HGV GUIDANCE, ROAD DATA AND APPLICATIONS

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Abstract

HeavyRoute (HR) is a European Union funded research project with the aim to develop an advanced route guidance system for Heavy Goods Vehicles (HGV) as a tool for deriving the safest and the most cost effective routes for road freight transports throughout Europe. The HR system will integrate information of road network characteristics with a route planning and driving support system. The network characteristics are used for calculating travel time, vehicle operating costs, road and bridge damage, environmental impacts as well as accidents risks. This paper gives an overview of the concept demonstrating the possibilities to combine periodic road condition data in route guidance services to find the most cost effective routes in society's view.

Keywords: Heavy goods vehicle (HGV), Pavement management system (PMS), Route guidance, Road surface characteristics, Effect models, Noise, fuel consumption, Road deterioration.

Résumé

HeavyRoute (HR) est un projet de recherche financé par l'Union Européenne pour développer un système avancé de routage des poids lourds (HGV) et leur indiquer les itinéraires les plus sûrs et les plus économiques pour le transport routier de fret en Europe. Le système HR intégrera l'information sur les caractéristiques de la voirie dans un système d'aide au choix d'itinéraire et de conduite. Les caractéristiques de l'infrastructure sont utilisées pour calculer les temps de parcours, les frais d'exploitation des véhicule, les dommages aux routes et aux ponts, et les impacts sur l'environnement ainsi que les risques d'accidents. Cet article donne une vue d'ensemble du concept et montre comment il combine des données périodiques sur l'état des routes pour aider à trouver les itinéraires les plus économiques au plan sociétal.

Mots-clés: Poids lourds, aide à la gestion routière, routage, guidance, aide à la conduite, couche de roulement, caractéristiques de l'infrastructure, modèle d'effet, bruit, consommation de carburant, détérioration de route.

1. Introduction

An overall view of the HeavyRoute project is presented in (Ihs et al, 2008). An important part of the HR project has been to identify and adapt the models that should be used to assess the traffic effects for further use in the routing process. The assessment includes calculation of the "optimum" or "most cost effective routes". There are two major providers of road data NAVTEQ and Tele Atlas, se figure 1. They make agreements with land survey offices, road administrations etc to get access to national road databases making it possible to build up road maps. They also perform a collection function to add more attributes to the datasets.
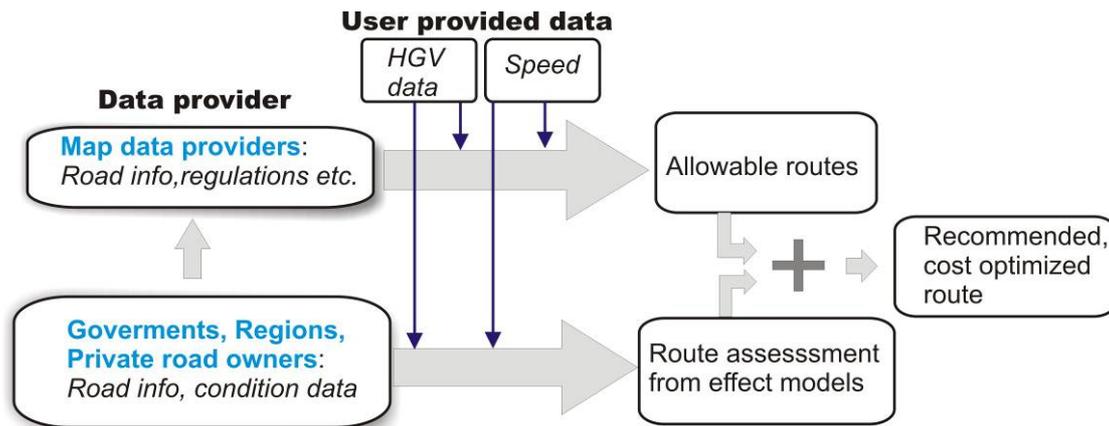

Figure 1 – Map data providers and data flow in HR concept.

The support of relevant data to the effect models is another important part of a functioning HR system. Therefore, in order to identify the availability and quality of data needed as input to the models, questionnaires have be sent out.

A selection of available traffic effect models, such as fuel consumption and emissions, ride quality, noise as well as road and bridge deterioration, for deriving the "optimum" route and reducing impacts on the infrastructures has also been performed. The most relevant models have been selected to be used for the further HR route guidance/planning concept. This paper will describe some of them in more detail.

For estimating the fuel consumption and exhaust emissions it is suggested to use the so called ARTEMIS model (Keller, 2007), whereas for estimating the noise impact the HARMONOISE model (de Vos, 2005) is found to be suitable. A literature review was used to select a model for the estimation of ride comfort/quality where it is suggested to use the truck ride index HATI (Heavy Articulated Truck Index) developed in Australia. HATI was developed by Swinburne University of Technology on commission by the VicRoads department (Hassan, McManus, 2004).

The available data needed for the effect models derives from so called periodical data (road surface condition data) collected to support road management systems (PMS). The primary use of this data is the PMS which is described in more detail below.
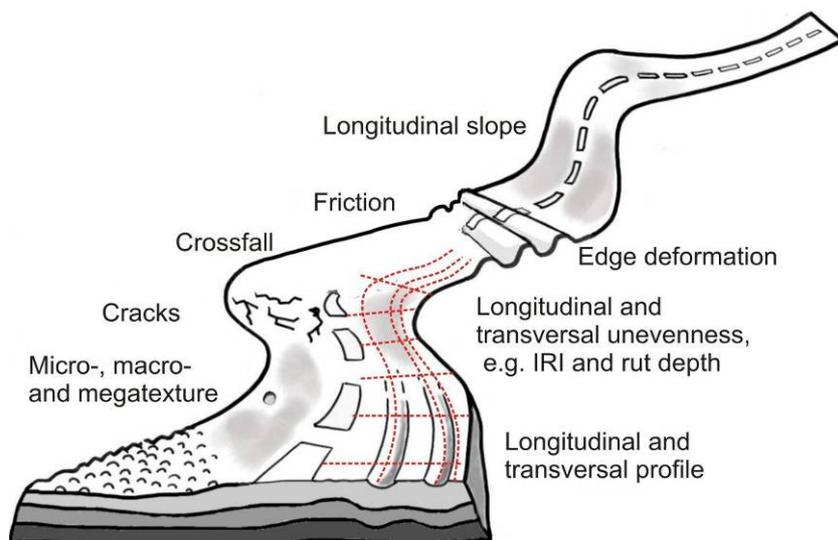
Figure 2 – Example of periodic road data used as support to pavement management systems

2. Results from questionnaires

Almost all countries in Europe do inventories and monitor road condition, at least on part of the road network, where major roads are of primary interest for HeavyRoute (HR). This can be stated from accomplished inventory in HR and many other sources e.g. (http://cost354.zag.si). The situation on how the periodic data collection is managed is very different in the EC countries. The management of the road network can be handled by private companies, some are divided into regions and other is handled by national governments.

Unfortunately it is apparent that the data is not easily available. More promising is that the up date frequency in general is each year. But this is very much depending on national or local measurement strategies and may change with short notice. The accuracy of localization and for the parameter itself is unknown. The geo referencing of data is not standardized despite initiatives such as EuroRoads. The section length that a single parameter is presented varies between 10, 20, 50 and 100 meters. The most common collected parameters are:
- Rut depth
- Longitudinal unevenness (IRI or other)
- Friction
- Macrotexture
- Longitudinal, transversal profile
- Longitudinal slopes
- Crossfall
- Road width

A lot of the conclusions, from this minor investigation indicate the same results as major similar inventories done by e.g. PReVENT project MAPS&ADAS (see MAPS&ADAS). They conclude that a uniform approach for data by application collection to support ADAS is missing and there are significant differences over Europe for road data management. This project focuses on enhancing the digital maps with look-ahead capabilities. One prioritized ADAS applications is e.g. an active cruise control incorporating the advantage of look-ahead capabilities. The data quality is low and geo-referencing of information is a major problem.

The MAPS&ADAS inventory focused on safety related data and data able to be used for general ADAS applications, not specific data to support HGV applications as is the focus of the HR project. This fact has led to that an initiative called ROSATTE (Road Safety ATTributes exchange infrastructure in Europe) has been proposed. One limitation is that ROSATTE will only consider safety related attributes. HR needs a more extended area looking on more attributes that support ride quality, environmental issues and road deterioration.

3. Road management

A well-functioning road network is a necessity for every country. Basically everyone in a country is affected by roads and uses them every day. The Swedish Road Administration (SRA) is responsible for long-term strategic planning and road design specifications as well as operation and maintenance of state roads. This is the situation for road administrations in most European countries. In some cases the roads can be operated by private road owners or consortia's or by local governments. In any case they all need strategies and long term planning to manage political goals.

PMS, pavement management system
The SRA has been commissioned by the Swedish Government with issues relating to environmental impact, road safety, accessibility, transport quality, regional development and gender equality. For an efficient development in this work tools such as a pavement management systems (PMS) have been created. A PMS consist of a strategy to prioritize maintenance and operations including the ability to assess the condition due to traffic loads and climate and to assess different levels of condition standards related to political goals and budgets. In the PMS effect models have been developed for prioritized effects, e.g.:

- Traffic Safety
- Road deterioration
- Environmental impact
- Vehicle operating costs
- Ride quality
- Accessibility etc.

The models have to be supported with data. This is to a great extent managed by specialized traffic speed measurement vehicles. This data collection support is done periodically, often each year. The collected data is stored in PM databases. For each effect numerous models have been developed during the years. To conclude extensive information on road condition are collected each year and stored in data bases to be used in road management. So far the use has been to make prognosis and assess effects.

4. Traffic effect models used in HR

With the introduction of HeavyRoute (HR) and consequent intelligent route guidance of heavy trucks, this road data can be used to protect the environment, road infrastructure and increase the safety. In HR the idea is to suggest routes that are the most cost effective in the society's view. This implies that not only the fastest or shortest route needs to be the optimum. Consideration has to be taken also to the safest, less environmental impact, most road surface friendly and high ride quality route. Therefore a number of effects have been chosen to demonstrate a functional framework for such a routing concept. The following models have been chosen in HR:
- Environmental effects : the European ARTEMIS (exhaust emission) and HARMONOISE (Noise),
- Vehicle operating costs: the European ARTEMIS (fuel consumption),

- Road Deterioration/Bridge damage: pavement performance model assessing the strength of the road/bridge,
- Safety: roll over warning system, jack-knifing,
- Ride Quality: HATI, Heavy Articulated Truck Index.

Artemis, exhaust emissions and fuel consumption
ARTEMIS is an EU model for inventories of road exhaust emissions on the macro level. The model also includes fuel consumption calculations. ARTEMIS distinguishes between different road and traffic conditions i.e. for the same average speed there can be many different fuel consumption levels. ARTEMIS input demands:
- Vehicle inclusive trailer
- Load
- Road
- Traffic conditions.

Road data includes type of road and gradient. In practice road type and traffic conditions are collected as input data. For each road type there could be four degrees of traffic saturation described. In total there are 256 emission factors per substance and vehicle type available. Since the influence of load factor and gradient are continuous functions there is in practice an infinite number of emission factors available.

HARMONOISE, external noise generation
Traditional route guidance applications can minimize the travel time or the distance. This is closely related to for instance the exhaust emissions from the vehicle or the tire wear. But within the HeavyRoute project more advanced so called external effects are taken into account, and one of them is noise emission and exposure. The noise emission is influenced by the speed of the vehicle, driving behavior such as hard accelerations, and by the design of the vehicle components such as silencers and tires. But the noise exposure is determined by the number of people living close to the road and the noise levels they are exposed to. This is influenced mainly by the route taken by the vehicle, i.e. if the vehicle is traveling through rural or urban areas. These effects are illustrated in a number of examples, where the new common European noise calculation model HARMONOISE is used together with example data from an example area in Sweden.

HATI, estimation of ride quality
The ride quality environment of the truck driver involves among other factors the effects of vibrations. Vibrations are the product of the applied excitation and the response characteristics of the truck. Road surface unevenness is the major source of excitation. Other sources are the rotating wheels, the driveline and the engine. Surface unevenness with different lengths and amplitudes excites vibration modes of the truck body. The resulting vertical, lateral, longitudinal and rotational motions affect the drivers comfort and perception of ride quality.

Therefore a truck ride index has been developed called HATI (Heavy Articulated Truck Index). HATI is developed in Australia by Swinburne University of Technology on commission from Vicroads department.

The longitudinal profile from the two wheel paths is needed as input. From the profiles a quarter car index is calculated. This is calculated with the same algorithms as for IRI (International Roughness index) but with parameter setting for trucks. As a start the

Australian HATI scale can be used as output although it is calibrated for Australian requirements.

5. Conclusions

Traditional routing calculates the fastest and shortest route possible between A and B. By entering the characteristics of the specific heavy vehicle (length, number of axles, height, width etc) the allowable routes can be specified. In principle the next step is to calculate and assess the status of all the remaining, allowable routes regarding the selected traffic effects; which routes uses the least fuel, make least emissions, creates least noise, least road damage and have the highest ride quality and finally which route is the safest route? The optimal choice will be the most efficient for the society. Why a HGV should follow this advice is another question which is discussed in a separate paper by Ihs et al.

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