

## HEAVYROUTE – INTELLIGENT ROUTE GUIDANCE FOR HEAVY VEHICLES



**Anita IHS**  
VTI  
Lindköping, Sweden



**Damaris OMASITS**  
Arsenal Research  
Vienna, Austria



**Gunnar LINDBERG**  
VTI  
Lindköping, Sweden

### Abstract

HeavyRoute (HR) is a European Union financed research project with the aim to develop an advanced route guidance system for Heavy Goods Vehicles 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. The paper will give an overview of the conception phase, involving all potential users and stakeholders, of the HR project and how the process succeeded in a common understanding of the system's design and functionalities. The paper also examines the characteristics of the HR system vis-à-vis the probability that a market product could emerge or if market imperfections exists preventing a market to materialize. In the latter case possible alternatives, including tax differentiation, subsidies and different form of legislation, to promote the non-market features of HR are discussed.

**Keywords:** Heavy goods vehicles (HGV), Route guidance, Driving support.

### Résumé

HeavyRoute (HR) est un projet de recherche financé par l'Union Européenne pour développer un système de routage avancé pour les poids lourds, en vue de déterminer les itinéraires les plus sûrs et économiques pour le transport routier de fret en Europe. Le système HR utilisera les informations sur les caractéristiques du réseau routier pour une planification d'itinéraire et une aide à la conduite. Les caractéristiques de l'infrastructure seront utilisées pour calculer le temps de parcours, les coûts d'exploitation des véhicules, les dommages aux routes et ponts, les impacts écologiques et les risques d'accident. Cet article donne un aperçu général de la phase de conception, impliquant les utilisateurs et parties prenantes potentiels du projet, et montre comment on est arrivé à une compréhension commune de la conception et des fonctionnalités du système. Les caractéristiques du système sont aussi examinées pour évaluer les chances de faire émerger un produit commercial, ou si des difficultés pourraient entraver la concrétisation d'un marché. Des solutions alternatives pour ce cas sont proposées, dont la modulation des taxes, des subventions et une réglementation adaptée, pour promouvoir les solutions non commerciales du projet Heavyroute.

**Mots-clés:** Poids lourds, système de routage, aide à la conduite.

## **1. Introduction**

The transport of goods between EU Member states is set to increase by 50% between 2000 and 2020. Road transport – which already conveys more than 70% of goods on land – can be expected to take the main part of this expansion. The increase of Heavy Goods Vehicles (HGVs) on the European road network will obviously have consequences for safety and congestion as well as for the environment.

In addition, increasing gross weights and changing load configurations of HGVs are causing accelerated damage of bridges and pavements. Consequently, traffic management problems to maintain safety as well as to reduce congestion and the damage to the infrastructure can be foreseen. Finding means to reduce the costs associated with the increasing traffic volumes is a major challenge for the road research community as well as the road authorities and operators.

The HeavyRoute project, which is co-funded by the European Commission, aims to develop an advanced route guidance system for HGVs in Europe, based on the improvement in the generation and usage of digital maps, as a tool for deriving the safest and the most cost effective routes for road freight transports throughout Europe.

The system will be built on available and implemented technologies such as fleet management and logistics systems, guidance/rerouting systems, traffic monitoring and management systems, dynamic map updating and various ITS solutions.

## **2. Development of the HeavyRoute System**

As a first step in the project a State-of-the-art survey has been carried out (Delefosse, 2007). This was based on a review by the partners of projects, systems, technologies and services with different levels of maturity, either already available on the market or still in the R&D phase within national, EC or international programs. The following domains were covered: Logistic systems, Traffic and infrastructure management, ADAS system for trucks and “Other topics” such as evaluations and assessments, environmental issues, etc. The further steps in the project are described in the following chapters.

### **2.1 System conception and user requirements**

The objectives of the HeavyRoute project are to improve road safety and capacity while reducing the negative effects on the environment and the road and bridge maintenance costs. These are very ambitious aims and require the involvement of a great number of different relevant stakeholders to ensure a suitable solution for all affected parties.

One part of the project was to identify the requirements for the proposed advanced HGV management and route guidance system, taking into consideration various key stakeholder groups. This was done in three steps.

#### ***Interview study***

Stakeholders from a wide variety of sectors (from the four countries Austria, Belgium, France and Sweden) were interviewed: HGV drivers, planners and representatives of logistics companies, management, road authorities, road safety engineers and experts in areas of traffic, roads, bridges and or telecommunications (Forward, 2007). The results from the

interview study illustrate the problems experienced with route guidance system in the past, along with potential benefits and disadvantages of such systems.

Requirements for any future implementation to be realized were also mentioned, such as:

- Some degree of obligation or a decision at the European level
- A cost-benefit analysis
- Protection of driver privacy (should not be used to track and act as an informer on driver behaviour)
- Fiscal advantages and that the system should not be too expensive

***Survey study: Questionnaires to drivers and planners in five countries***

Based on the results of the interviews questionnaires for the two main user groups, truck drivers and planners, were developed.

For the truck drivers and for the planners there have been different parts in the questionnaires. The truck driver's questionnaire consisted of three parts:

Part A was dealing with the factors that should be minded by the planners during pre-trip route planning. Those factors would then influence the selection of the suggested route that the truck driver has to take.

Part B was asking the truck drivers what on-trip support they would wish to get during their journey.

Part C covered the aspects of HGV monitoring and management on-trip. Here they were also asked about the degree of acceptability, that the head office has certain information on their vehicle or on themselves.

The planner's questionnaire consisted just of two parts:

Part A dealt, as for the truck drivers, with the factors that should be included in pre-trip tour planning.

In Part B the planners had the possibility to indicate what information they would like to regard as important concerning HGV monitoring and management.

The questionnaires were sent out to a large number of people in different countries. All in all 175 questionnaires (137 from drivers, 38 from planners) from six different countries (Austria, Belgium, France, Sweden, The Netherlands, Germany) have been answered and offered possibility for analyses (Forward, 2007). Questions were asked about the importance of different factors for the three different applications considered within HeavyRoute. Some of the aspects considered the most important are given below:

- Pre-trip planning
- HGV restrictions of the infrastructure (e.g bridge heights/weight restrictions)
- Current European roadwork information
- Support during journey (only drivers)
- Information on accidents, congestion, worksites, temporary lorry bans, unsuitable infrastructure and alternative routes
- Monitoring and management
- Drivers: Warning other vehicles of hazards
- Planners: Driver/vehicle location, adherence to selected route, adherence to rest-time rules, vehicle axle loads/overloading, new routes

### ***Workshop***

A workshop was organized to discuss, validate and prioritize the results from the previous user requirements studies. An important outcome from the workshop was also the need to find incentive schemes for logistics companies to use the system, for the truck drivers to follow the advice from the system and for the road authorities/managers to provide up-to-date input information/data of good quality (Omasits, 2007)

A second part of the project was the identification of actors and entities related to an intelligent route guidance and management system, of user needs and of use cases. This was the bases for the description of system concepts for the four main parts of the overall HeavyRoute systems, including the map integration process, intelligent route guidance, driving support and management at critical infrastructure.

## **2.2 System architecture and visions**

Additionally to the user and stakeholder requirements study a problem analysis was conducted to identify the most relevant and important issues for the transportation sector as well as for the society in connection with the routing and guidance of HGVs.

Based on all the results that have been created and derived during the HeavyRoute conception phase it was possible to develop visions and a system architecture on a meta-level for the HeavyRoute system (see figure 1).

The system architecture was based on the system concepts and therefore reflects the four main system elements:

### ***Map integration process***

The map integration process can be seen on the left hand side of the system architecture, where raw data (static, dynamic, periodic) are provided by different information providers. The raw data are then integrated into the map basis, up-dated and geocoded. The processed data as well as the information concerning the respective tours (e.g. delivery addresses, goods, fleet information) build the relevant basis for the HeavyRoute system and is used by all actors.

### ***Intelligent Route Guidance***

Based on the processed data the traffic management centre calculates the current traffic situation, considering specialties for HGVs. The traffic situation and the effect models (e.g. emission model, fuel consumption model, bridge and road damage index) are the basis for the route planning service provider to offer route planning, routing and HGV monitoring to the logistics company. The navigation service provider uses the data to offer a navigation service to the logistics company.

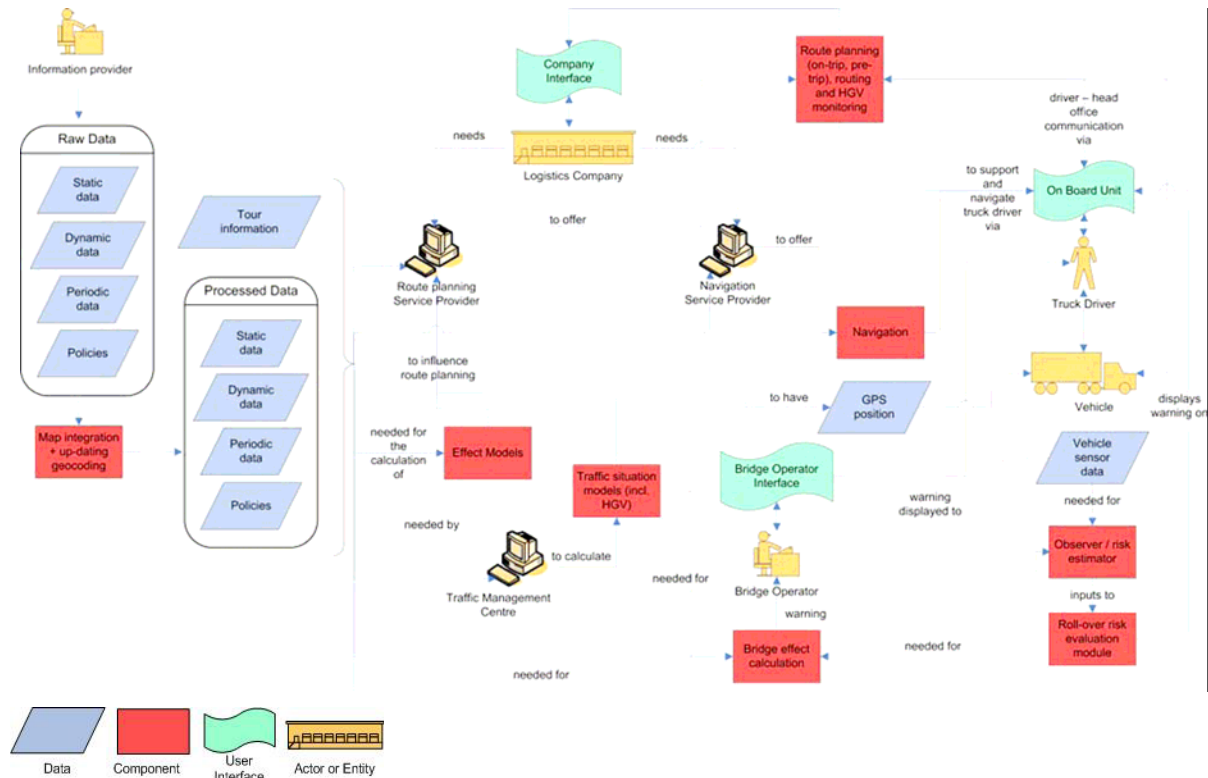
### ***Driving support***

The logistics company requests the route planning, routing, HGV monitoring and navigation services to support and navigate the truck driver during the tour. The company user interface enables the logistics company to monitor the HGV and to communicate with the driver via the on-board unit.

On the driver-vehicle-side the vehicle safety system works through observing the current vehicle status while taking into consideration the available processed data. If e.g. a roll-over risk exists a warning is shown to the driver via the on-board unit.

## Critical Infrastructure Management

The Bridge Operator uses the processed data for the bridge effect calculation to decide if the bridge is in danger to be damaged. In case of severe damage (safety) risk the bridge operator can display a warning to the truck drivers and advise them to either reduce their speed or increase vehicle distances.



**Figure 1** – The suggested HeavyRoute system architecture (Omasits, 2007).

For the visions a HeavyRoute scenario was developed, that shows in a very demonstrative way how the system could work after its development. The scenario covers the role of the dispatcher, the role of the truck driver as well as the position of road/bridge operators, traffic management centers and the environment. Future developments that lie without the scope of the HeavyRoute system were summarized in a best case scenario that offers potential for further elaboration.

### 2.3 Databases and vehicle/infrastructure interaction models

An important part of the project has been to identify and adapt the models that should be used to calculate the “optimum” or “most cost effective routes” as well as identifying the data needed as input to the models. This part is presented in more detail in a separate paper by Sjögren, 2007).

Questionnaires have been sent out in order to do an inventory of available static, periodic and dynamic road, bridge and traffic data in national databases.

An inventory of available effect models, such as fuel consumption and emissions, ride comfort, noise as well as road and bridge deterioration, for deriving the “optimum” route and

reducing impacts on the infrastructures has also been done and the most relevant models to be used for route guidance/planning have been chosen. Several relevant models have been developed within recent European projects. For example 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 the most suitable. An exception is 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, 2004).

### 2.4 Route guidance and driver support applications

The work with developing the different applications in HeavyRoute is based on the results derived in terms of user requirements, use cases and the system architecture specification as well as information about the availability of static, periodic and dynamic data and the first model descriptions. The objectives are to derive more detailed use cases and to make a first specification of the different applications and algorithms for map integration, intelligent route guidance, driving support and critical infrastructure management.

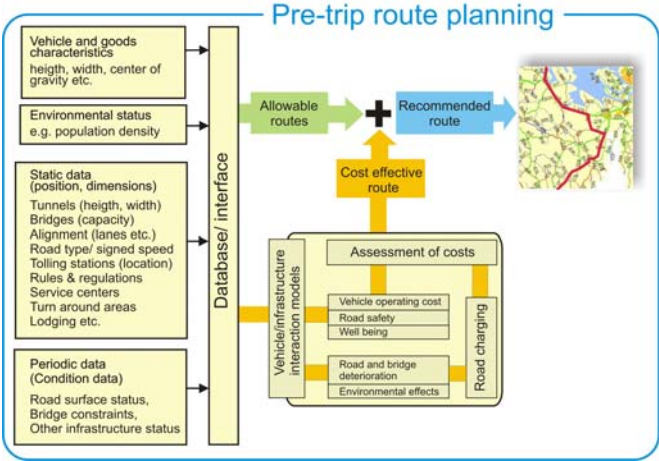


Figure 2 – Illustration of the use of data and vehicle/infrastructure interaction models for the pre-trip route planning application.

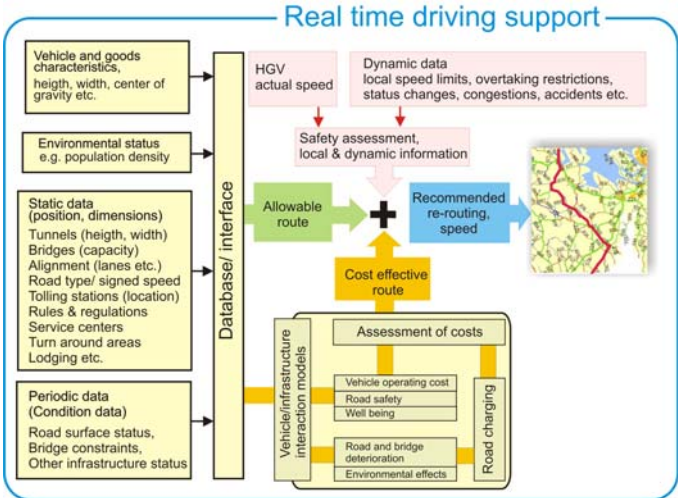


Figure 3 – Illustration of the driving support application where also dynamic data is used.

## **2.5 Traffic simulation and effects of management**

The likely traffic effects of a limited number of different system configurations/scenarios will be simulated at two levels of aggregation, i.e. for the network level as well as for critical, specific points or road segments (e.g. bridges). The levels correspond roughly to effects on network traffic flow levels due to pre-trip route planning and effects on traffic flow at critical road segments due to driver response to information/messages, respectively.

The simulated traffic effects will then be evaluated in a Cost Benefit Analysis (CBA) with the aim to guide towards the best/most likely development path of the HeavyRoute system.

## **3. The HeavyRoute system - a market product or a legal requirement**

### **3.1 Individual vs. collective routing**

Route planning and guiding systems are already today available on the market based on GPS technology and digital road maps with algorithms that support the haulier with the optimization of his logistic decision. The benefits to the haulier's have obviously outweighed the system cost and a market product has emerged. The HeavyRoute concept has features that have a market potential but it has also characteristics that is more difficult to see a private interest in. Based on traditional economic theory we know that the market will not provide the optimal quantity of a good or service which displays non-excludability, non-rivality or externalities. Some of these characteristics may fit into the description of the HeavyRoute system. For example, it could be argued that a user that follows the advice of the system on the welfare optimal path creates a positive externality towards other fellow road users (due to less congestion and risks) and the society at large (due to less environmental burden). However, the question is why the hauliers should choose this non-selfish solution.

The dual objective of the system - private and social interest - is operationalized in two different routing algorithms – Individual routing and Collective routing. The Individual routing algorithm will optimize the individual generalised cost, mainly vehicle operating cost and time cost of drivers and cargo, irrespectively if this means a higher total system cost. The algorithm will ignore non-private costs (e.g. air pollution) and in a dynamic model congestion will only be limited as far as it minimizes individual costs (Wardrops first principle). The Collective routing algorithm will optimize the total system cost and thus include minimization of the society cost for accidents, air pollution, noise, road deterioration and global warming. In a dynamic context congestion will be at its system optimal level (Wardrops second principle).

If we assume the private operator to maximize profit, and that this profit is independent on their behavior vis-à-vis the external costs, a classification of the Heavy Route modules as in the table below can be done (in some situations the conflict may be limited if the external cost function is similar to a private cost function (e.g. fuel consumption and CO<sub>2</sub>-emissions). We can hardly expect the private market to provide and use the information of collective benefits, i.e. how to reduce the collective costs (benefits).

We know that user cost is the dominant element in the macro economics of transport (UNITE 2002). The table below summarizes the Swedish transport accounts for the road sector in 1998. The dominant element is the supplier operating cost of the operators. The external cost,

although reflecting large amounts and a huge human tragedy, is only approximately 30% of the total cost.

**Table 1 – Beneficiaries of Heavy Route.**

<b>Module</b>	<b>Individual benefit</b>	<b>Collective (external) benefit (h)</b>
Grade, alignment etc	User cost	As input for the external cost calculations in the modules below
Roll over warning	Internal safety	External safety
Other safety features	Internal safety	External safety
Road deterioration information	-	Reduced cost for road authority
Bridge load warning	-	Reduced cost for road authority
Noise level information	-	Reduced cost for population near road
Air pollution information	-	Reduced cost for population near road
Green house gases	-	Reduced green house effect
Dynamic routing	Reduced own travel time	Reduced overall travel time

**Table 2 – Summary of costs in Swedish transport sector 1998, M€**

<b>Cost component</b>	<b>M€</b>	<b>Percentage</b>	<b>Benefit from a 10% improvement (M€)</b>
Infrastructure cost	2 159	16%	216
External accident cost	953	7%	95
Environmental cost	982	7%	98
Internal accident cost	2 502	19%	250
Supplier operating cost	6 564	50%	656
Sum costs	13 160	100%	

Source: UNITE

If we assume that each module above will reduce the cost with 10% (this is a question for the forthcoming evaluation) we can expect that for the private information that will improve transport and logistics a willingness-to-pay (WTP) of M€656 exists (this is for the whole road sector in Sweden), for a reduction of 10% in the internal accident cost a WTP of M€250 exists. To reduce the air pollution with 10% the society could spend M€98 and to reduce the external accident cost M€95. The road authority would benefit M€216 and could thus accept to pay this amount.

### **3.2 Incentive schemes to solve the conflict**

As suggested above, the public sector would have a WTP for reductions in road deterioration, bridge damage, air pollution, external accident cost (and reduced congestion). Let us assume, first that a CBA of a public involvement in Heavy Route shows a positive result, and that the public sector provides the information on externalities described in the HeavyRoute modules above.

If the two principles discussed above, individual and collective, are applied, as alternatives, in a route planning and guidance system the conflict between them will be apparent. Why should



an operator avoid increasing the noise exposure or why should he accept a longer travel time to reduce congestion for other operators?

The conflict occurs because it is a difference between the private and social objective function. The welfare economic optimum is only reached if we can create incentive schemes that move these objectives closer to each other.

We can see a number of different alternative ways to make this happen;

- Change the preferences of the private operator – be green
- Tax the polluter (Pigouvian taxes) or subsidize the cleaner producer
- Use restrictions

Of moral or market reason the private company may wish to behave more in line with the social objective – e.g. to behave green. Research on private individuals shows that a significant proportion behaves with reciprocity or have some sort of altruism in their behaviour (Lindberg (2006)). However, it is not clear why a market firm should behave in this way except for market reasons. Environmental lobbyist and individual preferences may create an environment where the market rewards firms that behave green. Following the advice on air pollution and accidents in Heavy Route may thus be a prerequisite for better customer relations. This behaviour has to be monitored in some way.

Internalise the external cost through taxation is a common way to handle this conflict. Currently taxation includes taxes on fuel, distance based taxes and time based user charges in the European road sector. The legal base for the taxation is set in a directive from the European Union (Directive 2006/38). While these charges are an improvement of the transport policy it is rather blunt instruments which will not be able to capture the differences in external cost between vehicle types, road types and environment. A further differentiation of the pigouvian taxes would be a benefit for the society (if it comes with a reasonable system cost).

We could envisage a system where users of a monitoring scheme of the HeavyRoute type could be allowed to pay the tax according to the monitored external cost in HeavyRoute (or other system). Other users, which do not have a HeavyRoute system, can still pay the tax according to the current blunt average taxation system. Obviously, only users with ‘well behaved’ costs functions will follow the advice of the HeavyRoute system. However, this will nevertheless increase the average cost for the users outside the system as the ‘well behaved’ operators will join the HeavyRoute system. A cycle will be created that moves users voluntary into a HeavyRoute system with tax differentiation.

The other common way to solve the problem of an externality is to use a restriction. Current European legislation limits the weight and dimension on HGV:s to 18,75 meters and 40 tonnes. An increase in the length or weight may create an externality per vehicle (road damage, accidents etc). On the other hand the transportation and logistic costs will be reduced as the number of vehicles will be reduced (and probably outweigh the external costs).

We could foresee a system that allows heavier and longer vehicles on a road network if their trips are informed by a HeavyRoute system. The legal requirement to allow these longer vehicles could be that they have to follow the advice of the system. In return they will reap the benefit of longer and heavier vehicles.

#### 4. HeavyRoute information

Call: Fp6-2005-Transport -4 Research area: SUSTDEV-2002-3.4.2.4.16  
Coordinator: Swedish National Road and Transport Research Institute (VTI)  
Partners: Arsenal research, ERTICO, Forum of European National Highway Research Laboratories (FEHRL), Laboratoire Central des Ponts et Chaussées (LCPC), NAVTEQ, PTV Planung Transport Verkehr AG, Swedish National Road and Transport Research Institute (VTI), Volvo Technology AB  
Start: Sept 2006.  
Duration: 30 months.  
Budget: 3.3 M€  
Website: <http://heavyroute.fehrl.org>

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