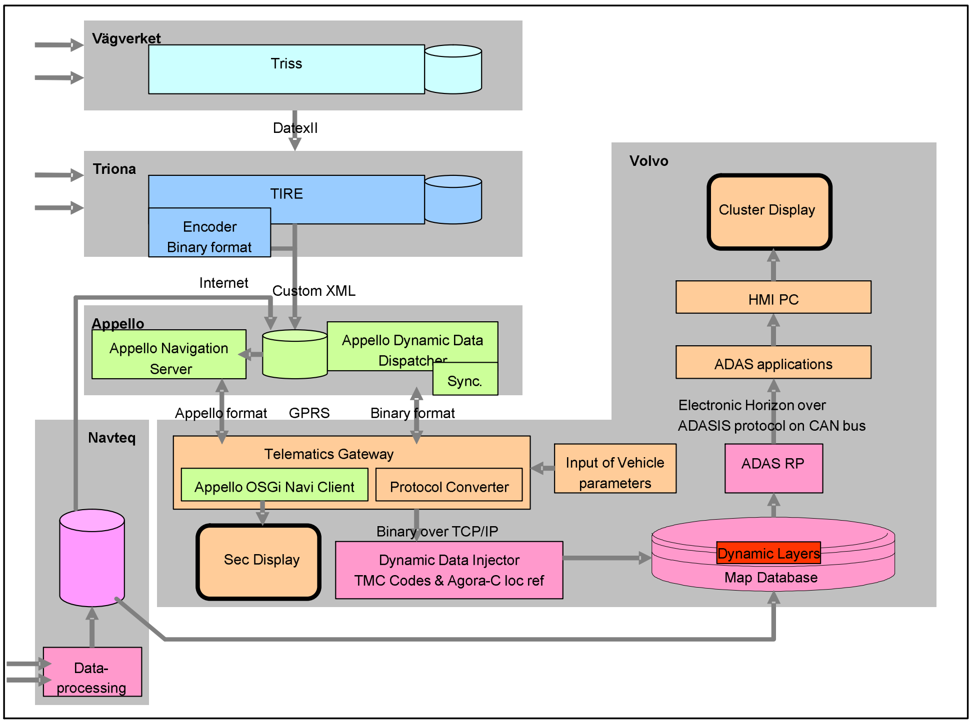
Vägverket Konsult laser measuring device

There are other processes used by the road authorities that generate useful data. For example, there is a road measurement method used in Sweden by SRA subsidiary, Vägverket Konsult, based on a vehicle fitted with special sensors. The vehicle is used primarily for road surface testing. The intention of its measurements is to show precise surface profiles of the roads, but slope, curvature and banking data are delivered as a "bonus". The measuring vehicle can travel at approximately 80 km/h, making it a highly efficient data collection method.

Another important component of truck-based ADAS and truck-based routing is the provision of dynamically changing data, and this is addressed by two additional SOLVI Project partners, Triona and Appello. Triona are processing traffic information data normally delivered by SRA in the form of TMC messages and coding the data in a more robust form using the newly developed TPEG-TEC format. An on-the-fly location referencing method is also being tested. Appello has created an OSGi component for its Wisepilot off-board navigation client so that can be easily integrated with the on-board telematics gateway being used by Volvo in its Telematics Gateway, and it has adapted its routing algorithms to account for truck-based attributes.[1]

[1] For more information on the SOLVI Project, contact SOLVI Project Manager, Michael L. Sena (ml.sena@mlscab.se).

SOLVI Architecture



Issues with Public Data Usage

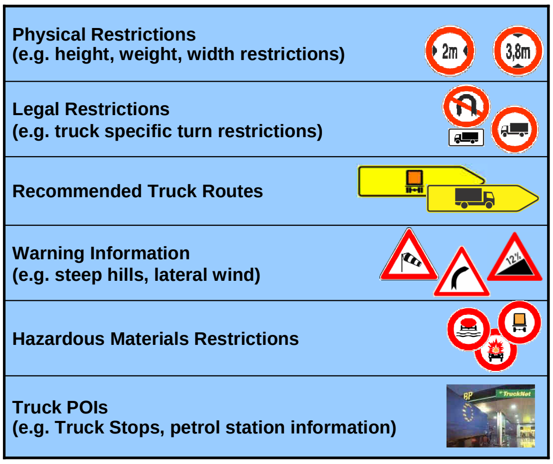
Issues that are of principal concern to national road authorities and their municipal counterparts are quite different from those of the navigation system developers. The authorities gather and store information in order to build and maintain the infrastructure so that it provides for safe travel by its users and the lowest possible maintenance costs for the public. The principal technical problems with public data usage are how the data is structured in the public authorities' databases, compared to the structure of the map data suppliers' data, including both the logical data model and the geographic reference system (each country has its own geographic coordinate system and origin point for this system); and the different requirements for the data resulting in widely different specifications for the types of data that are collected, and the frequency that the data is collected and updated. The lack of compatibility between public and private sector approaches to representing the physical world has been one of the most important reasons that direct data usage has not been practical.

Each of these issues on its own would be a major hurdle to using public authority data in an advanced driver assistance system. Taken together, they offer a formidable hindrance. Nevertheless, the advantages of accessing the wealth of data available from the national road authorities are a significant incentive to resolving these varied issues. The lessons learned thus far in the SOLVI Project are offered as a possible model for future cooperation between the road authorities and the map data suppliers for ADAS applications.

A set of attributes was used to match SRA to Navteq data. Several iterations of the matching process were necessary until a proper mix of attributes was determined, and the data sets could be matched precisely. Once the two data sets were referenced geometrically, it was possible to compare and contrast the different attributes. A combination of automatic and visual matching was made for each of the overlapping attributes, such as bridge heights and signage. In some cases, the SRA data was selected, and in others Navteq's data was used. An example of the former was speed limit data, which could be taken from the SRA data set into the Navteq data.

Conclusions

While the SOLVI Project has addressed only the technical issues, the results have been encouraging. It has been shown that there are methods that can be used for creating compatibilities between the different data models by using attributes of features that are common to both data sets, and that by first converting the road authority data to the international standard WGS84 geographic reference system, the matching task can be accomplished more easily and more accurately.



Certain attributes, such as those listed to the left that are not currently included in the navigable databases used for navigation in cars and light trucks, can be collected by the private map data suppliers. These attributes are among those necessary for routing large trucks on both major roads and on the minor roads that they are increasingly taking to get to their destinations. Overpass heights and width restrictions are among the most basic attributes that need to be part of a truck routable database.

Other data, especially slope and banking, require a higher level of positional accuracy than has been possible to achieve with standard GPS-based measuring techniques, and this is where data from the national road authorities can provide an excellent supplement. The national road agencies and the commercial map producers will need to work closely together to overcome the obstacles to the use of the public data, and this cooperation will need to address both the technical and financial aspects of such collaboration.

Dynamic data needs to be part of an ADAS application for large vehicles. Since the safe and efficient operation of these vehicles is so dependent on the maintenance of an even speed, any unforeseen hindrances along the road can have severe negative consequences. Combined with the necessary truck-specific attributes for all roads, knowing in advance the existence of roadworks, temporary speed limit reductions or accidents will allow the re-planning of a route along an appropriate path, or the recalibration of the ADAS tools to account for changed conditions along the originally planned route.

The SOLVI Project will be demonstrating the results of its work with large vehicle ADAS at the ITS World Congress to be held in Stockholm, Sweden in September 2009.

Michael L. Sena