DANGEROUS GOODS TRANSPORTATION:
A European cooperative system for routing, monitoring, re-routing, enforcement and driver support, for dangerous goods vehicles

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ABSTRACT

The current publication, entitled “Dangerous Goods Transportation: A European cooperative system for routing, monitoring, re-routing, enforcement and driver support, for dangerous goods vehicles” is based on the major outcomes of research work performed by the Hellenic Institute of Transport in the research project: “Dangerous Goods Transportation Routing, Monitoring and Enforcement - GOOD ROUTE” (co-funded by the European Commission under FP7 Contract: IST-4-027873-STREP performed between 01/01/2006 and 31/01/2009, http://www.goodroute-eu.org).

Although, according to statistics, the risk of accidents in critical infrastructures such as tunnels and long bridges is lower than on open roads and motorways, when accidents/incidents do happen in them may have multiple effects. Over 200 people have died in Europe as result of tunnel fires (successive effect of collisions) in the last decade (16 fire accidents occurred in road tunnels in Europe from 1986 until 2006), while 3% of the accidents in bridges are fatal (vs. 2% in total accidents). The Mont Blanc, the Tauern and the Gotthard tunnel catastrophes, among others, have demonstrated the urgent need for improving the prevention and mitigation of tunnel accidents, including adequate detection systems in combination with being prepared operation staff and emergency services.

Besides loss of human life and the tremendous economic cost (the Gotthard tunnel accident cost was estimated to be 12 million Euros, only in terms of repair and insured losses for vehicles), a single crash may close the infrastructure for many hours, creating long queues and delays, with vast financial cost induced for the whole business chain, let alone the environmental cost due to traffic pollution in queues, noise pollution and wasted energy (fuel) during queuing.

As a result of accidents, traffic jams but also road works and other unexpected events but also due to the different national regulations and individual infrastructure policies (i.e. Dangerous Goods vehicles are not allowed in Gotthard tunnel), truck drivers are often forced to follow secondary roads and alternative routes. But the actual accident risk and impact when using secondary roads or other alternative ways is not calculated. They have no

1 GOOD ROUTE has been executed by a multidisciplinary Consortium of 14 Partners, coming from 6 European member countries coordinated by CERTH. The partners were: CERTH/ITI (Coordinator), CERTH/HIT (Technical Manager), PTV, SIEMENS, TID, CRF, IVECO, GST, FINRE, SITAF, ELPA, UPM, USTUTT, ICCS and COAT.
particular guidance on the safest alternative when they need to re-route, whereas the consequences of road choice are not known to the business chain.

*GOOD ROUTE* attempted to address these problems by developing a cooperative system for Dangerous Goods Vehicles (DGV) routing, in order minimise the Societal Risks related to their movements, while still generating cost efficient solutions for all logistic chain actors involved. Besides routing, the developed system supports monitoring, re-routing (in case of need), enforcement and driver support, achieving its aims by utilizing dynamic, real time as well as historical data.

The core of the system is a real time decision support system (DSS) that optimises the routing (and re-routing) of Dangerous Goods Vehicles within a transportation network by balancing the economic costs and societal risks associated with their transport. It takes into account dynamic data about the vehicle, the cargo, the infrastructure and the environment; individual risk, societal risk, as well as logistic chain requirements, constraints and equity schemes. The decision support system has been integrated with an on-board route guidance system and an infrastructure control operators’ management system. In addition, a monitoring and enforcement system has been developed, that makes use of all gathered data and the local traffic rules, and applies enforcement automatically, whenever required. Dangerous goods drivers and all actors of the logistic chain are being supported through ICT interfaces which allow them to get information and warnings automatically and without the need for further communication. Through these interfaces, emergency situations are also handled automatically.

The system was integrated with an automatic, local node based, enforcement functionality and was tested in three European Pilot sites, namely the Finnish highways and bridges (DESTIA), the Gotthard tunnel in Switzerland (GST) and the Frejus tunnel in Italy (SITAF).

Starting from the overall recognized needs, problems and limitations in the area of DG (Dangerous Goods) transportation and the outcomes of the in-depth accident and user needs analysis performed in the project to verify them, the publication discusses the overall cooperative system architecture, case studies and major functionalities developed, whereas special reference is being made to the evaluation and impact assessment results performed in the context of the project, leading, finally, to a set of training and policy recommendations for consideration by the relevant stakeholders in the DG transport area. The deployment potential of *GOOD ROUTE* and its position in the relevant market is also discussed, resulting, finally, in the identification of the major strengths,
weaknesses, opportunities and threats of the developed integrated cooperative system.

*Important Note: All market related data, as well as the technological, political, regulatory and socioeconomic framework of reference, are those of project GOOD ROUTE, i.e. of the years 2008 – 2009.*
ΠΕΡΙΛΗΨΗ

Η παρούσα έκδοση, με τίτλο «ΜΕΤΑΦΟΡΑ ΕΠΙΚΙΝΔΥΝΩΝ ΦΟΡΤΙΩΝ: Ένα Ευρωπαϊκό συνεργατικό σύστημα για την δρομολόγηση, παρακολούθηση, αναδρομολόγηση, τήρηση κανονισμών, και υποδοχή του οδηγού Οχημάτων Επικινδύνων Φορτίων» βασίζεται στα κύρια αποτελέσματα της δουλειάς που έκανε το Ινστιτούτο Μεταφορών του Εθνικού Κέντρου Έρευνας και Τεχνολογικής Ανάπτυξης - ΕΚΕΤΑ στα πλαίσια του Ευρωπαϊκού Ερευνητικού έργου "Dangerous Goods Transportation Routing, Monitoring and Enforcement - GOOD ROUTE" (συγχρηματοδότηση από την ΕΕ στα πλαίσια του 7ου Προγράμματος Πλαισίου, αριθ. Συμβολαίου: IST-4-027873-STREP, την τριετία 01/01/2006 έως 31/01/2009, ıδε και http://www.goodroute-eu.org)2.

Το αντικείμενο της παρούσας έκθεσης είναι η μεταφορά επικίνδυνων φορτίων οδικά και η πρόταση συστήματος για την παρακολούθησή τους, τον έλεγχο της κίνησής τους, την εκπαίδευση των οδηγών, και άλλων θεμάτων για την αύξηση της οδικής ασφάλειας από την κατηγορία αυτή οχημάτων. Ειδικότερα ενδιαφέρει ο κίνδυνος να συμβούν ατυχήματα σε υποδομές όπως οι σήραγγες και οι γέφυρες. Αν και η συχνότητα με την οποία συμβαίνουν ατυχήματα σε τέτοιες υποδομές είναι μικρότερος σε σύγκριση με ατυχήματα στα «ανοικτά» οδικά τμήματα και τους αυτοκινητόδρομους, όταν αυτά συμβαίνουν, οι συνέπειές είναι πολλαπλές και πολύ περισσότερο επικίνδυνες. Πάνω από 200 άνθρωποι έχουν πεθάνει την τελευταία δεκαετία στην Ευρώπη ως αποτέλεσμα της πυρκαγιάς σε σήραγγες (που έχουν προκύψει από συγκρούσεις). Μεταξύ 1986 και 2006, 16 τέτοια ατυχήματα συνέβησαν στο τούνελ στους δρόμους της Ευρώπης, ενώ το 3% των ατυχημάτων σε γέφυρες υπήρξαν μοιραία (έναντι 2% του αντίστοιχου ποσοστού στο σύνολο της κυκλοφορίας). Τα καταστροφικά ατυχήματα που συνέβησαν την προηγούμενη δεκαετία στο Mont Blanc, το Tauern και το Gotthard τούνελ, έδειξαν, ανάμεσα σε άλλα, την άμεση ανάγκη για θελτώση της πρόληψης αλλά και αντιμετώπιση των ατυχημάτων σε σήραγγες, με αυτήν να συμπεριλαμβάνει κατάλληλα συστήματα αναγνώρισης και συνδυασμό με κατάλληλα προσωπικό και υπηρεσίες εκτάκτου ανάγκης.

2 Το έργο GOOD ROUTE εκτελέσθηκε από ένα ερευνητικό Consortium με 14 εταίρους από 6 Ευρωπαϊκές χώρες και συντονίσθηκε από το ΕΚΕΤΑ. Οι εταίροι του έργου ήταν ΕΚΕΤΑ/ΠΙΤΗΑ (Συντονιστής), ΕΚΕΤΑ/ΙΜΕΤ (Τεχνικός Συντονιστής), PTV, SIEMENS, TID, CRF, IVECO, GST, FINRE, SITAF, ELPA, UPM, USTUTT, ICCS και COAT.
Πέρα από την απόλυτη ασφάλεια της ανθρώπινης ζωής και το μεγάλο οικονομικό κόστος (ενθετικά αναφέρουμε ότι στο ατυχήμα στη σήραγγα του Gotthard, μόνο η ανόρθωση και επισκευή του και οι ασφάλειες αυτοκινήτων κοστολογήθηκαν στα 12 εκατομμύρια ευρώ περίπου), μια συνηθισμένη (μη μοραία) σύγκρουση μπορεί να κλείσει μια μεταφορική υποδομή για πολλές ώρες, δημιουργώντας μεγάλες ουρές αναμονής και κάθωστηρήσεις, με σημαντικό συνεπαγόμενο οικονομικό κόστος για την επιχειρηματική αλυσίδα στο σύνολό της. Και όλα αυτά, χωρίς και να αναλογιστούμε το επιπρόσθετο περιβαλλοντικό κόστος, εξαιτίας της ατμοσφαιρικής ρύπανσης, της ηχορρύπανσης και της αδικαιολόγητης σπατάλης ενέργειας (καυσίμου) στις σειρές αναμονής.

Η κυκλοφοριακή συμφόρηση ως αποτέλεσμα των ατυχημάτων, τα έργα επί της οδού και διάφορα άλλα μη προβλέψιμα συμβάντα, όπως και η εκάστοτε εθνική πολιτική πρόσβασης υποδομών (για παράδειγμα στο Gotthard τούνελ δεν επιτρέπεται πρόσβαση στα οχήματα επικίνδυνων φορτίων) έχουν σαν αποτέλεσμα την επιλογή δευτερευόντων εναλλακτικών οδών από μέρους των οδηγών επικίνδυνων φορτίων. Ο πραγματικός όμως κίνδυνος ατυχήματος σε αυτές τις περιπτώσεις δεν έχει υπολογιστεί. Οι οδηγοί δεν έχουν καμία συγκεκριμένη οδηγία ως προς την ασφαλέστερη εναλλακτική οδό, όταν χρειάζεται να αλλάξουν διαδρομή, ενώ οι συνέπειες της επιλογής οδού δεν είναι γνωστές στην επιχειρηματική αλυσίδα.

Προς την αντιμετώπιση αυτών των προβλημάτων, το έργο GOOD ROUTE ανέπτυξε ένα «συνεργατικό» σύστημα για τη δρομολόγηση οχημάτων που μεταφέρουν Επικίνδυνα Φορτία, με στόχο να ελαχιστοποιήσει το κίνδυνο που απορρέει από την κίνηση τους επί της οδού για το κοινωνικό σύνολο, αποσκοπώντας, παράλληλα, στην πιο οικονομικά αποδοτικότερη λύση για όλους τους επιμέρους κόμβους/φορείς της επιχειρηματικής αλυσίδας. Εκτός από τη δυνατότητα δρομολόγησης, το σύστημα που αναπτύχθηκε υποστηρίζει την παρακολούθηση, ανα-δρομολόγηση (σε περίπτωση ανάγκης), υποστήριξη του οδηγού, χρησιμοποιώντας τόσο δυναμικά όσο και ιστορικά δεδομένα και τεχνική λύση για την αυτόματη επιβολή των Κυκλοφοριακών Διατάξεων.

Ο πυρήνας του συστήματος είναι ένα σύστημα υποστήριξης αποφάσεων που λειτουργεί σε πραγματικό χρόνο το οποίο υπολογίζει κάθε φορά τη βέλτιστη δρομολόγηση και αναδρομική δρομολόγηση των οχημάτων που μεταφέρουν επικίνδυνα φορτία σε ένα δίκτυο μεταφορών υπορροφώντας το οικονομικό κόστος και τον κοινωνικό κίνδυνο που σχετίζονται με τη μεταφορά. Το πετυχαίνει αυτό, συνυπολογίζοντας δυναμικά δεδομένα σχετικά με το όχημα, το φορτίο, την υποδομή και το περιβάλλον και, στη συνέχεια, τον
δακρυηρό του συστήματος διεξήχθησαν σε τρεις πιλοτικές τοποθεσίες στην
Ευρώπη-συγκεκριμένα στους αυτοκινητόδρομους και γέφυρες της
Φινλανδίας (DESTIA), στη σήραγγα Gotthard στην Ελβετία (GST) και στη
σήραγγα Frejus στην Ιταλία (SITAF) - με χρήση των κόμβων για την
εφαρμογή του συστήματος αστυνόμευσης και επιβολής των Κυκλοφοριακών
diadiskón twn kantánknum twn chódon gia tin
εφαρμογή του συστήματος αστυνόμευσης και επιβολής των Κυκλοφοριακών
diastáseon pou anaptúxhíthke.

Συνεχώντας από τον εντοπισμό των αναγκών, των προβλημάτων και των
twn periorismón sthn periochή twn metaforás twn Epikíndunwv Empeυmáton kai twn
apotelésmátwn tis anályseis twn odoúmatwn kai twn chrímtwn twn

κατάσταση του συστήματος και την εκτίμηση των

ειδική αναφορά γίνεται στην αξιολόγηση του συστήματος και την εκτίμηση των

ενεργοποιήση κάθε εμπλεκόμενου φορέα στα θέματα αυτά . Γίνεται

υποθέτουν για την ενημέρωση και

και τις αναδυόμενες από την αγορά ευκαιρίες και απειλές (SWOT

ανάλυση).

Σημείωση: Τα δεδομένα που αφορούν την αγορά καθώς και τα
tа τεχνολογικά,

πολιτικά, κοινωνικο-οικονομικά χαρακτηριστικά αναφοράς είναι αυτά της

This work was partially funded by the EC FP6 project GOOD ROUTE European Commission STREP funded program, entitled “Dangerous Goods Transportation Routing, Monitoring and Enforcement” (DG Information Society and Media, Unit G.4-ICT in Transport, Contract Number: IST-4-027873-STREP; Duration: 01/01/2006-31/01/2009; http://www.goodroute-eu.org), falling under the scope of the IST-4 Strategic Objective: 2.4.12 eSafety – Co-operative Systems for Road Transport.

We would like to specially thank the EC project officer of the GOOD ROUTE project, Mr. Wolfgang B. Höfs, for his valuable support throughout the whole duration of the project and the project Coordinator, Dr. Dimitrios Tzovaras (CERTH/ITI), who was the leading force behind this very successful project.

Also, special reference should be made to the whole Consortium of GOOD ROUTE project for their excellent work and collaboration, namely all the colleagues participating from the Centre for Research and Technology Hellas (the Informatics and Telematics Institute and the Hellenic Institute of Transport), the Centro Ricerche Fiat, IVECO, Planung Transport Verkehr AG, SIEMENS S.A, the Universidad Politécnica de Madrid/ Life Supporting Technologies, Telefónica I+D, the Gotthardstrassentunnel, Società Italiana per il Traforo Autostradel del Frejus, the Center of Applied Technologies, the University of Stuttgart, the Institute of Communications and Computer Systems, the Automobile and Touristic Club of Greece and the Finnish Road Enterprise (renamed to DESTIA).
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<tr>
<td>3G</td>
<td>Third Generation</td>
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<tr>
<td>ADAS</td>
<td>Advanced Driver Assistance System</td>
</tr>
<tr>
<td>ADR</td>
<td>Agreement, concerning the International Carriage of Dangerous Goods by Road</td>
</tr>
<tr>
<td>AES</td>
<td>Advanced Encryption Standard</td>
</tr>
<tr>
<td>A-GPS</td>
<td>Assisted Global Positioning System</td>
</tr>
<tr>
<td>AJAX</td>
<td>Asynchronous Javascript and XML</td>
</tr>
<tr>
<td>am</td>
<td>ante meridian (before noon)</td>
</tr>
<tr>
<td>APRU</td>
<td>Average Revenue Per Use</td>
</tr>
<tr>
<td>AVL</td>
<td>Automatic Vehicle Location</td>
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<tr>
<td>B2B</td>
<td>Business to Business</td>
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<td>B2C</td>
<td>Business to Customer</td>
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<td>Cultural Diversity Focus Group</td>
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<td>Code Division Multiple Access</td>
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<td>CEN</td>
<td>Comité Européen de Normalisation</td>
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<td>CEN/ISSS</td>
<td>CEN's Information Society Standardization System</td>
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<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<td>CR</td>
<td>Conflict Resolution</td>
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<td>CRM</td>
<td>Conflict Resolution Module</td>
</tr>
<tr>
<td>CVIS</td>
<td>Cooperative Vehicle – Infrastructure Systems</td>
</tr>
<tr>
<td>CWA</td>
<td>CEN Workshop Agreement</td>
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<tr>
<td>D</td>
<td>Deliverable</td>
</tr>
<tr>
<td>DFP</td>
<td>Data Fusion Platform</td>
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<tr>
<td>DG</td>
<td>Dangerous Goods</td>
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<tr>
<td>DGV</td>
<td>Dangerous Goods Vehicle(s)</td>
</tr>
<tr>
<td>DS</td>
<td>Deployment Scenarios</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated short-range communications</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Support System</td>
</tr>
<tr>
<td>DTCO</td>
<td>Digital Tachograph</td>
</tr>
<tr>
<td>e.g.</td>
<td>Exempli Gratia (Latin: For Example)</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>ECE</td>
<td>Economic Commission for Europe</td>
</tr>
<tr>
<td>EEG</td>
<td>Electroencephalography</td>
</tr>
<tr>
<td>EG</td>
<td>Existing Guideline</td>
</tr>
<tr>
<td>ERA-NET</td>
<td>European Research Area Net</td>
</tr>
<tr>
<td>ETA</td>
<td>Estimated Time of Arrival</td>
</tr>
<tr>
<td>etc.</td>
<td>ET Cetera</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>EUR</td>
<td>Euro</td>
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<tr>
<td><strong>Abbreviation</strong></td>
<td><strong>Definition</strong></td>
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<tr>
<td>FACTS</td>
<td>Failure and Accidents Technical information System</td>
</tr>
<tr>
<td>FARS</td>
<td>Fatality Accident Reporting System</td>
</tr>
<tr>
<td>FIA</td>
<td>Federation Internationale de l'Automobile</td>
</tr>
<tr>
<td>FMS</td>
<td>Fleet Management System</td>
</tr>
<tr>
<td>FP</td>
<td>Framework Programme</td>
</tr>
<tr>
<td>GES</td>
<td>General Estimates System</td>
</tr>
<tr>
<td>GHz</td>
<td>Gigahertz</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GLD</td>
<td>Guideline</td>
</tr>
<tr>
<td>GPRS</td>
<td>General Packet Radio Service</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>GUNDI</td>
<td>Hazardous Substances Accident Database (Gefahrgutunfall-Datenbank der Redaktion Gefährliche Ladung)</td>
</tr>
<tr>
<td>h</td>
<td>Hour</td>
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<tr>
<td>H/W</td>
<td>Hardware</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>HOV</td>
<td>High-occupancy vehicle</td>
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<tr>
<td>i.e.</td>
<td>id est (that is)</td>
</tr>
<tr>
<td>I2C</td>
<td>Infrastructure to Car</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communications Technologies</td>
</tr>
<tr>
<td>ID</td>
<td>Identification Data</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<tr>
<td>IO</td>
<td>Infrastructure Operator</td>
</tr>
<tr>
<td>IP</td>
<td>Integrated Project</td>
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<tr>
<td>IPRs</td>
<td>Intellectual Property Rights</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ISSS</td>
<td>Information Society Standardization System of the European Standards Committee</td>
</tr>
<tr>
<td>IST</td>
<td>Information Society Technologies</td>
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<tr>
<td>ISTAT</td>
<td>Istituto Nazionale di Statistica</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>ITU</td>
<td>International Telecommunication Union</td>
</tr>
<tr>
<td>IVICS</td>
<td>In-Vehicle Information and Communication Systems</td>
</tr>
<tr>
<td>JSP</td>
<td>Java Server Pages</td>
</tr>
<tr>
<td>JTC</td>
<td>Joint Technical Committee</td>
</tr>
<tr>
<td>Km</td>
<td>Kilometres</td>
</tr>
<tr>
<td>Km/h</td>
<td>Kilometres/hour</td>
</tr>
<tr>
<td>LBS</td>
<td>Location Based Service</td>
</tr>
<tr>
<td>LC</td>
<td>Logistic Company</td>
</tr>
<tr>
<td>LdV</td>
<td>Light Duty Vehicle</td>
</tr>
<tr>
<td>LN</td>
<td>Local Node</td>
</tr>
<tr>
<td>LSS</td>
<td>Logistics Support System</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
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<tr>
<td>MG</td>
<td>Management Group</td>
</tr>
<tr>
<td>MHIDAS</td>
<td>Major Hazard Incident Data Service</td>
</tr>
<tr>
<td>Mio</td>
<td>Million</td>
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<tr>
<td><strong>Abbreviation</strong></td>
<td><strong>Definition</strong></td>
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<tr>
<td>mm</td>
<td>Millimetres</td>
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<tr>
<td>MMS</td>
<td>Multimedia Messaging Service</td>
</tr>
<tr>
<td>MN</td>
<td>Master Node</td>
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<tr>
<td>MNOs</td>
<td>Mobile Network Operators</td>
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<tr>
<td>MOF</td>
<td>Meta-Object Facility</td>
</tr>
<tr>
<td>MoU</td>
<td>Memorandum of Understanding</td>
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<tr>
<td>MP3</td>
<td>Moving Picture Experts Group Layer-3 Audio</td>
</tr>
<tr>
<td>NA</td>
<td>Non Applicable</td>
</tr>
<tr>
<td>NG</td>
<td>New Guidelines</td>
</tr>
<tr>
<td>OBU</td>
<td>On-Board Unit</td>
</tr>
<tr>
<td>ODM</td>
<td>Ontology Definition Metamodel</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer/Manufacturing</td>
</tr>
<tr>
<td>OSCi</td>
<td>Open Services Gateway Initiative</td>
</tr>
<tr>
<td>OWL</td>
<td>Web Ontology Language</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
</tr>
<tr>
<td>PIARC</td>
<td>Permanent International Association of Road Congresses</td>
</tr>
<tr>
<td>pm</td>
<td>Post meridiem (after noon)</td>
</tr>
<tr>
<td>PND</td>
<td>Personal Navigation Device</td>
</tr>
<tr>
<td>PPP</td>
<td>Public-Private-Partnership</td>
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<tr>
<td>px</td>
<td>Pixel</td>
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<tr>
<td>QoL</td>
<td>Quality of Life</td>
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<tr>
<td>QoS</td>
<td>Quality of Service</td>
</tr>
<tr>
<td>RAM</td>
<td>Random-Access Memory</td>
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<tr>
<td>RDS</td>
<td>Radio Data System</td>
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<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
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<tr>
<td>Ro-Ro</td>
<td>Roll-On/Roll-Off</td>
</tr>
<tr>
<td>RSA</td>
<td>Algorithm for public-key cryptography (stands for Ron Rivest, Adi Shamir and Leonard Adleman who first publicly described it in 1978)</td>
</tr>
<tr>
<td>RWIS</td>
<td>Road Weather Information System</td>
</tr>
<tr>
<td>S/W</td>
<td>Software</td>
</tr>
<tr>
<td>sec.</td>
<td>Second</td>
</tr>
<tr>
<td>SeVeCom</td>
<td>Secure Vehicular Communication</td>
</tr>
<tr>
<td>SIM</td>
<td>Subscriber Identification Module</td>
</tr>
<tr>
<td>SOAP</td>
<td>Simple Object Access Protocol</td>
</tr>
<tr>
<td>STREP</td>
<td>Specific Targeted Research Project</td>
</tr>
<tr>
<td>SUS</td>
<td>System Usability Scale</td>
</tr>
<tr>
<td>TC</td>
<td>Technical Committee</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Program/Internet Protocol</td>
</tr>
<tr>
<td>TD-SCDMA</td>
<td>Time Division Synchronous Code Division Multiple Access</td>
</tr>
<tr>
<td>TICS</td>
<td>Transport Information and Control Systems</td>
</tr>
<tr>
<td>TMC</td>
<td>Traffic Management Centre</td>
</tr>
<tr>
<td>TMIC</td>
<td>Traffic Management and Information Centre</td>
</tr>
<tr>
<td>TPMS</td>
<td>Tire-pressure Monitoring System</td>
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<tr>
<td>UC</td>
<td>Use Case</td>
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<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
</tr>
<tr>
<td>UMTS</td>
<td>Universal Mobile Telecommunications System</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
</tbody>
</table>
### Abbreviation | Definition
--- | ---
UNECE | United Nations Economic Commission for Europe
US | United States
V/C | Volume / Capacity
V2I | Vehicle to Infrastructure
V2V | Vehicle to Vehicle
VCE | Vapor Cloud Explosion
VG | Verified Guideline
VMS | Variable Message Sign
vs. | Versus
WCDMA | Wideband Code Division Multiple Access
WiFi | Wireless Fidelity
WiMAX | Worldwide Interoperability for Microwave Access
Win XP | Windows XP
WS | Web Services
WSN | Wireless Sensor Network
WS | Web Service
WTH | Willingness to Have
WTP | Willingness to Pay
XML | Extensible Markup Language
NET | Network
1 INTRODUCTION

1.1 The Need

Dangerous goods are defined as the substances that can have harmful effects for human, environment and property. The classification of Dangerous Goods follows the “ADR, Agreement, concerning the International Carriage of Dangerous Goods by Roads” of 30th September 1957, that has been included in the Annex E of the ECE/TRANS/215 (Latest version 2010, applicable since 1st January 2011).

Such products, according to European statistics, represent about 5% of all goods transported on roads – more than half of this share being attributable to flammable liquids. This share varies according to country specificities, from a minimum of 2.2 percent in the Netherlands to a maximum of 7.7 percent in Ireland (OECD 2006).

The transportation of dangerous goods involves risks, which exist due to the nature, the hazardous properties or the state of these substances, and has the potential to harm not only the truck’s driver, but also the population being present at a certain distance along the pathway of the truck, such as the off-road residents living along the pathway and the on-road drivers and passengers of the other vehicles moving near the truck, which carries the dangerous goods.

The most important hazards during the transportation of dangerous goods are due to possible loss of containment. Release of flammable gases or vapors can end up to flash fire and VCE, while flammable liquids usually result in pool fires. Jet flame is another type of fire that can be provoked by immediate ignition of a flammable gas released during an accident. Also, the containment might undertake a BLEVE or other types of explosions. In conclusion, flammable liquids result in fires rather than explosions. Explosion hazards exist mostly in the cases where the transported substances are quite unstable. If the dangerous good is toxic, its release will form a toxic gas cloud. Toxic and corrosive substances can spread during a release just like liquids do. Accident history has shown that the risks related to the transportation of dangerous goods can be of the same magnitude as those caused by fixed installations, both in terms of human life and economic damage.
Several thousands of trucks carrying dangerous goods circulate within European roads on daily basis. They utilised urban roads, rural roads, highways, tunnels and long bridges and in some cases they are not allowed in some of them. But the actual accident risk and impact when using secondary roads or other alternative ways is not calculated. In addition, when due to unforeseen events (traffic jams, accidents, etc.) they need to change route, they do not have any particular guidance on the safest alternative nor are consequences of road choice to the business chain and societal risk calculated. Thus, the management of risks involved in the transportation of dangerous goods has become a necessity. This process should include early recognition of potential problems (by on-board units and infrastructure based info; both in a dynamic manner), information about actual cargo and driver status, optimal routing and/or re-routing and monitoring and enforcement of dangerous goods movements within the transportation network.

1.2 A Cooperative Approach

Within the past few years, dramatic advances have been made in vehicle navigation systems, which however are being mostly utilised to facilitate the mobility of individual vehicles, so that they reach their destinations with the minimum cost or in the minimum amount of time. Moreover, this happens without regard to the presence of other vehicles on the road network. Given that the impact of a fatal accident involving a Dangerous Goods Vehicle (DGV) can affect a great number of people and infrastructure elements, this approach is not sufficient. Thus, the need arises for a system that will allow the necessary movement of Dangerous Goods in a manner that will not place unnecessary risks to society. Specifically, the actors involved (such as Dangerous Goods transporters, infrastructure operators, etc.) have so far implemented measures to mitigate such problems and deficiencies, but are lacking a global policy, an effective integrated technical infrastructure and the possibility of enforcement. As a result, the measures employed are limited in scope and can even be unfair to particular population groups. For example, a major highway or tunnel operator may wish to protect the other users of its infrastructure and the infrastructure itself by sending DGVs over high mountain roads, which however may pass through villages or other populated areas, inequitably exposing them to risks.

Recent advances in computing and telematics offer the opportunity to significantly decrease the impact of the accidents that may happen at a statistically predictable rate.
The GOOD ROUTE project has been a concerted effort towards this direction. By utilizing a systemic approach, real time infrastructure information, detailed and accurate knowledge of the materials being transported and the vehicles transporting them, on-board sensors, and V2V/V2I communications advanced routing algorithms have been developed.

These calculate and take into account transport risks as well as economic parameters, enabling in this way DGVs to reach their destinations efficiently and safely, without imparting unnecessary risks to the human populace in the vicinity of their trajectories. Moreover, risk distribution equity is an explicit element of the system, as is the incorporation of enforcement capabilities.

To this end, GOOD ROUTE developed a prototype cooperative system for dangerous goods vehicle routing, monitoring, re-routing (in case of need), enforcement and driver support, based upon dynamic, real time data, aiming to minimise the Societal Risks related to their movements, while still generating the most cost efficient solution for all actors involved.

The system envisaged and proposed is cooperative, in the sense that participation is voluntary. As such, strong incentives are needed to convince prospective participants that it is to their benefit to participate.

To satisfy the high data requirements of the system in an organized and efficient manner, a new ADR-based, classification scheme of dangerous goods has been developed.

The resulting integrated system has been tested in pilot sites across Europe (in Finland, Switzerland and Italy), with emphasis on densely populated areas, tunnels and bridges.
2 Accident Highlights

2.1 Introduction

Accidents in Dangerous Goods Transportation Sector are rare; still with especially high socioeconomic impact. Indicatively, it is worth referring to the fire accident taking place in the Mont Blanc Tunnel in the Alps, between France and Italy, on the 24th March 1999, one of the most well known accidents in the Dangerous Goods transport history for its tremendous cost, both in terms of human and economic losses.

The accident was caused by a fire in the engine of a truck carrying flour and margarine. The driver stopped the truck, mid-way in the tunnel, and tried to extinguish the fire, but it intensified and spread to the rest of the trailer. The ventilation system then carried the combustion gases to the French end of the tunnel, where a thick mass of smoke and unburnt gases formed. The emergency services had no information of the size of the fire or the number of vehicles involved, and failed in their attempts to access the burning truck. The shelters did not resist the heat of the fire, there was no service tunnel, and cars continued to enter the tunnel after the fire was detected. The fire went on for 53 hours, reaching temperatures of almost 1000°C, melting the asphalt and causing the concrete structures to collapse. All in all 39 persons died, mostly from asphyxiation, and direct damage was estimated at about EUR 200 million. The tunnel did not reopen for traffic until March 2002 (OECD, 2006). The Italian company responsible for operating the tunnel, SITMB, paid €13.5 million ($17.5 million US) to a fund for the families of the victims (http://en.wikipedia.org/wiki/Mont_Blanc_Tunnel).

Given the unavailability of wide accident statistics in this field, an attempt was made to take advantage of the records of the most significant databases (open or purchased) and conduct a thorough analysis that would reveal the key problems and deficiencies and consequently the main priorities in the area (Bekiaris and Gemou, 2006).

In short the following accident records/cases were investigated:

- GES Accident Database: 174 accidents reported in 2004 with regard to DG vehicles.
• FARS Accident Database: The raw data of 196 cases reported in 2004 with regard to DG vehicles.
• BP Road Trend Database: 161 Road Accidents from January 2001 to February 2003 with regard to DG vehicles.
• FACTS Accident Database: 50 road transport accidents from 2004.
• MHIDAS Accident Database: 100 road transport accidents randomly selected from 2004.
• National data: 25 road accidents related to DG vehicles from the Greek accident database records for 2004, Finnish accident data from 2004 (3486 personal injury accidents) and accidents distribution for years 1999-2004 and presentation of statistics on 318 dangerous goods vehicle incidents coming from the ISTAT database of the Polytecnico of Torino for the years 2003 and 2004.
• Short summation on fatigue-related accidents status (on international level) for DG vehicles and trucks.

The parameters identified as relevant and interesting for the accident analysis execution were the following:

• Country.
• Total Number of DG vehicles/ trucks accidents (including fatal, injury, damage).
• Number of DG vehicles/trucks fatal accidents.
• Number of injury accidents (including fatal) with DG vehicles/trucks.
• Visibility conditions.
• Road surface condition.
• Light conditions.
• Roadway Alignment.
• Special infrastructure.
• Road type.
• Traffic density.
• Type of vehicle.
• Speed of DG vehicle/truck before crash.
• Collision type.
• Manoeuvre type.
• Cargo type transported.
• Hazardous Cargo release.
• Accidents/incidents causes.
All above were parameterised per type of vehicle (Light truck; Heavy truck; Articulated truck; Light tank truck; Heavy tank truck; Articulated tank truck). For the classification per the above types of vehicles, the classification system of GES and FARS databases has been followed.

The table of the following section summarises the key accident figures coming from this analysis across the aforementioned parameters in order to help featuring the overall current picture of Dangerous Goods transportation in the Pan-European context and beyond.

However, it should be highlighted that the above accident data were not available in all cases. On the other hand, there have been cases, where more specific parameters, as for example, weather conditions, time of day, time of year, type of area, etc., were reported. Also, while considering the figures provided in the following sections, one should keep in mind that there is lack of exposure data to compare with the provided accident data. This, in some cases, implies that the percentages may not be representative enough; in some cases, the exposure data of the given environment should be envisaged to reach a reliable conclusion. For this reason, percentages that may be small, should be perhaps re-evaluated, under the corresponding circumstances of the country and be also taken into consideration for the final consolidation and prioritisation.

### 2.2 Key Accident Results from the Accident Analysis

The results coming from the accident analyses have been prioritised by the GOOD ROUTE Consortium experts; prioritization outcomes are shown in the table provided in Appendix A.

The table provided in Appendix A presents the ranking of the parameters according to the consolidation of all utilised sources results and in general is independent of the targeted vehicle type. However, whenever a significant percentage is provided for a specific type of vehicle, then this is indicated in the prioritisation and, in some cases, it is attached with a different weight regardless of the normalised prioritisation, which does not encounter the ratios per vehicle type. The relevant accident percentages are always placed in a parenthesis next to each entry.

For example, in the first row of the first column of the table (of Appendix A), corresponding to the GES database results, it is implied that 83.9% of the DG vehicles in the reported accidents drove in high visibility circumstances and 14.9% of them in medium visibility circumstances, so “high visibility
circumstances” reasonably constitute high level priority (“1”) and medium visibility conditions medium level priority (“2”).

The prioritisation of the parameters, investigated in both kinds of analyses, has been executed upon three levels, responding to the respective accident percentages (%) from the highest (“High Priority”) to the lowest (“Low Priority”):
1: High Priority
2: Medium Priority
3: Low Priority

The “High” and “Medium” priority values were finally those that were of main concern for the determination of system case studies after their qualitative consolidation with the stakeholders’ needs surveyed that are presented in short in the following Chapter 3.

The consolidated prioritised results are provided in section 4.2.2 of this issue.
3 Stakeholders’ Point of View

3.1 Introduction

In addition to accident figures, and due to the fact that, as aforementioned and shown, reporting, recording and classification of accidents in the DG transportation field is not exhausting in many cases, the point of view of the major stakeholders being involved in the DG transportation chain is equally important and necessary in order to complement the overall picture of current transportation of dangerous goods across Europe and beyond.

Given the above, the views of representatives of all important stakeholders, such as infrastructure managers, transportation/DG companies, DG vehicles drivers, and enforcement personnel and all other allied parties have been collected through a series of remote surveys and workshops in order to establish the reference (current situation and recognised weaknesses and needs) for four national case studies which would later apply to the test sites where the developed system would be assessed, namely the Finnish case study, the Italian and the Swedish case study and, in addition, the Greek case study, where no field tests took place; still, off-line impact assessment and other studies were scheduled to take place for some of them (see section 0).

In addition to the above, and towards the further recognition of the involved actors needs and views, two workshops, a Greek and a Pan-European one, took place in Year 2006.

This section provides in more detail the major findings of the Greek survey and workshop as well as of the Pan-European one, while the major findings of the other surveys are summarised in section 4.2.2 of this issue and have been taken into consideration for the construction of the system Use Cases.

3.2 Greek Survey Results

3.2.1 Introduction

A survey (through questionnaires) and a workshop were conducted in Greece in order to gather the most important view from experts of the DG transportation
chain and delineate the picture in Greece regarding DG transportation (Bekiaris and Gemou, 2006). The workshop was held at the ELPA premised in Athens.

The major conclusions drawn by both the questionnaire survey and the workshop conducted are summarised below. It should be noted that the following findings refer to Year 2006 (year of Greek survey and workshop conduct) and have not been updated on purpose, in order to reveal the need that led to the envisioning and design of the system.

3.2.2 Greek Case Study

3.2.2.1 The Greek Market
The relevant market in Greece is approximated to 8000 ADR vehicles, 1500 ADR transportation companies and 15000 ADR drivers (relevant companies and drivers do not transport/drive exclusively ADR goods though).

3.2.2.2 Greek Legislation
DG vehicles are not allowed to circulate in several parts of the modern highway and peri-urban infrastructure in Greece, such as several parts of the “Imittos Peripheric Road” and the highway network (i.e. “Kakia Skala”) tunnel after 15:00pm on a daily basis. 3 out of the 15 modern tunnels of the country cannot be used by DG vehicles [data of 2006]. One of the most dangerous cases is Egnatia road in Northern Greece, where such vehicles are not allowed to pass in the Port Beroia-Kozani, so they are forced instead to drive along the mountainous road of Kastania area, with high risk for a fatal accident.

There are also limitations depending upon the type of cargo and the time of day of the week. For example, for several days and hours DG vehicles can’t use the Preveza-Aktio submerged tunnel. For this reason, several DG cargos may not be declared (i.e. explosives) neither are obvious.

All trucks are not allowed to travel in the highway: to leave the city after 16:00pm on Friday, to enter the city before 15:00pm on Sunday. Thus, trucks that are blocked are usually parked just at the Emergency Lane, at the side of the road (due to non existence of other designated area).

In addition, the current law in Greece defines as maximum driving time the 8 hours and as maximum duty time the 12 hours [data of 2006]. As of 05/11/05, the electronic tachograph is implemented, which also controls the time the vehicle is continuously on the move.
3.2.2.3 ADR Inspection and Enforcement

In general, the current Greek legislation is being applied. The Greek legislation is harmonised to the European one (ADR). However, in Year 2006, when this study was conducted, the competent Greek Ministry of Transportation and Telecommunication was using the 2002 ADR version, since the 2004 ADR version was not yet incorporated in the Greek legislation.

About 350 inspections of new vehicles are performed on an annual basis. These inspections refer to the tanks (plate thickness, hydraulic test and impermeability test) and to the vehicle axles’ load. To the vehicles already in operation, the inspections refer to type of load and to the vehicles dimensions.

The average duration of inspection for each new vehicle is about four (4) hours, whilst for the vehicles already in operation two (2) hours are required per vehicle.

The Traffic Police performs checks according to rules imposed by ADR and, more specifically, they are checking the licenses for the transportation of the load, the transportation documents, the vehicle suitability, roadworthiness, etc.

Specifically regarding the vehicle check, traffic police is checking at check points the following attributes: speed (from tachograph), total load, load per axle, tire conditions, driving license of the drivers, loading documents of the vehicle, technical inspection documents of the vehicle and alcohol consumptions level of the driver.

The overall vehicle check is rather fast (takes 2-3 minutes). However, it requires specific load check equipment, which is expensive (15000€ per piece). Thus, in whole Greece, only 2 pieces of equipment in Athens and 1 in Thessaloniki exist [data of 2006].

As such, it is evident how much time and resources would be saved if this process was automatic and assisted by technology. Next to that, it was noticed that due to the fact that the central units of the traffic police in Greece lack proper training, even the not at all cost effective manual control is often not effective in any aspect alone.

The priority issues for further improvement, according to ADR inspectors and enforcement personnel representatives, are outlined in the following proposals:

- Internal reorganisation of the administration of the Ministry of Transportation and Telecommunication aiming at faster adoption of the international regulations;
- Continuous update of the educational material for training of the drivers and the inspectors of DG transportation vehicles;
- Systematic checks for compliance of the vehicles already in operation to the DG loading and transportation rules;
- Incorporation and extensive use of new technology devices to the DG transportation vehicles; and
- Identification of commonly used itineraries for DG transportation and improvement of road network conditions.

### 3.2.2.4 Infrastructure

Provisional or permanent passing restrictions are imposed to road sections with tunnels to the recently constructed motorways (from Year 2000 to Year 2006).

There is no procedure, defined by law, for demanding and issuing passage license of DG vehicles before entering the infrastructure. If such kind of procedure will be imposed, it is estimated that the claim for entering the infrastructure should be given at least 24 hours before, whilst if the issuing of a special license was needed, it should be at least a three days period for examining the relative request.

Some problems resulted from the insufficient knowledge of the infrastructure management personnel in charge to handle the DG vehicles passage through the road network of their responsibility.

The changes proposed by the infrastructure managers’ representatives, in relation to the current (of Year 2006) situation are the following:
- Enactment of a series of laws for controlling and issuing of transportation licenses for DG vehicles;
- Identification by the competent Ministry (the Ministry of Environment, Housing and Public Works) of the national specifications for the control stations of DG vehicles;
- Continuous training of the personnel involved in the transportation and control of DG (i.e. drivers, inspectors, traffic policemen, fire brigade personnel, infrastructure service personnel, etc.); and
- Mapping of the “sensitive” areas (rivers, lakes, populated areas, etc.) for determining the permissible or banned DG vehicles routes.

### 3.2.2.5 Transportation/DG companies

According to the representatives of transportation companies:
1. The route planning of a DG vehicle is made according to the shortest transportation time and the minimum transportation cost (fuel and toll) in combination with the available possibilities for vehicle refuelling.

2. In an emergency situation the driver communicates with the company via mobile phone and the company informs the load receiver accordingly.

3. There is not any kind of communication between the vehicle driver and the transportation/DG company with infrastructures managers except from specific cases.

4. The problems encountered with the current situation deal with the various restrictions imposed before entering to some road tunnels, and,

5. The main priority issue is the lack of clear reporting of all info related to the nature and the specifications of the load transported in the transportation documents, which should be obligatory.

### 3.2.2.6 DG vehicle owners

The most important statement of DG vehicle owners is that in the case of oil and gas transports, they would like to have dynamic info update every time a storage compartment opens and on the remaining level per compartment. In Greece, the delivery of gas is being done by whole compartments delivery, but, generally in Europe, also part of compartment delivery is feasible.

### 3.2.2.7 Fire Brigade personnel

The data the fire brigade is interested in knowing for each cargo transport is the type of cargo (per ADR division), the quantity, the level of cargo per each compartment, the contact person at the dispatching company and also the speaking language of the drivers.

It is also particularly important to know in advance the level of cargo in each specific compartment at the time of the accidents, in order to be able to move/turn/etc. the vehicle in the safest possible way.

A direct contact of the fire brigade en route (before reaching the accident location) with the cargo owner would help to inform the fire fighters on specific properties and dangers of the cargo, since their training and their equipment typically does not cover all types of dangerous goods.

### 3.2.2.8 Self-ignition problem

Heavy vehicles tires may self-ignite in high temperatures, if they have high wear. Also, quick loading may cause self-ignition due to static electricity.
The current practice is to pass the vehicle over shallow water before entering a long tunnel to cool-off its tires. This might be an additional attribute (i.e. tires temperature and wear) to be monitored by DG monitoring systems.

### 3.2.2.9 Towards a DG routing/monitoring system

The stakeholders interviewed provided recommendations on various aspects that a DG routing/monitoring system should address from their point of view.

Starting from the current situation, they explained that, nowadays, in Greece, most DG vehicles are connected to their dispatch centres by GPS/GPRS. A central database controls their positions speeds, stops, etc. The controller is informed, only in case of exceptions (i.e. violations). Thus, such a system should:

- Be linked to such existing systems.
- Monitor its date and inform the controller only in case of need (exception, violation, etc.) to keep the communication and organizational cost limited.

In addition, added value services could be supported, such as:

- Definition of the actual quantities of goods delivered at each stop in order to fight also relevant crime.
- Detection if the driver is smoking.
- Detection of the vehicle malfunctions (i.e. burned light) and communication to the Centre.
- Provision of the statistical data of each trip from one point to another, using alternative routes: mean time of journey per driver; productivity of each route per day, etc.
- Provision of information to the DG recipient (i.e. gas station owner) of the position of his/her cargo and the expected supply time (dynamically en route).
- Use of mobile phone by the driver.

It was also proposed that such a system could also:

- Inform the driver and authorities on the compatibility between tractor and trailer.
- Inform the driver about black spots ahead (especially foreign drivers).
- Apply lower speed limits to such vehicles (relevant Ministerial Decree is under way but would mean new technographs for these vehicles).
- Inform the driver about any cargo misalignment either during loading or later during the trip.
- Control if the vehicle is driving at the left-most lane(s) (not allowed for trucks).

However, it has been stressed that there is a need for a strong firewall between vehicle originated info and the Intranet of the companies, so that competitors do not have access to the whereabouts of the vehicles location, cargo, etc.

The major competitive advantages of such a system/service, that is envisioned to be equivalent to a “safe operator” card, would be:

- Passage through a specific infrastructure only if the vehicle is registered or reduction of passage fee in this case.
- Skip control processes (i.e. physical control, escorting waiting, time) if the vehicle is registered.
- Guarantee of passage/priority time slot through the system.

The major business benefits implied from the above are enhanced quality of service and guaranteed time of delivery.

Priority infrastructure for such a system was being considered the following from the stakeholders’ point of view:

- Tunnels (both urban and highway).
- Bridges.
- Ferry lines and harbors.
- Peri-urban motorways of big cities.
- New high speed roads.
- Borders to neighboring states (i.e. Albania, Bulgaria, Turkey, etc.). *Albania and Turkey do not apply ADR systematically and Bulgaria applies it non-optimally. However, Yugoslavia and its former countries seem to apply it successfully.*

In addition, priority key functionalities were recommended as follows:

- Issue of passage permission through a given infrastructure.
- Route guidance in case of trip change/extension due to business reasons (i.e. remaining cargo, client is closed, etc.).
- Performance of remote and non-stop enforcement control (especially at the borders).
- Fight of illegal operations through accurate cargo and vehicle monitoring and enforcement.
- On-line and dynamic client info on time of arrival.
- On-line and remote maintenance and problem notification to Operation Centre (through communication of all available info at CAN-Bus).
• Emergency notification (panic button for the driver) and mitigation.

It was highlighted that the whole Dangerous Goods logistic chain should be represented as much as possible in a potential cooperative system. Key users of the system should necessarily include:

• Vehicle driver.
• Transporter (company).
• DG owner/producer.
• Infrastructure operators.
• Enforcement and emergency response authorities.
• Client (i.e. gas stations).

3.2.2.10 Business Models
For the financing of the system it was proposed that PPP (Public-Private-Partnership) schemes would be the most appropriate. In such schemes, the infrastructure (i.e. road operators) would pay, in order to avoid danger and wear (overloading effect) of their infrastructure, while DG carriers would follow in order to be able to use the infrastructure.

Also, funds may come partly from fines to the unlawful vehicles. The same is true today for the financing of the control road cameras. They are installed, paid and maintained by infrastructure owners but their signal is being used as control measure by the traffic police.

It was highlighted that the infrastructure should be communicated only the info related to the cargo and no other business related info (i.e. owner of the shipment).

3.2.2.11 Other issues
The following issues have been proposed for further investigation:

• Car-to-car communication is a lower priority, since there should be many equipped cars, and, even in such a case, the chances of another equipped vehicle preceding the own vehicle at the incident spot are later low, at least in Greece. Though this could be revisited in case of a business model that would impose a mandatory registration of all DG vehicles.
• Another business model where the infrastructure lacks a Control Center needs to be investigated as well. Who should be the data recipient/controller in that case?
• Such a system could be “pushed” by insurance companies (i.e. different levels of insurance for the vehicle, the cargo and the infrastructure).
• According to stakeholders, drivers in Greece are rather expected to see this system positively in some ADR divisions (i.e. explosives, toxic, nuclear, etc.) but in others (especially fuel) they might react, as the system would reduce their ability to make marginal gains from handovers, etc.

3.3 On Pan-European Basis

3.3.1 Introduction

In addition to the workshop that took place in Greece, a Pan-European workshop, entitled “Taking the safest route: The GOOD ROUTE initiative” took place on the 8th September 2006. The workshop was organized by the Centre for Research and Technology Hellas (CERTH), the University of Stuttgart (USTUTT), which hosted the workshop, and the Institute for Communication and Computer Systems (ICCS).

The Pan-European Workshop aimed to bring together all stakeholders in the area of the Dangerous Goods Road Transportation, to communicate the system objectives and with all experts’ assistance, to refine and finalise its application scenarios. Plenary and keynote presentations were organised and the workshop closed with a round table discussion. 33 participants registered and participated in the workshop.

The main conclusions reached are provided in the following section.

3.3.2 Main Conclusions

The main remarks and conclusions arisen during the workshop (which, in reality, further support the findings of the national surveys and the Greek workshop) are summarised below (Bekiaris and Gemou, 2006):

• There are several differences in upper level management and operation of DG transport. For example, in each region the authorised body for the handling of DG accidents may be different (i.e. in Germany the authorised body is the Fire Brigade).
• In many cases and countries, the emergency services are not as efficient as they should be due to the lack of the relevant know-how of the personnel with regard to the DG accidents mitigation.
In some cases, there are some restrictions for DG transportation concerning specific regions and roads, especially in densely populated areas.

The main info needed for emergency services are the specific position of the accident, early notification of the type and mainly the properties of the cargo, preferably in national language, the in-time and accurate notification of provoked injuries and/or fatalities, the notice on involvement of other vehicles, detection of leakage and/or fire, the direction and speed of the wind, other weather conditions, etc.

In addition, info related to the reaction of DG transported as well as guidelines/tactics to be followed from the fire fighters (or other emergency personnel) in case of an accident/incident would be very helpful.

A portal that would enable connection of the Fire Brigade (or other services) to the information centre in a direct way would be helpful.

There are some regions (i.e. Greece), where DG vehicles are not allowed to use tunnels and some of the bridges, because there are great risks and costs related. Societal risk seems to be of great importance also for the companies’ profile. Companies need to convince on security provision and social sensitisation. Thus, they are in general keen in avoiding sensitive areas and vulnerable populations.

DG trucks may be also used as a means for other purposes, like terrorism; thus, the company needs to know exactly and in a dynamic way their route and position for security reasons.

There is an emerging need for safety enhancement and horizontal compliance with existing European and national regulations for DG transportation.

New technological systems need to support driver monitoring, their compliance to traffic regulations, etc.

There is an obvious need for as much as possible cost effective operations, engaging fewer vehicles, less mileage and low cost trips and, if possible, other added value allied services (i.e. tolls for special infrastructure).

The actual added value of a cooperative system like the one envisioned would be the most effective combination of added value services from safety, security if possible, cost-efficiency and minimisation of societal risk overall.

The most feasible Business Cases want such systems to be owned both by system owners and transporters, since some of the latest may want to buy it themselves.
There are three possible Business Cases\(^3\) (BC) for such a system successful penetration:

- **BC 1:** Voluntarily use for internal purposes.
- **BC 2:** Voluntarily use with additional benefits.
- **BC 3:** Mandatory use.

Such a system could be also used in a reverse way, for the establishment of a regulation for example. This would give added value in some countries like Greece. However, this would require availability of statistical data, which may be difficult to gather and process at the beginning but, in a few years horizon, these data will be available anyway.

Some of the parameters that were considered important for the system ontology were the type of trailer (if it is a bulk), the maximum dimensions of the vehicle, the turbo and the breaks temperature, etc.

Tyres pressure sensors and sensors measuring cargo temperature, leakage, etc. should be ideally incorporated in the system.

For the conflict resolution, the following two principles were proposed for consideration:

- **1st case:** Design of conflict resolution in view of the infrastructure operator benefit.
- **2nd case:** Design of conflict resolution taking into consideration the business priorities for the whole logistic network.

However, the principle “First in (first that requests) first out” was proposed to be the safest way to go in terms of various conflicts encountered.

- Expert rules that will be embedded in the system algorithms should be better customisable in order to comply with the infrastructure policy.

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\(^3\) Please note that this finding was the basis for the deployment scenarios elaboration, as presented in section 0 of this issue
4 GOOD ROUTE CASE STUDY

4.1 Introduction

Responding to the identified key concerns in Dangerous Goods Transportation as indicated by the major problems noticed in the field (see section 1.1), the accident statistics (Chapter 2) and, the needs of the relevant stakeholders of the Dangerous Goods logistic chain (Chapter 3), and, finally, the gaps and deficiencies in the current market and research solutions as these have been recognized in detail through a thorough market analysis (Bekiaris et al., 2006), a cooperative system for DG transportation was developed in the context of the GOOD ROUTE project.

The GOOD ROUTE initiative was launched, as a project of the FP6 eSafety initiative, starting on 01/01/2006 and lasting 37 months. It has been a multidisciplinary Consortium of 14 Partners, led by the Informatics and Telematics Institute (Coordinator) and the Hellenic Institute of Transport (HIT) of the Centre for Research and Technology Hellas (CERTH), including all key actors in the field, such as a route guidance manufacturers (PTV), a telematic systems developer (SIEMENS), a telecom operator (TID), vehicle manufacturers (CRF, IVECO), 3 major road operators (GST, FINRE, SITAF) with particular infrastructure elements, end user representatives (ELPA, an Automobile Club of FIA) and key know-how providers (CERTH, UPM, USTUTT, ICCS and COAT) for user needs, legal and ethical issues. In addition, one of the biggest dangerous goods producers and carriers worldwide, BP, was committed to provide support to the Consortium during the whole project duration.

In specific, the vision was a cooperative system for dangerous goods vehicle routing, monitoring, re-routing (in case of need), enforcement and driver support, based upon dynamic, real time data, aiming to minimise the Societal Risks related to their movements, while still generating the most cost efficient solution for all actors involved.

In order to approach this aim, the main objectives set were as follows:

- To analyse dangerous goods accidents and needs of the dangerous goods companies, transporters, drivers, recipient clients, transport infrastructure owners, authorities, etc., as well as the best practises followed so far, for the specification of an integrated, cost-efficient, fair and modular system.
• To develop an ontological framework, which will classify and correlate the dangerous cargo, vehicle types and road infrastructure elements, to automatically permit or re-route specific dangerous good vehicles through specific road infrastructures (i.e. tunnels, long bridges, etc.).

• To develop a collaborative platform, able to gather and process in real time vehicle, cargo and environmental data (road status, unexpected obstacles, weather conditions, population density) as input to an optimal routing and route guidance system.

• To develop a minimum risk guidance system, that is able to route and re-route dangerous goods vehicles, taking into account individual and societal risk (based upon the collaborative platform based dynamic data), as well as conflict resolution and equity schemes.

• To develop Control Centre algorithms that will deal with movements of all participating dangerous goods vehicles within a certain geographical area, to provide the necessary traffic and environmental data to them and inform in real time their logistic chain for any unscheduled re-routing required.

• To develop an on-board automatic data retrieval and storage system, to monitor key dangerous goods vehicle parameters (actual vs. planned route, speed, weight per axle, etc.), able to supply it to local nodes (i.e. police car at toll station or before tunnel/bridge, etc.) for enforcement purposes.

• To develop optimal user interfaces for both the drivers of the dangerous goods vehicle and the control centre operators, to provide them with appropriate information and/or warnings, without adversely affecting their workload or causing unnecessary behavioural adaptations.

• To integrate all functions in a prototype vehicle and test them in three Pilot sites, across Europe, to evaluate their reliability, usability, successfulness, cost efficiency and thus estimate their potential safety impact and viability.

• To involve all key actors in the dangerous goods transportation chain, as well as OEMs and sensor suppliers in order to result in a viable business strategy for wide and quick diffusion of the system.

Major innovation of the integrated system developed lies in the following:

• Development of a decision support system (and algorithms) for dangerous goods vehicles routing and re-routing, that takes into account dynamic data about the vehicle, the cargo, the infrastructure and the environment: individual risk, societal risk, as well as logistic chain requirements, constraints and equity schemes.
Integration of this decision support system within an on-board route guidance system, an infrastructure control operators’ management system and the dangerous goods supply logistic chain intranet.

Development of an appropriate monitoring and enforcement system, that makes use of all gathered data, and provides automatically key enforcement indicators to local enforcement positions.

Provision of priority to the safety of dangerous good transportation, while taking into account business demands, network efficiency and conflicts resolution.

Provision of support to dangerous goods drivers through “pushed” (when a traffic or other event requires it) or “pulled” (when they need navigation) services, without the need of communication to a control center (high cost) or a local node (language barriers).

In summary, the major intended innovation and impact envisioned was to contribute in making European infrastructure (roads, tunnels, bridges, etc.) safer, by providing supported and enforced minimum risk routing/rerouting of dangerous goods vehicles instead of the arbitrary and unguided practices of today.

The following Chapters of this issue elaborate on the approach followed in order to achieve the above targets as well as on the final outcomes and the assessment of the system impact in several aspects, with safety being the premium, followed by cost efficiency, transport operation efficiency, comfort and quality of life of interconnected users and, finally, market penetration, assessment of its competitiveness and deployment potential as well as contribution to dominating standards, policies and practices in the area.

4.2 System Use Cases and Ontologies

4.2.1 Research Approach followed

In order to define and specify the system main functionalities and set the requirements for them, the definition of a set of the basic Use Cases (scenarios of use) that should be addressed, directly responding to user needs, expert views and priorities emerging from the accident analysis conducted in the field, was considered critical. Next to the use cases, the identification of the user needs and their consolidation with accident analysis key outcomes was necessary in order to define the common ontological framework, which constituted an essential part of the system requirements (Bekiaris and Gemou, 2006).
The methodology followed for the extrapolation of the major scenarios of use as well as the ontological framework attributes is shown in the following figure. From the following, it is evident that both use cases and ontologies have been based on the thorough accident analysis and user and expert needs survey that was held in the early beginning of the project.

**Figure 4.1**: Overall methodology followed for the extraction of user needs (also accident statistically based) leading progressively to the system use cases and ontological framework.

The prioritised accident analysis results already presented in Chapter 2 of this issue were further consolidated with the key outcomes of the user needs analyses (through surveys and workshops) (indicative results presented in Chapter 3).

### 4.2.2 Prioritisation of accident and user needs analyses results

Having conducted an accident analysis (Chapter 2) and investigated the interrelated stakeholders’ needs (Chapter 3), and after having prioritised the accident parameters (see section 2.2), a further prioritisation was conducted (following the same principle: “High”, “Medium” and “Low” priority) taking in addition into account the major results/conclusions from the user needs surveys and the workshops (Greek and Pan-European). Overall prioritisation was conducted by 5 internal experts of the GOOD ROUTE Consortium.

As already mentioned, the “High” and “Medium” indices have led to the identification of the priority conditional parameters for the system use cases. The resulted priority conditional parameters for the system are the following:
Visibility conditions
1: High visibility conditions
2: Medium visibility conditions

Road surface conditions
1: Dry road surface
2: Wet road surface

Light conditions
1: Daylight conditions
2: Lighted roads (either during night or not)

Roadway alignment
1: Straight roads (no intersection)
2: Intersections/curves

Type of cargo
1: Liquid fuel (transport fuel)
2: Gas

Travel speed related to accidents
1: 51-80km/h
2: 0-50km/h

Vehicle manoeuvre
1: “Going straight”
2: “Negotiating a curve” (11.6%) & “Turning (left)”

Type of road/type of location
1: Highways/non-residential areas
2: Rural roads/residential areas and tunnels, bridges ferry lines and harbors, peri-urban motorways of big cities, new roads of high speed, borders
3: Urban roads

Weather conditions
1: Good weather conditions (clear and sunny)
2: Clouded/Mist/Rain

Time of day
1: 13:00-18:00
2: 00:00-06:00

**Time of week**
1: Weekends
2: Monday

**Time of year**
Country dependent. All times of year.

**Vehicle type**
1: Articulated tank trucks
2: Tank trucks (road tankers)

The above conditional parameters (together with the Use Cases below) constituted the basis for the specific evaluation scenarios that oriented the system evaluation (Bekiaris et al., 2006).

The values attached as more critical ones at each identified conditional parameter have been also taken into account for the Decision Support system algorithms formulation. However, some of the above values, such as “Time of Day” or “Time of Week” have been instantiated per Pilot Site, taking into consideration the local restrictions and special cases, leading to the identification of the expert rules, which have been used as a feedback for the DSS.

In addition to the above conditional parameters, a series of items and needs were identified with regard to the system routing, re-routing, emergency and enforcement functionalities, through the stakeholders needs surveys, which were very much considered in the formulation of the Use Cases (Bekiaris and Gemou, 2006). The ones related to the routing/re-routing and emergency functionalities are the following:

- **Adverse weather conditions (especially when resulted from wet, icy, snowy or slushy road surface) in combination with heavy traffic.** A big portion of accidents are related to adverse weather conditions and wet or icy road surface conditions. “Traffic conditions” was recommended to be a parameter to be taken into account in the DSS, being highly related to routing and re-routing functionalities. The system should monitor in real-time for such data in order to identify the most optimum route for the system or change the initially defined route in order to avoid unexpected delays or assure the safest possible trip.

- **Type of cargo transferred with special attention to transits of liquid (and especially transport liquid) fuel which may lead to fatal accidents, when**
released since lead to explosion and fire. The amount and the type of cargo transferred is very significant to be monitored, since it may imply restriction of passage or the opposite through the several infrastructures or types of areas (such as residential areas), according to the associated level of risk. In addition, it could be the case, that as soon as specific types of cargo are identified, other cargo related properties, such as cargo temperature, cargo ignition, cargo release should be dynamically tracked to lead to the activation of the emergency services in case of accident or dangerous incident (see also enforcement attributes below).

- **Vehicle failure (especially braking system, suspension, trailer hitch).** The real-time monitoring of the condition of some specific mechanical parts of the vehicle, like the aforementioned, or some other parts such as the vehicle engine and especially its temperature or the tyres condition is considered to be essential for a prompt and effective reaction of the emergency services. Moreover, in case of a early vehicle failure detection, the re-routing procedure of the other vehicles may be processed, to hinder from traffic congestion and other potential implicated accidents.

- **Fire explosion.** As in vehicle failure, the fire explosion, if not prevented earlier from the detection of the temperature of the cargo or a mechanical part of the vehicle, it should be known real-time for re-routing and emergency reasons. Of course, this is also a matter of enforcement (see below), since in these cases, the Traffic Police is also involved in the mitigation actions.

- **Crossovers & Spillages.** As mentioned above, the condition of the cargo, that may prove to fatal, needs to be monitored dynamically if not for all types of cargo, for those ones that are considered to be the most dangerous, especially when are mixed with other types of cargo loaded in other compartments, released or when their temperature arises, when their loading exceeds a specific limit allowed in each case and compartment, etc. This prerequisites the use of sensors and other monitoring tools that will monitor real-time the condition, the type and the quantity of the cargo and the compartments of the vehicles.

In addition to the above, the following needs have emerged and contributed to the formulation of the operational framework.

- Claim for passage should be given to the infrastructure at least 24 hours before and claim for “special passage’ should be given at least 3 days before to be examined by the infrastructure.

- Especially in case of radioactive material transit, permission for passage through infrastructure should be requested.
• Need for mapping of all areas and especially “sensitive” ones (e.g. rivers, lakes, residential areas, etc.).
• Route planning according to the shortest transportation time, minimum transportation cost (fuel and toll) and potentials for vehicles refuelling.
• Need for notification to the infrastructure for passage at least 60 minutes before.
• Need for dynamic dialogue between the operator of the infrastructure and the driver in emergencies.
• Need for real-time notification and re-routing functionality in case of adverse weather conditions (e.g. snow, ice, etc.) or road works or unexpected events.
• Need for booking of parking place, if foreseen, during the route (e.g. if night stay is foreseen).
• Need for real-time notification of the transportation companies on vehicle’s compartment opening and level of remaining cargo.
• Need for real-time notification of the Fire Brigade and all allied services on type of cargo (per ADR division), quantity of cargo, level of cargo per each compartment and in general some core info on the cargo on national language, contact person in the dispatching company, language of cooperation with the drivers, number of injuries and fatalities, involvement of other vehicles, existence of leakage or fire, direction and speed of the wind, weather conditions, etc.
• Need for possibility of communication of the Fire Brigade with the cargo owner for information on the specific properties and dangers of the cargo to identify the proper mitigation actions or direct uptake of information on the cargo properties.
• Need for the driver (especially when not native) notification of black spots ahead.
• Need for driver notification about cargo misalignment either during loading or later during the trip.
• Need for provision to the transportation company of the statistical data of each trip from one point to another, using alternative routes; mean time of journey per driver; productivity of each route per day, etc.
• Need for provision of continuous real-time information to the DG recipient and the company with regard the vehicle position, the status of the cargo, the expected supply time and finally the time of arrival (dynamically en route).
• Need for firewall to protect competitors’ access to the transportation company vehicles and routes info.
• Need for route guidance in case of trip change/extension due to business reasons (i.e. remaining cargo, client is closed, etc.).
• Need for on-line and remote maintenance and problem notification to company operation centre.
• Need for emergency notification from the driver to the company and the allied emergency services (either through the infrastructure or not).

The related to enforcement attributes identified are the following:

• **Cargo release/spillage, especially in case of transport fuel transported.** There is an obvious need for real-time monitoring of cargo release, as mentioned above, especially in case the cargo is considered highly dangerous. Apart from the other functionalities of the system, a notification is also important for the enforcement module, since the Traffic Police is also involved in the mitigation of the emerging consequences of such incidents.

• **Cargo ignition, especially in case of transport fuel transported.** Cargo ignition which may result to total or partial burn of the cargo is a very common incident related to fatal accidents and highlights the necessity of the cargo temperature monitoring in terms of the enforcement functionality.

• **Cargo explosion.** The real-time tracking of the cargo explosion is very critical and is a request by the system enforcement module (it also concerns the Police, besides the Fire Brigade).

• **Travel speed exceeding 80 km/h or inappropriate according to conditions & other traffic, transport and loading violations.** In general any traffic violation needs to be detected in real-time for enforcement purposes. An alarm could be provided in case the vehicle speed exceeds the (respective) traffic limit or is considered by the system to be inappropriate for the conditions. Thus, at least traffic speed should be monitored real-time. Other violations that can be encountered by means of the respective sensors and tools are the loading level of each compartment of the vehicle, the total weight transferred, the weight per axle, etc. for which there are also respective regulations imposed either on national and/or regional level or on European level (by the ADR). Moreover transportation regulations with regard to the type of the cargo transported, the condition and the requirements of the vehicle may be violated. For this reason, there is a necessity of checking the driver, vehicle and cargo papers, as a mitigation measure of the transportation violations.

• **Type of driving licence, years of holding.** In more specific, the drivers’ documents such as the driving license and the years of holding are some attributes that should be checked in addition to the origin of the license (from which country, etc.).

• **Driver distraction, human failure, loss of control due to driver impairment/fatigue/physical condition.** Although the envisioned system did not intent to incorporate any fatigue monitoring sensors and tools to detect the driver state, at least the detection of the working hours of the driver and the co-driver was considered to be a prerequisite and a critical factor into the DSS, while configuring which the “safest option” is in each case. Such info is
also applicable for the enforcement functionality, since may prove a violation
of the relevant regulations that are valid in each country.

- **Alcohol in driver.** As above, no system for automatic detection of alcoholism
was planned to be integrated within the system. However, future
consideration could be held for a potential update of the system. Alcohol is
definitely associated with many accidents (although not so many in this
sector) and is a standard check criterion for the enforcement in every case.

- **Driver lane departure.** Lane departure is an interesting item to be monitored;
however requires the integration of the relevant ADAS (Lane Departure
Warning) in first place, which should communicate the critical warnings also
to the Traffic Police. This was also not implemented in the system developed.

- **Fire occurrence.** Fire occurrence and the monitoring of all those parameters
that may prevent from fire explosion (cargo and engine temperature, etc.) are
also an issue of enforcement. An immediate warning should be provided to
Traffic Police, in case of occurrence.

- **Overturning/roll-over of vehicle.** This is a case, for which Police definitely
needs direct notification and is also associated with parameters mentioned
above, as the type of cargo, etc. since some of these properties are very
significant for the determination of the mitigation plan.

- **Crossover.** Risky crossovers notice is important info for Police, in order to
prevent an accident. However, this requires the deployment of a series of
sensors that will monitor real-time the condition and the content of the
compartments of the vehicles.

- **Theft.** Since no automatic driver identification was envisioned to be integrated
(i.e. through EEG, etc.), the only relevant check that could be done is the
documents of the driver and the cross-reference with the initial info that could
be provided to the system by the company of the driver him/herself and the
identification of any extended unexpected interruption of the route (parking of
the vehicle in non-allowed place, etc.), deviation from initial route without
particular reason (i.e. accident, re-routing by the system, etc.). Furthermore, a
continuous authentication of the driver could be held (i.e. after each break, at
each gas station, etc.) to confirm the identity of the driver.

The above identified critical attributes related to the driver, cargo, vehicle, etc.
and in reference to the several functionalities of the system (i.e. routing, re-
routing, etc.) and the involvement of the potential actors (i.e. company, driver,
etc.) have been also taken into account for the formulation of the system ontology
(Chapter 4.2.4 of this document).
4.2.3 System Use Cases

Nine (9) priority system Use Cases (UCs) were defined reflecting the major intended functionalities of the integrated system, constituting the major outcome of the requirements phase (Bekiaris and Gemou, 2006). These are namely the following:

- UC1: “Passport”
- UC2: “Route guidance”
- UC3: “Environmental-related re-routing”
- UC4: “Business-related re-routing”
- UC5: “Enforcement”
- UC6: “Logistics”
- UC7: “Emergency”
- UC8: “C2C communication”
- UC9: “Critical info”

All system Use Cases have been described across the following fields:

- Context of use. This includes the description of the main use case, i.e. routing, re-routing, etc.
- Primary actor. This is the actor who initiates the use case and may be the driver, the infrastructure, the company, the Police, etc.
- Input (trigger). This is the first action/request that is provided by one actor.
- Output. It is the feedback and the reaction of the system to the Input (trigger).
- Main success scenario(s). This includes the upper level description of the Use Case, taken that the system will operate as expected.
- Connected UCs or extensions. This refers to any extension or connectivity of the current UC to other UCs.
- Indicative scenarios of use. A number of indicative scenarios (envisaged from the primary actor aspect) are outlined.

The conditional parameters are the same in each case, as outlined in the previous Chapter. However, the parameters identified that deal with the routing, re-routing, emergency, notification and enforcement functionalities of the system have been taken into consideration, whenever applicable for the use case and scenarios of use description.

**UC1: “Passport”**
Context of use. The driver or the company, according to the initially defined route, notifies the system of estimated time of passage through an infrastructure and books the passage through a relevant request.

Primary actor. Driver or company.

Input (trigger). The user (driver or company) provides the vehicle and cargo data, notifies the system of the estimated time of arrival of the specific vehicle at a specific infrastructure and makes a request for passage approval and booking.

Output. The system returns the answer to the user (driver or company) with regard to allowance of passage (potentially with a receipt of booking. For alternative cases, please see at the connected UCs and extensions.

Main success scenario(s).

⇒ Step 1: The user makes a request for the permission of passage to the infrastructure at least 24 hours before the estimated time of arrival at the infrastructure. Vehicle and load info are provided to the infrastructure in the context of the request.

⇒ Step 2: The system provides the permission of passage on behalf of the infrastructure or notifies for non-feasibility of booking (see connected UCs and extensions) within a time horizon of 15 minutes from the time of request.

⇒ Step 3: When vehicle arrives at the infrastructure, it is allowed to pass by priority, even in traffic congestion case. The time-horizon of allowed passage is 30-40 minutes around the declared/booked time of arrival.

Connected UCs and extensions. An extension of the UC is the booking of special transits (i.e. big caravans, big amounts of loads or cargo, associated with high level of risk, etc.), where a permission for “special passage’ is required and the request for passage booking should be made at least 3 days before by the user. In case of non-feasibility of passage at the requested time, the system has two options (after user consent): either identifies another time of passage through the specific infrastructure, which is close to the initially requested one, or, if this is not possible at all, due to many reasons, such as big expected traffic, business reasons, etc., it initiates the procedure for re-routing (see UC’s 3,4). Moreover, there is a connection to UC9. If the driver is notified for incidents ahead that will cause delays or will totally hinder him from passing through the specific infrastructure, then a relevant notification should be done from the driver (or the system automatically, when receiving the relevant info).

Indicative scenario(s) of use.

⇒ “Vehicle X^4 (if the user is the company) or I (if the user is the vehicle) need/s to pass the Y tunnel around 19:00pm tomorrow”.

^4 X refers to the ID of the vehicle and the load.
**UC2: “Route guidance”**

- **Context of use.** The user (driver or company) provides the intended destination, makes a request to the system for route guidance and the system provides the route guidance to the user taking into consideration real-time traffic and weather data (through UC9), feasibility of passage through infrastructures, etc. and finally estimating by default the “safest” solution (by calculating the associated risk). Other criteria may be also given as input to the system by the user for the route planning, like the “shortest” route, the “fastest” route, etc. They should be taken into account, but by inferior weights to the “safest” route criterion.

- **Primary actor.** Driver or company.

- **Input (trigger).** The user (driver or company) provides vehicle, cargo and route criteria (origin-default: current location, destination, intended time or arrival to destination, type of route i.e. shortest, etc.) data to the system and makes a request for route guidance.

- **Output.** The system takes into consideration the given criteria and provides the determined route to the user.

- **Main success scenario(s).**
  - *Step 1:* The user makes request for route guidance. Vehicle, load and route info and criteria are provided to the system in the context of the request.
  - *Step 2:* The system provides the estimated route within a time horizon of 5 minutes from the time of request.

- **Connected UCs and extensions.** During the route planning and if the time interval is sufficient, the system may also proceed, without further request by the user, with automatic booking of passage through the applicable infrastructure at the estimated time of arrival there and provides the receipt of booking to the driver (see UC1). With regard to key info communication, UC9 is related.

- **Indicative scenarios of use.**
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) need/s to reach to Y destination until today evening around 20:00pm”.
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) need/s to reach the Y destination today the soonest possible”.
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) need/s to reach the Y destination by today noon in the less expensive way”.
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) is/am lost and I need to be in Y destination by today 21:00 am at latest”.

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“Vehicle X (if the user is the company) or I (if the user is the vehicle) is/am running out of fuel”.

“Vehicle X (if the user is the company) or I (if the user is the vehicle) is/am in need to stop unexpectedly for the night”.

**UC3: “Environmental-related re-routing”**

- **Context of use.** The system identifies an imminent reason for re-routing, based on real-time info (accident, road works, denial of passage from infrastructure, etc.) and provides the driver with the most optimum re-routing solution with regard to safety together with estimated time of arrival at destination. In case the initial routing has not been planned by the system (and therefore the vehicle, load and route data including destination, etc. are not stored), then the system, before starting the estimation for the safest route planning, it makes a request to the driver (or the company), in order to receive the needed info (or through TMC-UC9). As soon as driver (company) consent about re-routing is provided, all involved actors in the logistics chain are notified on new expected time of arrival at destinations (UC6).

- **Primary actor.** System (which however may use as an input a relevant notification by the infrastructure or the Police).

- **Input (trigger).** The system, taking into consideration real-time data related to weather conditions, traffic flow, road works, accidents, other data coming from the infrastructure regarding change in potential for passage, etc., identifies need for re-routing.

- **Output.** The system, taking also in consideration the vehicle, load and route data (stored or acquired upon request by the company or the driver), proceeds with the “safest” alternative re-routing planning and provides it to the driver, together with notification about estimated time of arrival.

- **Main success scenario(s).**
  - **Step 1:** The system identifies need for re-routing *(it may also send the key info to the driver to justify re-routing-UC9).*
  - **Step 2:** The system plans the new “safest” route alternative and provides it to the user, together with any confirmation of passage booking through “special infrastructures” and a notification on estimated time of arrival in declared destination, within a time horizon of 5 minutes from the time of re-routing identification and asks for driver receipt of route guidance and approval of alternative route.
  - **Step 3:** The user confirms the approval of the system given alternative and initiates re-routing according to the system guidance.
⇒ **Step 4 (UC6):** As soon as the driver confirms re-routing proposal acceptance, all involved actors in the logistics chain (mainly customers and company) are notified about new expected time of arrival at declared destination(s).

- **Connected UCs and extensions.** During the re-routing procedure and in case special infrastructures are interfered (i.e. tunnels, etc.) and if the time interval is sufficient, the system asks for booking of passage from the new infrastructure (or the same at a different time) and provides confirmation of receipt to the driver (see UC1). Another possible extension of the UC is the fact that the driver or the company is not satisfied with the estimated time of arrival, if the safest route, as estimated by the system, is followed, and makes another request for re-routing according to another criterion such as “shortest route”, etc. (see UC2); thus the system proceeds with the re-estimation and performs the route planning according to the new defined criteria. Another case is that the user (driver/company) does not approve the first alternative given by the system for any reason. Then the user sends denial notification and the system provides the user with the second “safest” alternative and so on. In any case of re-routing, the system notifies all actors of the logistic chain, mainly the customers and the company, for re-routing and estimated time of arrival in claimed destinations (see UC6). Finally, key info communication is related to UC9.

- **Indicative scenarios of use.**
  - “An unexpected road work has occurred during the initial route of the vehicle X and has interrupted completely the traffic flow-need for re-routing”.
  - “A considerable traffic congestion is noticed in the initial route of vehicle X and the estimated delay in time of arrival will be about 2 hours-need for re-routing”.
  - “The tunnel Y has denied booked passage to the vehicle due to accident occurring-need for re-routing”.
  
  *After the first re-routing...*
  - “I need another alternative/route”.
  - “I have to be at destination Y with a delay of 1 hour at most”-“UC2”.

**UC4: “Business-related re-routing”**

- **Context of use.** The system identifies an imminent business-related reason for re-routing (i.e. change of customer site, need for re-fuelling, etc.) and provides the driver with the most optimum re-routing solution with regard to safety together with estimated time of arrival at destination. In case the initial routing has not been planned by the system (and therefore the
vehicle, load and route data including destination, etc. are not stored) and the criteria for routing remain the same (same destination, same wanted time of arrival, etc.) then the system, before starting the estimation for the safest route planning, it makes a request to the driver (or the company) to uptake the needed info. In case the request for re-routing is being made by the driver or the company and is not output of the system, then the system requests all aforementioned info again, updated with the new criteria. As soon as the driver (company) consent about re-routing is provided, all involved actors in the logistics chain are notified on new expected time of arrival at destinations (UC6).

- **Primary actor**: System (which however may use as an input a relevant notification/request by the company).
- **Input (trigger)**. The system identifies need for business-related re-routing (either own estimation or request-notification from the company).
- **Output**. The system processes with the alternative “safest” re-routing planning and provides it to the driver together with notification about estimated time of arrival.

- **Main success scenario(s)**.
  - **Step 1**: The system identifies need for re-routing.
  - **Step 2**: The system plans the new “safest” route alternative and provides it to the user, together with any confirmation of passage booking through “special infrastructures” and a notification on estimated time of arrival in declared destination, within a time horizon of 5 minutes from the time of re-routing identification and asks for driver receipt of route guidance and approval of alternative route.
  - **Step 3**: The user approves/confirms the system given alternative and the system initiates re-routing according to the system guidance.
  - **Step 4 (UC6)**: As soon as driver confirms the re-routing proposal acceptance, all involved actors in the logistics chain (mainly customers and company) are notified about new expected time of arrival at declared destination(s).

- **Connected UCs and extensions.** As in UC3.

- **Indicative scenarios of use.**
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) need/s to pass also from intermediate Y destination (i.e. gas station) before it/I reach/es final destination”.
  - “Vehicle X (if the user is the company) or I (if the user is the vehicle) need/s to refuel within 2 hours at most”.

*After the first re-routing...*

- “I need another alternative route”.
- “I have to be at destination Y with a delay of 1 hour at most” - “UC2”.
UC5: “Enforcement”

- **Context of use.** This UC deals with the automatic enforcement on behalf of the Police or the competent authority in case traffic or other type violation (transit against local transportation rules, etc.) is detected, that presupposes the Police involvement in mitigation or at least notification and presence. The system provides an alarm to the enforcement for intervention, taking into consideration the values of key data (vehicle speed, vehicle and driver profile, type and amount of cargo, total weight per axle, etc.), compared to defined thresholds on local, regional (i.e. instantiated per infrastructure) level. The alarm is provided to a local or central checkpoint. *It may be the case that the alarm is provided either by the driver or the infrastructure, depending on the system’s architecture.*

- **Primary actor.** The system/infrastructure (which identifies need for enforcement) and finally the enforcement nodes.

- **Input (trigger).** The system identifies need for enforcement, taking into consideration key info values or critical incident detection.

- **Output.** The system provides alarm to central or local enforcement nodes for intervention, gives all needed info (vehicle and driver ID, vehicle position, type of cargo, etc.) and indicates type of violation or type of incident.

- **Main success scenario(s).**
  - **Step 1:** The system identifies need for enforcement and provides relevant alarm to the enforcement nodes (central/local) with all required info.
  - **Step 2:** The enforcement actor proceeds with intervention (which may include check of the vehicle, the driver or the cargo, change of route, issue of fine, etc.).
  - **Step 3:** All interested parties (company, gas stations) are notified on changed route plans, if this is the case (UC6) and the system proceeds with re-routing if enforcement actor gives approval (UC3.4).

- **Connected UCs and extensions.** A potential extension of the UC is the notification of all involved actors of the changed plans on route, if this is the case (UC6 + UC3/4).

- **Indicative scenarios of use.**
  - “Exceeding traffic limit of Vehicle X is detected”.
  - “Vehicle X is not allowed to pass tunnel Z due to exceeding amount of total load”.
  - “Vehicle X has excessive load to an axle after subsequent loadings”.

UC6: “Logistics”
Context of use. Provision of real-time information by the system to all stakeholders in the DG logistics chain (dispatcher, transporter, client, recipient, etc.) regarding vehicle position and status, expected arrival time, cargo level and condition, etc., in case of re-routing or incident/accident occurrence.

Primary actor. The system.

Input (trigger). Re-routing, detection of accident or other incident that influences the cargo (i.e. cargo explosion, etc.), the vehicle (i.e. vehicle malfunction, etc.) and the route (i.e. reach of destination, expected time of arrival, etc.).

Output. Key info, depending on the incident (i.e. accident) or the event (i.e. re-routing) are transmitted to all interested parties.

Main success scenario(s).

⇒ Step 1: The system identifies incident/event that requires notification of the interested parties.
⇒ Step 2: The system provides all relevant key info to the interested party and notification to emergency teams (UC7).
⇒ Step 3: The interested party sends receipt of notification.

Connected UCs and extensions. A potential extension in this case would be the request on behalf of the third party (i.e. company) for re-routing plans in case an accident or an incident (i.e. vehicle malfunction) has happened (UC3/4). Moreover, this UC is also connected to the UC7, in the context of which, notification of the emergency teams is held in case of accident/incident. It definitely pre-supposes UC9.

Indicative scenarios of use.

⇒ “Malfunction of Vehicle X is detected-Expected delay of Y minutes”.
⇒ “Re-routing of Vehicle X for business reasons is held-Estimated time of delay: Y minutes”.
⇒ “Cargo explosion detected at Vehicle Y- Reach of destination non-feasible”.

UC7: “Emergency”

Context of use. Automatic and semi-automatic accident/incident notification and key info (i.e. type of cargo, level of loading, location of different compartments’ loading, etc.) provision to emergency support teams.

Primary actor. The system (in semi-automatic cases could be the driver).

Input (trigger). The system identifies emergency (with regard to accident).

Output. The system provides all required info to emergency teams (i.e. vehicle position, type of cargo, type of accident/incident, etc.) and the emergency teams proceed with the mitigation of the accident/incident.
Main success scenario(s).

⇒ **Step 1**: The system identifies incident/event that requires intervention of the enforcement teams.
⇒ **Step 2**: The system provides alarm to the enforcement teams, together with all required info with regard to the load, the vehicle, the driver, etc.
⇒ **Step 3**: The enforcement teams confirm receipt of alarm, key info notification and availability for mitigation and proceeds with the intervention.
⇒ **Step 4**: Notification to interested parties of the logistics team is held (UC6).

Connected UCs and extensions. There is an interrelation with UC6: in some cases alarm is provided in both emergency and enforcement teams. In case the emergency unit that has been provided with the alarm is not available for mitigation, then notifies the system for non-availability and the system redirects the alarm to the closest emergency unit and so on... Connection to UC9.

Indicative scenarios of use.

⇒ “Cargo explosion detected at Vehicle Y”.
⇒ “Vehicle Z roll-over”.
⇒ “Leak detected in Vehicle Z…”

**UC8**: “C2C communication”

Context of use. Automatic and semi-automatic notification of critical info (mostly dynamic info, such as environmental restrictions/problems concerning weather, traffic, road condition, road works, accidents, etc.) to other vehicles.

Primary actor. The system/the vehicle.

Input (trigger). Detection en-route of a critical event that may influence the transit (i.e. accident, road works, interruption of work flow for any reason, snowstorm, etc.).

Output. The driver redirects the key info concerning the event to the other vehicle, providing coordinates and time of event detection (if these are not done automatically by the system).

Main success scenario(s).

⇒ **Step 1**: Key event detection by the system or the driver.
⇒ **Step 2**: Provision of key info data together with coordinates and time of event detection to other vehicle(s).

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5 This is a functionality that was not tested in the Pilots, since there was only one demonstrator, the IVECO one. However, this Use Cases is the basis for any future testing.
\[
\Rightarrow \text{Step 3: Other vehicle(s) provide confirmation of receipt.}
\]
- Connected UCs and extensions. Pre-supposes UC9.
- Indicative scenarios of use.
  - “Road works 100m before Tunnel Z”.
  - “Snowstorm in Turin”.

**UC9: “Critical info”**

- **Context of use.** Automatic accident and other critical incidents notification/warning (i.e. vehicle malfunction, etc.) and key info (i.e. type and condition of cargo, vehicle condition, level of loading, etc.) provision from DG vehicle to the Traffic Management Centre (TMC) and respective key info (i.e. environmental conditions, road works, etc.) provision from the Traffic Management Centre to the DG vehicle.
- **Primary actor.** Driver/Vehicle and TMC respectively.
- **Input (trigger).** Accident/incident occurrence or potential for that (from the TMC point of view).
- **Output.** Warning to TMC by the driver and provision of all related key info and respectively warning from the TMC to the driver and provision of all related key info.
- **Main success scenario(s).**
  - **Step 1:** Key event detection by the driver or the TMC.
  - **Step 2:** Provision of key info data to the TMC (or the driver respectively).
  - **Step 3:** TMC or driver confirmation of receipt respectively.
- Connected UCs and extensions. This UC is connected with UC’s 5, 6, 7 and potentially UC8.
- Indicative scenarios of use.

**From the driver to the TMC**
  - “My vehicle has crashed to the road barrier”.
  - “Flat tyre!”.

**From the TMC to the driver**
  - “Snow storm in 10km!”.
  - “Road works in tunnel Y”.

The above Use Cases and scenarios of use have constituted the basis for the formulation of the Pilot scenarios for the assessment of the system. The specific conditional parameters were defined per scenario and Pilot site depending on the local restrictions.
4.2.4 Ontological framework

4.2.4.1 About Ontologies
Ontology in philosophy is the study of the nature of being, existence or reality in general, as well as of the basic categories of being and their relations. Traditionally listed as a part of the major branch of philosophy known as metaphysics, ontology deals with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences.

During the second half of the 20th century, philosophers extensively debated the possible methods or approaches to building ontologies, without actually building any very elaborate ontologies themselves. By contrast, computer scientists were building some large and robust ontologies with comparatively little debate over how they were built.

Since the mid-1970s, researchers in the field of artificial intelligence have recognized that capturing knowledge is the key to building large and powerful AI systems. All researchers argued that they could create new ontologies as computational models that enable certain kinds of automated reasoning. In the 1980s, the AI community began to use the term ontology to refer to both a theory of a modeled world and a component of knowledge systems. Some researchers, drawing inspiration from philosophical ontologies, viewed computational ontology as a kind of applied philosophy (Gruber, 2008).

In the early 1990s, the widely cited Web page and paper "Toward Principles for the Design of Ontologies Used for Knowledge Sharing" by Tom Gruber (1993) is credited with a deliberate definition of ontology as a technical term in computer science. Gruber introduced the term to mean a specification of a conceptualization. That is, an ontology is a description, like a formal specification of a program, of the concepts and relationships that can exist for an agent or a community of agents. This definition is consistent with the usage of ontology as a set of concept definitions, but more general. And it is a different sense of the word than its use in philosophy.

Ontologies are often equated with taxonomic hierarchies of classes, class definitions, and the subsumption relation, but ontologies need not be limited to these forms. Ontologies are also not limited to conservative definitions – that is, definitions in the traditional logic sense that only introduce terminology and do not add any knowledge about the world (Enderton, 1972). To specify a
conceptualization, one needs to state axioms that do constrain the possible interpretations for the defined terms (Gruber, 1993).

In the early years of the 21st century, the interdisciplinary project of *cognitive science* has been bringing the two circles of scholars closer together. For example, there is talk of a "computational turn in philosophy" that includes philosophers analyzing the formal ontologies of computer science (sometimes even working directly with the software), while researchers in computer science have been making more references to those philosophers who work on ontology (sometimes with direct consequences for their methods). Still, many scholars in both fields are uninvolved in this trend of cognitive science, and continue to work independently of one another, pursuing separately their different concerns.

### 4.2.4.2 Ontology in computer science and information science

A ontology in *computer science* and *information science* is a formal representation of a set of concepts within a domain and the relationships between those concepts. It is used to reason about the properties of that domain, and may be used to define the domain.

![Example of an ontology visualized: the Mason-ontology](image)

*Figure 4.2: Example of an ontology visualized: the Mason-ontology*

*Source:* Negkas, 2009

In theory, an ontology is a “formal, explicit specification of a shared conceptualisation” (Gruber, 1993). A ontology provides a shared vocabulary, which can be used to model a domain – that is, the type of objects and/or concepts that exist, and their properties and relation (Arvidsson and Flycht-Eriksson, 2008). Ontologies are used in artificial intelligence, the *Semantic Web*, software engineering, biomedical informatics, library science, and information architecture as a form of *knowledge representation* about the world or some part of it.

In reality and practice:
most ontologies, which – on the basis of an array of existing ontology standards – arrive at a certain dimensions of quantity and complexity are difficult to maintain and update;

there are nearly as many approaches as there are ontologies revealing a proliferation of competing or even conflicting theoretical and methodological variation;

the world of ontologies is still widely monolingual (mostly meaning English only).

This shows that in spite of existing standards and best practices, the field of ontology suffers to some extent from underspecified standards as well as gaps in the methods of practical implementation, not to mention competing and conflicting approaches. As a matter of fact most ontologies are highly heterogeneous – and thus not interoperable from the point of view of content interoperability. Furthermore, existing approaches mostly start off from (written) linguistic data and neglect non-linguistic representations of knowledge as well as other forms of communication, such as non-verbal communication, sign language (eInclusion aspects at large), etc. On the other hand, there is a fundamental need for new approaches to cope with today’s information overflow and to make knowledge explicit and able to process with an engineering approach – i.e. based on standards – with reproducible results and implemented in robust systems⁶.

4.2.4.3 Components of Ontologies

Contemporary ontologies share many structural similarities, regardless of the language in which they are expressed. As mentioned above, most ontologies describe individuals (instances), classes (concepts), attributes, and relations. Common components of ontologies include:

- **Individuals**: instances or objects (the basic or "ground level" objects),
- **Classes**: sets, collections, concepts, types of objects, or kinds of things,⁷
- **Attributes**: aspects, properties, features, characteristics, or parameters that objects (and classes) can have,
- **Relations**: ways in which classes and individuals can be related to one another,
- **Function terms**: complex structures formed from certain relations that can be used in place of an individual term in a statement,
- **Restrictions**: formally stated descriptions of what must be true in order for some assertion to be accepted as input,

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⁶ Regarding GOOD ROUTE approach towards its ontologies standardisation, see section 8.2.2 of this issue.

⁷ Re. class (in set theory), class (in computer science), and class (in philosophy), each of which is relevant but not identical to the notion of a "class" here.
• **Rules**: statements in the form of an if-then (antecedent-consequent) sentence that describe the logical inferences that can be drawn from an assertion in a particular form,

• **Axioms**: assertions (including rules) in a logical form that together comprise the overall theory that the ontology describes in its domain of application,\(^8\)

• **Events**: the changing of attributes or relations.

Ontologies are commonly encoded using **ontology languages**. **Ontology engineering** (or ontology building) is a subfield of **knowledge engineering** that studies the methods and methodologies for building ontologies.

### 4.2.4.4 Benefits of creating an ontology

Ontologies have become common on the World-Wide Web. Many (web) services may be implemented by many different parties (companies) in many different programming languages (or conjunction of many languages and tools). It is necessary to define a generic template in order to export these service's structures.

In general, ontology consists of classes and objects. “Classes are the focus of most ontologies. Classes describe concepts in the domain” (Noy and McGuinness, 2001). A class can also be a subclass of another class, it can be a superclass, it can inherit methods and properties from imported libraries such as JADE-LEAP, and of course objects with variety of data types (integer, float, Boolean, etc).

To summarise, the ontology can be used for the following reasons:

- To share common understanding of the structure of information among people or software agents.
- To enable reuse of domain knowledge.
- To make domain assumptions explicit.
- To separate domain knowledge from the operational knowledge.
- To analyze domain knowledge.

### 4.2.4.5 Ontological framework developed for the system

Thus, as can be seen from the above, in practical terms, an ontology can be defined as a common vocabulary among users, who need to share information with each other. It includes definitions of basic concepts in a domain and may also declare the relations between concepts. Finally, an ontology together with a

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\(^8\) This definition differs from that of “axioms” in generative grammar and formal logic. In these disciplines, axioms include only statements asserted as *a priori* knowledge. As used here, “axioms” also include the theory derived from axiomatic statements.
set of individual instances of classes constitutes a knowledge base (Noy and McGuinness, 2001).

In order to develop an ontology, appropriate steps should be followed such as:
- defining classes in the ontology,
- arranging the classes in a taxonomic (subclass–superclass) hierarchy,
- defining slots and describing allowed values for these slots,
- filling in the values for slots for instances.

The Protégé 3.2 beta version was used for developing the specific system ontology.

A unified coding has been used in all subsequent parts of the system ontology, in order to enable their interfacing by other ontologies and also their update.

The system ontologies address the cargo, the vehicle, the driver and the environmental conditions. In the “From whom” and “To whom” columns of Figure 4.4 below, the primary sender and the final recipient of the information related to the cargo, vehicle, etc. is respectively filled in.

It should be noted that the ontologies developed reflect the initial senders and recipients of info in the logistic chain, even if in the context of the integrated centralised system, some of these communications are being done automatically. For example, the critical info that are needed to be communicated by the driver/vehicle to the police is being given upon request to the TMC directly and not through the driver.

Each couple of sender recipient corresponds to a “Profile”, as the following figure shows.

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Please note that for the classification of the “cargo” in the ontology, the UN numbers according to ADR have been used.
Thus, as seen in the above figure, the “From whom” and the “To Whom” columns in the templates get the following values, according to the profile that is being addressed:

1: Other vehicle  
2: TMC  
3: Infrastructure  
4: Police  
5: Business chain  
6: Emergency agencies

In the same way, the “Profile column” gets the values:

1: Warning  
2: Critical info  
3: Passport  
4: Enforcement  
5: Logistics  
6: Emergency

The Use Cases of the system, as described in 4.2.3, are depicted in these “Profiles”. The interrelation of the system Use Cases and the “Profiles” of the system ontology is presented in the following table.
Table 4.1: Interrelation of the system Use Cases and the “Profiles” of the system ontology

<table>
<thead>
<tr>
<th>Ontological “profile”</th>
<th>Use Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Warning”</td>
<td>UC8: “C2C communication”</td>
</tr>
<tr>
<td>“Critical info”</td>
<td>UC9: “Critical info”</td>
</tr>
<tr>
<td>“Passport”</td>
<td>UC1: “Passport”</td>
</tr>
<tr>
<td>“Enforcement”</td>
<td>UC5: “Enforcement”</td>
</tr>
<tr>
<td>“Emergency”</td>
<td>UC7: “Emergency”</td>
</tr>
</tbody>
</table>

An abstract of the system ontology is provided below:

The full ontology developed is provided in GOOD ROUTE Deliverable 1.1 (Bekiaris and Gemou, 2006). It should be noted that several updates of the ontology have been held until the end of the project, for the sake of compliance with the specifications and the architecture of the system.
4.3 Overall System Outlook

4.3.1 Introduction

The envisioned system synthesized real time and dynamic data regarding vehicle, cargo, road and weather conditions into an advanced route guidance system.

The core of the system is a real time decision support system (DSS) that optimises the routing of Dangerous Goods Vehicles within a transportation network by balancing the economic costs and societal risks associated with their transport.

Transport risks are calculated using the methodology of Probabilistic Risk Analysis applied to the material being transported and a time-dependent path optimisation algorithm is used for routing. Inputs to the system include the road network, population distribution data, real-time as well as statistical traffic data and historical accident data. Novel methods were developed for obtaining real time response from the system in spite of the complexity of the associated computations.

From an architectural view, the system can be divided into three areas, namely the mobile part (on board unit), the roadside part (local node) and the core part (DSS, data fusion, portal) and the connected external modules (logistics support) as depicted in Figure 4.5 (Paglé and Amditis, 2009). The mobile, roadside and external modules collect data in real time and feed the DSS for producing the optimal minimum risk route.
National systems architectures were investigated (i.e. Artist: Italian Architecture for transportation systems) together with the CVIS and the SAFESPOT project architectures.

The development of the system architecture has been based on the use cases and scenarios of use which do not only describe the situations the system will handle, but, in addition, they create a clear picture of the functional concept of the system.

Therefore, the Use Cases were decomposed according to the individual requirements of all involved stakeholders and UML diagrams were developed for all of them.

A flexible and modular architecture which allows different implementations corresponding to different business cases has been developed (see section 6.4.2). The design principles have been chosen in such a way, so that existing components do not have to be changed principally but only extended by integrating system specific functionalities or additional, new applications.
The following figure shows the context diagram which is a description of the main input and output of system applications and the external environment.

![General Context Diagram](image)

**Figure 4.6: General Context Diagram**

*Source: Paglé and Amditis, 2009*

The terminators that constitute the boundary of the system are the following:

1. On Board System;
2. GOOD ROUTE Core System;
3. Logistics Support System;
4. GOOD ROUTE Portal and Data Fusion Platform (DFP);
5. Local Node;
6. DGV Driver;
7. Control Centre Operator;
8. Enterprise Room Operator;
9. Final Client;
10. Allied services.

The subsystems that compose the system are presented in the following diagram:
More details of the developed system components and its integration are provided in the following sections.

4.3.2 Integrated System Core Part

4.3.2.1 Expert Rules

A series of interviews were undertaken among companies in order to identify the business rules that are applicable at a company level concerning the logistics and routing of the dangerous goods vehicles. Two major DG transportation companies, namely SHELL and BP (Greek departments) were interviewed as example case studies, in order to extract the basic business rules and principles applied in the routing of their vehicles. In addition, the local rules of the Pilot sites (FINRE\(^{10}\), SITAF, GST) were being captured, in order to serve as major case studies for the system (Kauber and Emmanouilidis, 2009).

According to the outcomes of this work, in general terms, the DG companies comply with the national legislation rules for the transportation of dangerous goods in the reference network. These rules concern the basic driver restrictions, safety standards, speed limits, etc. Even if there is no concrete National Reference network, the companies use the safer road network in terms of quality of infrastructure and accessibility in case of incidents.

On the other hand, each company has different approach in monitoring each of the vehicles, the set-up and the policy in terms of re-routing. However there is a clear view that re-routing procedures are basically due to traffic reasons and in scarce cases. Since the real-time communication between the driver and the

\(^{10}\) Later renamed to DESTIA.
companies is not established through any telematic system (some pilot applications were reported from BP however), the re-routing procedure is available to the driver only at the subsequent stop.

There is a clear gap in this part of the logistics chain of the dangerous goods as well as the inflexibility in organising the chain at real time and on demand since all orders are scheduled a day before, with limited possibilities for alterations.

All retrieved local rules have been embedded as rules into the DSS. For example, the re-routing alternatives, as described in each Pilot site, constitute the most significant info for the Re-routing Use Case, since the system has to have embedded from which routes is allowed to select in case the main infrastructure passage is closed for any reason (national holiday, maintenance, other event). Of course, dynamic real time traffic, weather and other data are also to be taken into account, through the establishment with the corresponding TMC of the region. This would cover extraordinary events, which cannot be foreseen or extreme weather conditions (storms, etc.) that would not allow the passage through specific routes, etc.

Thus, if the optimum route (or re-route) selected by the DSS in first place is one of the routes that are not allowed at specific days or hours, the time-related embedded local rules (which have been correlated to specific GIS data with regard to specific coordinates), will function as “flags” which will make the system to proceed automatically to the next optimum route. In a similar way, the parking and rest areas are used, whenever available. The system needs to know where is the closest resting area when the issued route includes stops (also applicable in the “Passport” Use Case or the “Business-related re-routing” Use Case). The working hours regulations in each region are also important, since, if violated, may fall under penalties for the specific region, thus the system needs to know in advance what the maximum duration of the route that is permitted to issue is.

4.3.2.2 Decision Support System (DSS) and Conflict Resolution Module (CRM)

The aforementioned Decision Support System (DSS) is the vital part of the integrated system. It is responsible for calculating the optimum route, which is either the lowest-cost route, the lowest-risk route, or a combination of the two. It calculates the optimum route for every requested dangerous goods transport by checking for conflicts regarding this route with the Conflict Resolution Module (CRM) (Kauber, Emmanouilidis et al., 2009).
The DSS takes into account the individual and societal risk-related cost, in addition to the economic cost, and calculates the optimum route by eliminating the combination of them. The combined cost, which is eliminated, is the result of the linear combination of the economic and risk related cost, by the use of a weighting factor. The inputs to the system include the road network, population distribution data, real-time as well as statistical traffic and weather data, historical accident data, road characteristics, real-time vehicle and cargo status. These data are, whenever possible, time-dependent, with the day being divided into a certain number of time intervals, each of which corresponds to a different value of the time-dependent data.

As aforementioned, the DSS calculates either the minimum risk, the minimum cost, or the minimum combined-cost route. The calculated route is then submitted to the Conflict Resolution Module (CRM), which, having a complete view of the road network, the ongoing and the scheduled routes, it accepts it or rejects it. The DSS calculates an alternative route, avoiding the problematic parts of the road network in case the proposed route is rejected, i.e. because certain road segments have exceeded their DGV capacity. In case information is not available for some links capacity, it is moderated by means of a random number, using as input the road category of the link. However, this is static information that won't change so often.

The above process continues until the CRM finally accepts a proposed route. Thus, as it was described above, the DSS considers every DGV transport individually. In order to achieve its goal, it combines data from various sources, both static and real-time. The data that are used are the following:

- The Transportation Network Database, which contains information about infrastructure and all possible routes. In fact, it is a Geographic Information System (GIS), consisting of nodes and links.
- The Impact Area Database, which contains information relevant to population distribution. The control area is divided into a number of polygon-shaped areas, with different population densities.
- The Past Accident Database, which is used in order to exploit general and specific causes of accidents, as well as severity of risk factors and indicators. In case past accident data do not exist for the particular road, relevant road type averages are used.
- The Real Time Data, consisting of current and forecasted weather conditions, traffic conditions, vehicle and cargo properties (such as substance type, tank temperature and pressure, etc). In case of lack of some real time data, the corresponding static historical data are used.
The DSS consists of two parts, the Risk Estimation Module, which calculates the risk related cost that is associated to each segment of the road network, for the particular transport, and the Optimal Route Calculation Module, which produces the optimal route, that is to say the one with the lowest overall combined cost.

What the Risk Estimation Module does, is applying a single risk-related cost value to every link of the road network for the particular dangerous goods transport, implementing the Risk Estimation Algorithms (through Event Tree analysis) (Patrinos, Vayiokas et al., 2009). The risk-related cost value is time-dependent, in other words it may change throughout the day as the various parameters that affect it (weather conditions, population density, etc.) also change. The Optimal Route Calculation Module is responsible for providing the optimal route for the requested dangerous goods transport, taking into account the risk-related costs that were previously calculated by the Risk Estimation Module. What it really does is minimising the total combined cost of the route, finding the minimum combined cost route. With the term combined cost we mean the combination of the risk-related cost and the economic cost. That combined cost, which is time-dependent, is minimised by the Optimal Route Calculation Module.

Finally, the calculated optimal route is submitted to the Conflict Resolution Module, which decides whether it will accept it or not. In case that the proposed route is rejected, because one or more road segments have exceeded their DGVs capacity, a new route is being calculated and submitted. That process continues until a route is finally accepted.

A decision support methodology has been decided for the developed Conflict Resolution Module for the selection of best route for each transport of dangerous good, based on social demand for risk reduction, and industry demand for minimum costs. The conflict resolution runs together with the DSS on a separate server and it is based on business rules, but also on the alternative rules given by the DSS, which operates upon the Minimum Risk Rules (Kauber, Emmanouilidis et al., 2009).

Basically the CRM receives routes queries from the DSS Module and, taking into account some information coming from the Control Centre Module, some internal real time information (i.e. incidents) and some historical information (link capacity and transit time through the different links), decides, based on the heuristic algorithm selected, which of the routes are allowed to proceed and
which have to wait some time. DSS is informed of the delayed routes and of the links that caused these delays.

The input to the module is a file including a scenario consisting of different routes, each of them composed of a route identifier, different nodes and the company owner of the DGV. The outputs are namely the simulated response consisting of the different routes identifiers, a Boolean response and a list of the nodes with incidents, so that the DSS module will be able to perform the rerouting of the affected DGVs. To ease the final integration of the CRM a Web Service has been developed to get all the needed information and to receive route requests and answer them.

The DSS was developed in C++ by CERTH/ITI and has the form of a library that can be used by other modules. That library is wrapped in a web service that was developed in Managed C++, and which forms the final state of the DSS.

Thus, the DSS communicates with the other modules of the system through web services. It acts even as a client (invoking other web services to get the necessary information) or as a server (receiving route requests).

The routing process starts with the Navigation Client (see section 4.3.3.2) requesting a new DGV transport request, by calling the respective DSS web service and passing all the respective parameters (source node, destination node, transport type, departure/arrival data, vehicle parameters, cargo parameters) to it. The DSS then invokes other Web services if necessary, in order to gain real-time traffic and weather data. After the route calculation, the DSS calls a Web service, exposed by the Conflict Resolution Module (CRM), in order to submit the proposed route.

The CRM's reply is the approval or rejection of the route. In case of rejection, the IDs of the road segments that exceeded their capacity will be returned to the DSS, so as to calculate an alternative route by excluding them.

The three cooperating modules (the Decision Support System, the Conflict Resolution Module and the Navigation Module) have access to the same GIS data (concerning the road network, the nodes/links and their IDs), in order to properly communicate and understand each other.

A standalone windows application was also developed by CERTH/ITI, in order to test the DSS’s operation during the development process. That application, the GOOD ROUTE Simulator, wraps the DSS in a clear and efficient user interface.
in Windows, and can be used independently from the rest of the system, for testing various scenarios and use cases where the DSS is involved.

The *GOOD ROUTE* Simulator applies the DSS algorithms on the GIS data (road network, population distribution), providing the optimal route(s) as an output. That output can be displayed on the screen and can also be stored in a file. The display of the network and population data, in addition to the proposed route(s) can be configured in several ways (Kauber, Emmanouilidis et al., 2009).

### 4.3.2.3 Control Centre

At the Control Centre, a data fusion and information synthesis module was developed. Its front end, through which the user can access the system, is implemented in the form of an Internet portal and the respective Human Machine Interfaces (HMI's) for the different actors having different authorisation rights have been developed (Romero, Los Santos et al., 2009 & Charalampous, Aifandopoulou et al., 2009).

The backend architecture of the Control Centre is mainly consisting of two modules: the business logic that handles the general tasks like the profile and map management, and the data fusion, that takes care of all the incoming messages and their correct fusion and distribution. All components of this platform support web services by providing SOAP XML interfaces so that they can be easily linked to other enterprise applications or portals.

The user front-end can be developed with JSP/Servlet technology, Microsoft.NET, or other front-end technologies like stand-alone Java or Macromedia Flash or AJAX. The Control Centre front-end is actually the so-called *GOOD ROUTE* Portal. The *GOOD ROUTE* Portal has the task of visualising the users’ actions and to present the system results in a concise way at a central access point. The results that are presented to the user are selective according to his status and access rights. The main features of the portal are:

- User account management
- User profile management
- Vehicle monitoring and status display
- Route planning
- Data and parameter entry
- Display of dynamic data
- Implementation of the LSS module (see section 4.3.5).
A concept was defined to manage the different user rights, profiles and user accounts. A database was developed to host all the necessary parameters there are to be transferred between the Control Centre and the external modules.

The following table lists the main operations that can be done by the major portal users. Some of the operations are reserved to the company that owns a truck, other operations are especially dedicated to operators in control rooms, for example a tunnel control room. The system administrator is allowed to access the whole system, whereas the truck driver has only a very restricted access. This is due to the fact that route planning and event management is done by an operations department, whereas the driver of a truck has just to follow certain instructions. Thus, it is, for example, possible for a dispatching company to create an account on the GOOD ROUTE portal, but the driver of this company is only allowed to see the planned route, or to trigger re-routing in case of a serious incident on his/her current route.

**Table 4.2: User rights matrix on GOOD ROUTE Portal**

*Source: Charalampous, Aifandopoulou et al., 2009*

<table>
<thead>
<tr>
<th></th>
<th>Driver A, B, etc.</th>
<th>Truck Owner A, B, etc.</th>
<th>TMC A, B, etc.</th>
<th>Administrator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Delete account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Login</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Change account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Plan a route</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Change activation of driver route</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Change activation of company routes</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Change activation of all routes</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Trigger re-routing</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Change driver routes</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Change company routes</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Delete driver routes</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Delete company routes</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Monitor company trucks</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Monitor all trucks</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Monitor company routes</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Monitor all routes</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Enter (alert) messages in portal (to be sent to mobile device)</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>See logistic data per vehicle in</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### 4.3.3 Integrated System Mobile Part

#### 4.3.3.1 On-Board Telematic System

There are two telematic units in the truck (Bianconi, 2009). The first is installed in the tractor in order to collect information about the vehicle operations and to manage the short/long range communications and the second one is hypothetically installed in the trailer in order to collect information on the transported goods status (dangerous goods are stored in the trailer).

In the GOOD ROUTE demonstrator the second telematic unit is installed in the trailer emulator. In the context of the project, it was decided to develop a trailer emulator and to adopt it for the vehicle demonstrator integration. The main reasons that pushed this decision have been the following:

- To assure the capability to perform tests everywhere, also in CRF (project beneficiary) premises, and with any truck driver. In fact, in Italy, truck drivers that wish to drive truck with trailer should own a particular driving license.
- The specific selection of the type of the trailer (container, tank, etc.) and the type of goods transported (solid, liquid, explosive,...) was out of the GOOD ROUTE vehicle demonstrator scope because the objective of testing activity was to validate the overall system and scenarios. The design of the trailer equipment has been as general as possible, not focused on specific commercial sensors used for monitoring specific goods carried in specific trailers.
- The developed trailer emulator could guarantee all the needed functionalities and represents a good starting point for any future.
application in the field. The information on emulated cargo, as ADR identification code, dimension and weight were stored in a RFID tag and could be easy changed. The “cargo” status was monitored through WSN and through setting different internal alarm thresholds was possible to emulate different cargo status.

Both the tractor and the trailer OBU’s (On-Board Units) were integrated into the same type of device, the Blue&Me™ device developed by Fiat Auto, Magneti Marelli and Microsoft Automotive Business Unit, an innovative solution based on Windows Mobile for Automotive, which performs in-car communication, information, and entertainment functionalities. Blue&Me is available on new and restyled models from the Fiat Group (FIAT Automobiles, IVECO, CNH).

The Tractor was equipped with the IVECO Telematic platform (“Blue&me Fleet”) and provided with a front panel display for HMI, WABCO tyre pressure monitoring system and DSRC module for short range communication. The on board unit was also connected to a radio system and integrated with a microphone. The tractor telematic platform was connected to the CARGO equipment so as to receive cargo data and warning of irregular condition on goods status.

The main subsystems of the tractor architecture are the following:

- OBU (On Board telematic Unit) for wireless communication; it is connected to the vehicle CAN bus network and to the trailer OBU through a dedicated CAN link;
- The HMI system;
- The Dedicated Short Range Communication (DSRC) system for enforcement application;
- The tyre pressure monitoring system (WABCO);

From the communication links architecture point of view, the tractor on board unit uses:

- BlueTooth short range communication link toward an on board navigation system.
- DSRC short range communication link toward the infrastructure and local nodes.
- GPRS long range communication link towards the GOOD ROUTE Control Centre.

The main functionalities of the tractor OBU are as follows:

- To monitor vehicle operating parameters.
- To monitor driver behaviour.
To provide position information to the navigation subsystem.
To receive the status of the goods in the cargo, to handle the status and provide warning to the driver in case of specific events.
To interface TPMS sensor and provide information on the wheel status.
To manage HMI with the driver.

While, the main functionalities of the trailer OBU are:
- To monitor the presence of the cargo, and the ID so to understand if some part is lost or stolen during the trip or during the storage; this is being achieved through the reading of one or more RFID tags (one in our case).
- To monitor the status of goods in tanks by a specific set of sensors installed on (or inside) the tanks; this will be achieved through the use of wireless sensors network.

Thus, the main subsystems of the trailer emulator in order to achieve the above are:
- OBU (same model as tractor OBU);
- Wireless Sensors network for cargo monitoring;
- RFID reader + RFID tag for cargo identification.

The unit installed in the tractor has the capability to communicate with the unit installed in the trailer and with the Control Centre. All the information is gathered in the relevant OBU and after a processing is sent to the tractor OBU. The tractor OBU sends general information to the trailer OBU (i.e. start, stop,), while the trailer OBU sends information about the cargo and cargo status.

The information exchange between the two on-board telematic units is achieved through a dedicated CAN link. The tractor unit is connected to the vehicle control network through the CAN FMS protocol.

In order to monitor dangerous goods, the trailer has been equipped with sensors, RFID, specific TAG sensors with low power consumption.

A WSN (Wireless Sensor Notes) system is deployed for acquiring important parameters about cargo. The information on emulated transported goods, as ADR identification code, dimension and weight are being stored in a RFID tag. The RFID reader selected for this system is the Baracoda, IDBlue Bluetooth enabled RFID 13,56 reader/writer. It is interfaced to the trailer OBU telematic platform through Bluetooth link.
The wireless sensor nodes that have been selected for the vehicle are light, temperature, barometric pressure and humidity. Every node periodically acquires one or more parameters from the sensor unit and forwards those to the transceiver that is connected to the trailer OBU through the dedicated CAN line.

All data are collected by the trailer unit and sent to the tractor telematic unit which gathers all the information about the truck. The data acquired by the on-board telematic unit can be sent to the control centre and/or to a local node upon request or spontaneously after a warning condition detection.

The tractor OBU sends messages to start and stop the trailer OBU cargo monitoring activity. The trailer OBU sends messages at a constant rate about the cargo status information. If the tractor OBU doesn't receive any message from the trailer OBU within a certain time interval, it sends to the GOOD ROUTE Control Centre a warning message in order to communicate technical problems on cargo status monitoring system.

The local node provides enforcement procedures applied locally and notifies the driver about them. Alternatively, other solutions can be provided by the control centre taking into account global suitable strategies. The control centre is able to exchange information with the vehicle through GSM/GPRS while local nodes will use DSRC short range communication link.

The control centre monitors the vehicle and verifies if the driver has appropriate driving behavior. If necessary, the control centre can apply some enforcement policies that are established in accordance with the local authorities and can decide to send messages to the driver with the suggested guidelines or with the indication to stop the vehicle.
A police car, with the assistance of a device having the capability to communicate with the truck telematic unit, can request the truck to send information about the vehicle functionality and the transported dangerous goods status; after having checked the received data, the police can adopt an opportune strategy to stop the vehicle.

A specific tool has been developed on the IVECO OBU with the purpose of acquiring vehicle data; these data are then analysed in order to determine the status of the vehicle and the driving behaviour of the driver. The two status parameters provide information to the GOOD ROUTE Control Centre about the vehicle capability of continuing the travel and the driver respect to the driving rules respectively.

The information is provided also to the driver through a specific HMI: messages can be displayed on the OBU front panel or converted to voice and heard through the radio system. The same HMI is used for the enforcement messages received from the local node.

The OBU is perfectly integrated inside the tractor cabin. It is placed in front of the driver near the stereo, the navigation system and the chrono-tachograph and can be easily managed by the driver him/herself.

The OBU functionalities don’t require any interaction with the driver: they are almost automatic and the on-board HMI is simple and oriented only at the visualisation of elementary messages.

The HMI functionalities are based on front panel display visualization or on vocal messages obtained through a text to speech tool, already integrated in the OBU. The voice messages are managed through radio connection and microphone integration.

The OBU Platform uses the on-board Radio Equipment to play announcements to the driver; these announcements can be relevant vocal messages on vehicle and cargo status and on re-routing requests from the Control Centre. In order to do this, the system is connected to the Radio by means of an analogical channel in order transport the audio signal and an On/Off signal to control the radio.

The OBU is connected to a front panel display (through a B-CAN interface) equipped with a dot matrix display; the visible area is 67 mm x 35 mm (W x H), where short text messages can be displayed. On the front panel some pre-configured push buttons are available to the driver.
The parameters that are shown on the front panel display are cargo status, cargo data, WSN configuration, tyres status. All these parameters can be shown on the display simply selecting the respective entry in a pull-down menu. The driver can gain access to the Menu pressing the button with the receiver symbol and move inside the directory scrolling the UP/DOWN items. This allows to go respectively to Previous page (arrow DOWN) and to Next page (arrow UP).

About the cargo status, the driver can have information about light, temperature, pressure and humidity of the trailer environment in real time, simply selecting the respective entry in the pull-down menu.

The parameters for the cargo data that can be displayed are ADR codes, cargo weight length, width, height. The driver can have this information simply selecting the respective entry in the pull-down menu.

The driver can also have information about different tyres pressure, simply selecting the respective entry in the pull-down menu, as follows:

- Within the WSN directory there is also a configuration section that allows the driver to set and change the reference threshold values of the sensed parameters for all the wireless sensor nodes. In the WSN area the driver can select different options, one for each node and a configuration reset command.
- During the trip, in case of need, the driver can send an emergency message simply pushing an eCall button on the OBU front panel. Moreover, to report and signal a generic event from the navigation system the driver can push a dedicated button symbolizing a stylized truck.

4.3.3.2 Navigation Client

The navigation client is based on the on-board principle, that is, the route calculation is being executed on the mobile device. A tablet PC by PTV was deployed for client navigation (Bianconi, 2009).

A hybrid system was implemented which allows to exchange routes between the mobile client and the backend server. The data transfer is done by using GPRS. This approach has also the advantage to be able to run more complex processes regarding the "safest route" on the backend and just transfer the result to the mobile client. It is also easier to integrate dynamic information during route calculation on a backend server system.
The mobile client navigation is communicating directly with a server hosted at PTV and which receives its input from the Data Fusion Platform (Control Centre including the business logic of the system). The route calculation receives input from different sources, such as traffic management centres, weather data bases and the DSS as well.

The system is also able to push event information to the client device (e.g. accident warning).

The navigation application is a standard product available in the market. The necessary adaptations have been made regarding the backend server connectivity and the message display. It is a software package that runs on mobile tablet PC. The task of the navigation is to give the driver exact driving directions, calculate routes and display maps. Especially the latter function requires a map render engine on the device which consumes a high percentage of the device hardware resources.

The navigation system prototype includes a mobile PC, Bluetooth GPS-receiver and a mobile phone, which offers the connection to the internet via GPRS.

The Tablet PC runs Win XP and the screen size of the device is 1000px width and 600px height. The system settings could be adjusted to show the scrollbars width 40 to 50px width to be able to handle it with a finger on the touch screen of the tablet PC; a stylus pen can also be used.

![Figure 4.9: Mobile client](image)

*Source:* Bianconi, 2009

One of the main tasks in this case was to find a mechanism to convert the routes provided by the DSS as a segment list into navigation readable waypoints. This was done by using a so called WayPoint Server and a conversion module.
An interface was developed for the navigation module. Fully fledged for the system, the Tablet PC is connected to the internet via a GPRS or an UMTS connection and receives GPS position information via a GPS device. The driver utilises the touch screen to operate the Tablet PC and get the route guidance. The calculated route is being displayed to him/her on the map. A maneuver list provides him/her with further details, e.g. distance and arrival time. Further features are the list of points of interest and the list of traffic information, which are displayed to the drivers by characteristic icon on the map.

The client is linked permanently to the GOOD ROUTE Server, thus in case of a change in the traffic situation, e.g. an incident on the calculated route, the driver receives an update information.

### 4.3.4 Local Node and Enforcement System

The enforcement module deals with the automatic enforcement on behalf of the Police or the competent authority in case traffic or other type violation is detected, that presupposes the Police involvement in mitigation or at least notification and presence (Carisio, 2009).

The system provides an alarm to the enforcement for intervention, taking into consideration the values of key data (vehicle speed, vehicle and driver profile, type and amount of cargo, total weight per axle, etc.), compared to defined thresholds on local or regional (i.e. instantiated per infrastructure) level. The alarm is provided to a local or central checkpoint. The communication protocol between the local node and the OBU is part of the GOOD ROUTE Communication Protocol. This is an application level protocol based on XML messages which allows performing the several phases of the communication session (see also section 4.3.6.3.1 of this issue).

In order to perform the communication between the local node and the vehicle, communication modules were developed and deployed at both entities. Their aim was to implement the protocol, building and sending messages, as well as receiving and parsing them. Communication modules include the software modules which handle the communication as well as the hardware modules which handle the wireless transmission. The wireless transmission technology chosen for this task was DSRC.

The DSRC module is a communication module which implements the 5.8GHz DSRC standard. The module is composed by three different components: a control
card, which implements the control logic, a DSR transceiver, able to transmit and receive data through 5.8GHz radio band and the antenna, which determines the intensity and the shape of the emission lobes of the radio signal.

The DSRC module can receive input from and produce output to a serial port (RS232) or the vehicle’s BUS CAN define acronyms; in addition it can also receive input from analogical sensors. It provides security features only by means of identification; the master / slave identity number is checked against a mask to verify the identity. Any other security features, including data encryption or a stronger identification based on RSA public / private keys have to be implemented outside in a higher level. The maximum payload which is transmitted in every packet is 16 bytes, so that longer messages have to be split at the origin and reassembled at the destination.

The local node is an autonomous processing unit with communication capabilities. It is provided with two communication modules, in order to transmit and receive data to and from vehicles and the control centre.

The module which manages communications with the vehicles’ OBU is the one able to send and receive messages, implementing in this way the protocol.

The principal tasks of this module are:

- To receive and to parse message from the OBU, containing vehicle’s parameters, and to pass them to the data analysis module.
- To send to the OBU messages generated by the data analysis module; they can be requests for subsets of parameters or requests for actions.
- To implement the optional security features, represented by the implementation of the RSA and AES algorithms.

The other module, the so-called enforcement module, is intended to be used both for enforcement infrastructure, installing the local node in the edge of the streets before strategic points as bridges, tunnels or the frontier of countries, as well as for mobile enforcement, installed over a police cup in order to check vehicles by a car-to-car connection.

After the truck’s check, if an alarm has occurred, the Local Node unit sends the information to the check point, via GPRS (or UMTS) connection, and inform it about check site’s coordinates and type of alarm.

The Central checkpoint is to be imagined as a Web service, which processes information including input from users like infrastructure operators.
The Local Node’s business logic is ADR (“European Agreement concerning the International Carriage of Dangerous Goods by Road”) based and can be updated via messages from the Central checkpoint.

The following figures provide an overview of the enforcement module operation and architecture.

4.3.5 Semantic Service Network and Logistics Chain Support

Upon the project ontologies (see section 4.2.4), the formulation of the semantic service framework for the system has been established (Charalampous, Aifandopoulou et al., 2009).

The main outcome of the overall work held is the compliance of the entire logistics support system with the system Use cases. Based on the above, the main information flow - “the Semantics Service Network”- was designed for the logistical component of the system and is depicted in the following figure:

*Figure 4.10: Enforcement System Overview.*
The Semantic Service Network is based upon the results from the surveys and structure of the supply chain of dangerous goods, the information flow and transactions between the actors of the dangerous goods supply chain (info related to the goods, driver and vehicle status, position, route, estimated time of arrival, estimated transportation cost and any actual or foreseen events during transportation), being compatible to the most widely used logistic systems in the area. It allows actors in the chain to add info on the network that will have as recipients other actors or the vehicles’ drivers, through the Control Center.

The logistics support system is a tool that is integrated in the Control Centre of the system (section 4.3.2.3) and has an interface in the portal. The basic role of the module in real life would be the information capture from the industry through the portal. This communication interface would also provide back to the user of the system alerts that would be available concerning the status of the delivery, incidents, etc.

The levels of communication between the LSS and the company may be achieved according to the possibilities of the system according to the following:

**Tactical level planning**
• **Collect information from the industry**
  - Cargo characteristics
  - Vehicle characteristics
  - Itinerary characteristics

• **Provide the requested data to the Control Centre**

• **Store collected information and scenarios for further use either temporarily or permanently**

*After route execution communication*

The completion of the route may have two different results:
- The planned route has been successfully followed and executed.
- The planned route has been changed during its development due to several reasons.

In both cases the LSS returns to user the log of the route held and a comparative of the planned itinerary and the one actually held. The reasons of the deviation are also mentioned. The Logistic Support System validates those data, stores them and passes them to the Control Centre when a request is made. When an actor’s request is made, the LS System requests the necessary data from its repository and along with other data (user’s data or other subsystem data) passes them to the appropriate subsystem for execution.

After this process the data of the routing is being erased from the system for security and data protection reasons.

**4.3.6 Cooperative System Integration**

**4.3.6.1 Semantic Interoperability**

Semantic interoperability in the system was required to enable the exchange and the integration of data between heterogeneous information systems and their data model and repositories.

The state of the art of data exchange in the traffic and transportation domain is represented by the DATEX standard. DATEX was designed and developed as a traffic and travel data exchange mechanism by a European task force set up to standardise the interface between traffic control and information centres. In the
road sector, the DATEX standard was developed for information exchange between traffic management centres and constitutes the reference for applications that have been developed in the last decade.

DATEX II was used as a “common data model and dictionary and exchange protocol” and served as a starting point from which to take inspiration. The protocol defined is a high level protocol based on XML messages which carry information to manage the protocol and a payload. The XML Schema has been designed from scratch without the initial UML model and the conversion phase, as the data model was defined in the context of ontologies (section 4.2.4).

DATEX II defines a service oriented protocol to enable the provision of information in a server/client paradigm. The client subscribes to a certain service to receive information in several modalities. Every DATEX II message is then composed by two parts:
- The exchange section, describing the protocol;
- The payload section, containing the data.

In the communication protocol being developed, the same general structure was followed rearranging and extending the elements for the payload section, and completely redesigning the exchange section. Such changes were necessary because of the different necessities of the communication between enforcement entities, which is closer to a peer to peer model than a server/client one.

As a result, communication protocol messages are divided in two sections:
- The exchange section, which describes the protocol, identifying the message type, the sender, the recipient and other information;
- The payload section, which, depending on the message type, is more or less extended and can contain several kind of information.

\[\text{Figure 4.12: GOOD ROUTE message Schema’s main structure.}\]
4.3.6.2 Security Aspects

In order to comply with all corresponding Directives and to increase user acceptance of the system, it was mandatory to implement a strong security service to protect the collected private data from companies and trucks and organize/authorise the access to contents (e.g. the decision support system will make use of company data that should not be accessible by other actors of the system).

Most of the wireless communications in the system are being executed via GPRS, which is secure; for example, the communication between the OBU and the Control Centre, with its security functionalities (performing authentication and ciphering setting procedures based on the same algorithms, keys and criteria as in existing GSM, also using a new ciphering algorithm optimized for packet data transmission) is inaccessible for extern agents. All the communications, both wired and wireless have been designed over http, but the migration to https is possible.

The three elements integrated in addition to extend the security are the following:

- **AES**: The AES encryption algorithm has been finally adopted due to its higher performance in comparison to other possibilities considered. Sensitive data in the Control Centre and the On Board Unit are being encrypted with this module prior to storage. Optionally, it could be used to encrypt the information before its transmission between the different modules increasing the security (i.e. before the transmission via DSRC between the OBU and the Local Node, but this proprietary technology implements its own security, so it is not necessary).

- **Web Services**: The web services have implemented different levels of security to exchange information. In case of sensitive information, the specification WS-Security (WS-Security describes enhancements to SOAP messaging to provide quality of protection through message integrity, message confidentiality, and single message authentication) is adopted.

- **Centralized Security**: A centralized security system is suited for the system, and for this reason Kerberos features have been described. During the integration and experimentation phases, it was not planned to implement and install any kind of security protocol to supervise the whole network authenticating all its nodes, users and components, but in the
future this option must be adopted, taking into account diverse initiatives like SeVeCom.

- **GOOD ROUTE Portal**: It was mandatory to implement a strong security service to protect the collected private data from companies and trucks and organize the access to contents (e.g. the decision support system will make use of company data that should not be accessible by other actors of the system). The access to sensitive data was restricted, based on user-defined policies and automatically classify real-time information based on its nature. For this reason different kinds of actors have been implemented, restricting the accessible information for each class. All these users have defined along the project (DGV driver, Control Center Operator, Enterprise Room Operator, Final Client, Allied Service) (Romero, Los Santos et al., 2009).

According the implementers, the technologies and add-ons adopted were secure enough for the demonstration of the system. For future wide implementations, other solutions must be adopted, in order to control large scale systems with significant number of users that increment the number of communications and risks.

### 4.3.6.3 Integration

#### 4.3.6.3.1 Integrated System Interfaces

In order to accomplish the system and its instantiation at the three Pilots sites, the complete system was treated as a set of individual components-modules, where only the information flow between them was of interest.

For this purpose, a number of interfaces were clearly defined and developed. Each one of these interfaces consists of one or more web services modules running over the telecommunications layer. The main objective of the integration process was to define the rules and the architecture for the information flow in order to provide homogenous, robust and flexible system despite of the underlying technology used in every core module and sub-module of the system. The success of the integration was a single system which had its core modules distributed in three countries (Greece, Germany, Spain), that would be used for testing in the three Pilot Sites (Italy, Switzerland, Finland) with minor interventions, like the Enforcement Node placement.
The interfaces between the core modules of the system are as follows and as such were used for the instantiation and demonstration of the system in the three Pilot sites:

- **Web portal to Decision support system interface:**
  Interface for web portal to contact the DSS in order to estimate a new route.

- **Control Centre to On-Board Telematics System interface:**
  Three calls are supported:
  1. *Tracking*, where the vehicle transmits data gathered by various sensors;
  2. *Statistics*, where the vehicle transmits general own characteristics (e.g. height, weight, etc.);
  3. *Alarms*, where alarms from local node are transmitted to the control centre.

- **Decision Support System to Conflict Resolution Interface:**
  Interface to accept or decline the optimal route estimated by the DSS module.

- **Control Centre to On-Board PDA interface:**
  This interface is used to display navigation information, messages, alarms to the driver on his/her trip and handles all the interaction of the driver with the system for route and passage configuration.

- **OBU to Local Node interface:**
  This interface is used to interchange data between the OBU and the local node. For instance, data can contain information for the truck and its cargo.

- **Local Node to Web Portal interface:**
  The local node uploads the data collected from the vehicles using this interface. Also the configuration data for the enforcement policies can be downloaded using this interface.

- **GUI of the Control Centre (Web Portal):**
  Web front-end that interconnects operators, users and logistic support users with the *GOOD ROUTE* Control Centre system.

The integration of the system can be divided into two levels: a) the telecommunications level and b) the information level. The telecommunications level includes all the network devices and networking protocols required to physically interconnect and transfer the data between the different subsystems. At the information level, the protocol that is used to exchange meaningful information between the heterogeneous sub-systems that compose the integrated system is described. This protocol defines the data model, the messages, and the
parameters exchanged and, in combination with the communication protocols, provides a transparent interface between the different sub-systems and modules.

Three pilot sites were chosen to test, validate and demonstrate the system. These were the Finnish Road Enterprise/FINRE located at Finland between Turku and Helsinki, the Gotthard Road Tunnel/GST located at Switzerland and the Frejus/SITAF tunnel located at Bardonnechia in Italy. As aforementioned, the system consists of a number of distinct and autonomous core modules and sub-systems interconnected and integrated by a number of interfaces, in a manner that absorbs the network and operating systems heterogeneity. This architecture and integration strategy gives the flexibility to distribute the various sub-systems in distant places, without any degradation in system’s performance and quality of service.

The configuration that was used for the Pilot sites tests is as follows: the Web Portal was installed at PTV/Germany, the DSS at CERTH-ITI/Greece and the Conflict Resolution at TID/Spain. The main reason for the chosen configuration was that during the Pilots testing, technicians from each Partner site that had been responsible for the corresponding module, would have the opportunity to monitor, evaluate and optimize their modules performance at run-time.

The only sub-system that required special treatment in each Pilot site was the Local Node. Since the Local Node utilizes short range communications in order to exchange data with the vehicle demonstrator, it requires visual contact with the truck. So, before the start of testing at each Pilot site, the Local Node was transferred and placed in a proper location within truck’s route.

The Local Node needed to be positioned in a box of a cabin, containing the Local Node System, the DSRC module and the DSRC antenna. The Local Node communicated with the Control Centre with a GPRS or UMTS modem. The Local Node cabin needed also to be projected to be immune by any kind of bad weather that could compromise the communication or any hardware module.

It is obvious that this is a fairly complicated system which combines many different technologies in software, middleware and hardware level. The objective of the integration process was to absorb this heterogeneity and to transform it into a robust but also a flexible system.

Based on the defined system architecture, the methodology followed in order to accomplish this task was first to define TCP/IP as the communication network layer and then to develop a number of interfaces between the different modules.
based on web-services technology. This approach has the following main advantages:

- TCP/IP protocols hides the underlying communication network transmission technology which can be wired or wireless, local or remote.
- Web Services permits system modules to exchange data regardless of the operating system and hardware platform used.
- The system can be implemented as a distributed or a concentrated system as well according to the application needs with minimum costs and complexity.
- System’s modularity permits easy maintenance, administration and expandability.

4.3.6.3.2 Vehicle Integration

Within GOOD ROUTE, there was only one truck demonstrator developed, by IVECO, which, for the needs of the Pilots, travelled around Europe from one site to another. The tractor and trailer OBU functionalities have been described above (section 4.3.3).

The system architecture defined for the OBU took into account the feasibility aspects of the demonstrator integration. A concrete methodology for automotive systems integration does not exist and, as such, the procedures followed were mainly based on existing practices; therefore, the integration work held in this context can be summarised in the following steps:

- Design of cabling schemes for the connections of all the devices that have to be integrated;
- Preparation of required harnesses;
- Installation of harnesses and connecting devices in the vehicle;
- Conduct of electrical tests;
- Conduct of functional tests;
- Conduct of field validation tests (prior to the Pilots).

The first subsystem that was integrated was the tractor OBU, because it represents the focal node of the vehicle application. The DSRC system and the trailer emulator were developed autonomously and then integrated in the vehicle. The last system that was integrated was the navigation system; it is independent from the OBU and it needs only power supply by the vehicle, through a cable connected to the standard vehicle lighter interface.
The electrical validation activity was oriented to validate the harnesses designed and installed in the vehicle and then the system components electrical integration into the vehicle. All the electrical contacts were verified with a tester while the engine of the vehicle was off. The CAN messages availability has been verified with the engine on and the vehicle stopped. Different trials have been carried out with the vehicle in motion in paved roads and various driving conditions to check the solidity of the wiring and of the internal integration. All the connections proved to be robust.

The functional validation consisted primarily of separate validation of the main functionalities of the vehicle systems. Both the CAN bus and the vehicle CAN network were constantly monitored by means of dedicated tools to verify the right flow of messages between all the modules. This validation has been performed
with the engine on and the vehicle stopped. After having validated the single system components, the overall functionalities have been tested in a testing circuit while the vehicle was moving. In all the tests, the vehicle system functionalities were positively performed, although the DSRC device, used for the enforcement use case, seemed to be rather sensible to antennas positions.

After these validation tests, the conclusion was that the vehicle demonstrator fulfilled the system functionalities expected from the truck. The OBU, although being a prototype, operated correctly and the developed tool seemed to be quite robust.

More effort should be dedicated to analyze data acquired from the vehicle and from the trailer during real on road driving, in order to tailor algorithms more efficiently and with more precision. Another aspect that should be considered for the future is the integration with a vehicle to vehicle communication system, as for example the one of CVIS EU IP project (http://www.cvisproject.org/). Because the CVIS router box for wireless communication was still on testing (when system integration was taking place), it was not possible to be integrated in the system vehicle architecture.

The G truck demonstrator was used for the final trials with users (see section 4.4 below), in order to systemically validate the project concept and the target use cases in real life conditions. For this reason, the demonstrator travelled in the area around Turin, then to Switzerland and Frejus tunnel and finally to the Finnish highways.

4.4 Indicative Evaluation Results

4.4.1 Introduction

The integrated system was tested both regarding human factors assessment aspects (usability and user acceptance) as well as system performance aspects in three test sites, namely the Finnish Road Enterprise/FINRE (now called DESTIA) located at Finland between Turku and Helsinki, the Gotthard Road Tunnel/GST located at Switzerland and the Frejus/SITAF tunnel located at Bardonnechia in Italy.

The Pilots scope was mainly three-fold:

- To evaluate the system performance and assess its robustness across all use cases defined:
To evaluate the system usefulness and user acceptance on behalf of all above types of users;

- To provide a preliminary insight on the expected impacts of the system in terms of safety, transport operation efficiency and inherent costs and finally comfort and Quality of Life (QoL).

In order to serve the above scope, both technical validation and human factor assessment were conducted. In addition, upon the relevant results and also the post-trials analyses performed (Bekiaris, Gemou et al., 2009), an insight in the expected impacts of the system in safety and transport operation efficiency was also made feasible (see Chapter 5 respectively).

In more detail, the **Technical validation of the system** was enabled through Quality of Service questionnaires, event diaries and logging mechanisms. A logging mechanism was developed for each module, for the recording of the respective module performance during the Pilots, namely for the On-Board Unit, the navigation client, the Control Centre, the Decision Support System and the local node. The **Human Factor assessment** (in terms of usability and user acceptance aspects) of the system was enabled through specific questionnaires developed, which were namely an informed consent form, an entry form, a user acceptance and usability assessment questionnaire for drivers, operators, Police, emergency bodies, consignees and dispatchers (different for each actor participating in the Pilots). Finally, an indicative impact assessment was enabled through the data logged, through the data recorded in the Quality of Service questionnaires and the event diaries and upon the post Pilots analyses conducted afterwards (Bekiaris, Gemou et al., 2009).

In all cases, the tests were conducted with the IVECO truck demonstrator (Bianconi and Fioretti, 2008). Also, in all cases, the trailer was emulated and the cargo emulated was liquid. 50 users participated in total, consisting of all types of users involved in the (envisaged) transportation chain, representing the Dangerous Goods drivers, infrastructure operators, consignees, local enforcement authorities and emergency bodies and the dispatchers.

The system was evaluated across the three aforementioned aspects following a common, more or less, pattern (experimental plan) in all three sites established on the basis of the common evaluation framework and evaluation scenarios developed for this purpose (see section 4.4.2 respectively).

Trials were executed with and without the Decision Support System, which is the main element which served to distinguish the current (without the developed
system) situation and the envisaged future (with the developed system) situation. In the “without the system” case, the DSS was replaced by a conventional (and commercial) navigation system.

4.4.2 Evaluation Scenarios

In order to support the system case studies (as presented in section 4.2.3 of this issue), 9 real-life scenarios were formulated, in order to constitute the basis for the evaluation, as shortly described below:

**Evaluation Scenario 1: “Passport”:** The driver makes a request for the permission of passage from the tunnel before s/he starts his/her trip. In that case, the system confirms permission of passage, and upon his/her arrival in the tunnel, priority of passage is given to him/her.

**Evaluation Scenario 2: “Passport-Rerouting”:** This scenario is similar to the above, with the exemption that, in this case, the system provides a negative answer, due to exceeded load or due to infrastructure special restrictions, thus the driver is obliged to re-route. After key info provision, the system plans the “safest” route alternative and provides it to the user with a notification on estimated time of arrival at declared destination. As soon as the driver confirms re-routing proposal, all delivery points and his/her company are notified about the new expected time of arrival at declared destination(s).

**Evaluation Scenario 3: “Route Guidance 1”:** The user (driver or company) makes a request for route planning providing to the system all key info needed (i.e. intended destination, wished time of arrival, vehicle and cargo attributes, etc.). The system, taking into consideration real-time or historical traffic data and weather data and feasibility of passage through any interfering infrastructure (tunnel), provides the user with the “safest route” planning with a confirmation for passage through infrastructure (it has proceeded to automatic booking), if applicable.

**Evaluation Scenario 4: “Route Guidance 2”:** The driver is driving according to his/her initial route plans. At some moment, s/he realises that s/he is running out of fuel. Upon his/her request, the system estimates the “safest” route that will include the passage from the closest gas station. Upon driver’s confirmation, the system initiates the new route guidance and all involved actors are notified about the itinerary change and expected delay of the driver, if any.
Evaluation Scenario 5: “Environmental-related re-routing”: The driver is driving according to its initial route plans. At some time, the system is notified (by the Police or the TMC or other responsible local actor) about unexpected road works occurring along the intended route of the vehicle. The system notifies the driver of the occurring event and its position and re-routes according to the safest route. Upon driver’s confirmation on the new route provided, all involved actors in the logistics chain (mainly customers and company) are notified about new expected time of arrival at declared destination(s).

Evaluation Scenario 6: “Business-related re-routing”: The driver is driving according to its initial route plans. The transportation company of the driver makes a notification to the system about a need for re-routing, due to the necessity of including in the initial itinerary an intermediate site (customer), before s/he reaches final destination, providing also the coordinates of the site and the intended time of arrival there. The system calculates the safest route whilst, again, all involved actors in the logistics chain are notified on new expected time of arrival at destinations.

Evaluation Scenario 7: “Enforcement”: The driver is driving according to his/her initial route plans. The driver stops at the entrance of the infrastructure (for which it has not requested special passage beforehand) and waits to get approval for passage, according to the local rules and procedures. The vehicle does not get approval, due to exceeding amount of total load (according to the local regulations/restrictions of the infrastructure). The system provides an alarm to the enforcement actor for intervention, taking into consideration the values of key data (i.e. vehicle speed, vehicle and driver profile, type and amount of cargo, total weight per axle, etc.), compared to defined thresholds on local or regional (i.e. instantiated per infrastructure) level. The alarm is provided to a local or central checkpoint. The enforcement actor proceeds with intervention, which may include check of the vehicle, the driver or the cargo, change of route, issue of fine, etc. depending on the local rules and scheduled processes. All interested parties (company, gas stations) are notified on changed route plans, if this is the case and the system proceeds with re-routing if enforcement actor gives approval.

Evaluation Scenario 8: “Emergency 1”: The driver is driving through an infrastructure. At some moment, a cargo explosion is simulated, which is identified by the system (depending on the architecture, in semi-automatic cases, the driver may provide a notification to the system). The system provides all required info (i.e. vehicle position, type of cargo, type of accident/incident, etc.) to emergency/enforcement. The type of actor that will be informed depends on the local/regional regulations. On the other hand, in case the responsible actor that
has been provided with the alarm is not available for mitigation, then it (the actor) notifies the system for non-availability and the system redirects the alarm to the closest emergency unit and so on, until a response is achieved. The enforcement/emergency teams confirm receipt of alarm, key info notification and availability for mitigation and proceeds with the intervention, according to the local/regional policies and emergency/evacuation plans of the specific infrastructure. At the same time, a notification to all interested parties of the logistics team with regard to the accident is held.

**Evaluation Scenario 9: “Emergency 2”:** This is similar to the “Evaluation Scenario 8”, with the difference that at the moment of the explosion, the vehicle is driving along a highway, a bridge or a residential area.

### 4.4.3 Pilots Experimental Plan

The Pilots in each test site were executed upon one full trial round encompassing in reality 4 routes. All 4 routes were held with the same co-driver in each case. Thus, each co-driver participating in the each site Pilots realised 4 routes (with always the same IVECO driver). Log files and event diaries were kept for each of them. The drivers filled in the questionnaires (after the conduct of the trials).

The first route started first with the ‘Passport’ Scenario, continued with the ‘environmental re-routing’ scenario without the DSS, which was used as a reference point and closed with the ‘enforcement’ and the ‘emergency’ scenarios. The second route started also with the ‘Passport’, then continued with the ‘environmental re-routing’ but with the DSS and closed with the ‘enforcement’ and the ‘emergency’ scenarios. The third route followed the same sequence but with the ‘Route Guidance 2’ with the DSS and the fourth the same but with the ‘Business-related re-routing’ with the DSS. Each full trial round, encompassing the four aforementioned described routes lasted around 3-4 hours (although there have been noticed several variations in each site).

**Figure 4.15:** Example route followed in Pilots
4.4.4 Methodology Followed for the Analysis

As aforementioned, log files were gathered during the trials (with and without the system), which were then further processed, to allow the assessment of the overall performance of the system, as well as the performance of each participating system module. This enabled to compare the performance with and without the system.

In addition to the logging mechanism, in each Pilot, a Quality of Service (QoS) questionnaire was filled in by the Pilot supervisor, encompassing an overview of the system performance in each case, provided together with a summary form, reporting on the main conclusions and remarks made during the trials.

In the context of the Human Factors assessment, a series of questionnaires were developed addressing all types of users participating as aforementioned. Willingness to Have (WTH), Willingness to Pay (WTP), Human Machine Interface (HMI) and general system usability aspects were addressed in these questionnaires; spare questions and free comments were also added, in order to retrieve the users’ opinion about potential optimisation and expected impacts of the system. In addition, the John Brook (System Usability Scale (SUS)) (Brooke, 1996) and the Van der Laan, Heino and De Waard 9-item 5-point rating scales (Van der Laan, Heino and de Waard, 1997) have been used. The results from the latest have been evaluated in scores on the two scales, the “Usefulness” scale denoting potential use of the system, and the “Satisfying” scale reflecting pleasantness. Standard deviations have been also estimated in each case.

All subjective forms were filled in by each subject participating at the end of the evaluation with the supervision of the test conductor. Whenever needed, the test conductors helped with the interpretation of the questionnaires in the local language. Furthermore, the event diaries, in combination with the log files and the Quality of Service questionnaires, allowed the preliminary impact assessment conducted.

4.4.5 Technical Validation Results

The technical validation analysis conducted (for all three Pilots) focused on the following main points:

- What is the overall time required from the moment the driver/infrastructure/any actor requests for the calculation of a route,
until this route (either it is the original route guidance or outcome of a re-routing) is received by the driver (and confirmed), when using the system DSS and when using a conventional route guidance system?

- What is in specific the overall time that is required for the accomplishment of the communication between the Control Centre and the DSS/internal calculator (in the “without the system” case): meaning the overall time taken from the moment the request leaves the Control Centre, goes to the DSS, the DSS calculates the route, the calculated route leaves the DSS and the route is finally shown in the Control Centre?

- What is the overall communication time between the Local Node and the OBU and the communication time between the Local Node and the Control Centre, and, consequently, the overall time required for the accomplishment of the enforcement scenario (this is independent of the DSS existence)?

- What is the communication time taken from the moment a message is sent by the OBU to the Control Centre until the moment the OBU receives back the response from the Control Centre (independent of the DSS existence: useful to know for the enforcement functionality performance)?

Some indicative results from the Swiss Pilot site are provided in Table 4.3 and Table 4.4. Table 4.3 provides the mean values that emerged for the ‘Passport’ scenario, and the several Routing and Re-routing cases (Business, Environmental, Re-fuelling related re-routing). The first column provides the overall time required from the time the actor requests for a route (or re-routing) (on in the ‘Passport’ case, for passport) until the time the driver receives the route in the navigation client and confirms, when the system operates with the DSS. The second column shows the corresponding values, when the system operates without the DSS (the reference case without DSS is only in the first trial of each round, when the environmental re-routing was performed without DSS). Finally, the third column indicates the specific overall time taken from the time the request is sent by the Control Centre to the DSS until the time the route is shown in the Control Centre (Control Centre-DSS-Control Centre), including both the communication and processing time and the last column, the corresponding values, when the system does not work with DSS.

A peculiarity, however, is evident in Table 4.3. The overall time required for the accomplishment of the scenario with the DSS is less than with the conventional commercial system (in the re-routing cases). The most possible reason for that is that the conventional commercial s/w used needs to reload much more data each
case a request is being processed, in opposition to the DSS, which reloads in each case the specific map data of the region.

One should not forget that, besides the map data processed in each case, a commercial router needs to load many more features related to the configuration on behalf of the user, etc., which is not the case for the DSS router.

In addition, it should be reminded that in one full round (encompassing 4 different trials for each co-driver), the reference case (without DSS) was only one (the environmental re-routing in the first trial). This means that much fewer log files were made available for the reference case, than for all the other cases.

However, it is still significant that the difference in two cases is minor, and, that at least the DSS does not increase the time of the operation. In addition, it is evident that, in specific, the communication time between the Control Centre and the DSS server is negligible.

**Table 4.3: Mean values for operation times with and without DSS-Swiss Pilots**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overall time for scenario accomplishment (with DSS)</th>
<th>Overall time for scenario accomplishment (without DSS)</th>
<th>Control Centre-DSS-control centre</th>
<th>Control Centre internal request processing time (without DSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Passport”</td>
<td>1.22 sec.</td>
<td>NA</td>
<td>Automatic</td>
<td>Non applicable</td>
</tr>
<tr>
<td>“Routing-Re-routing”</td>
<td>1.98 sec.</td>
<td>12.7 sec.</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

Table 4.4 shows in the first column the communication time between the Local Node and the OBU, in the second column the communication time between the Local Node and the Control Centre and in the third column the overall time required for the accomplishment of the enforcement scenario. Always the mean values of all log files (from the Swiss test site) are shown. The types of violations emulated were temperature, cargo related and speed violations. It is evident from the above that the communication between both the Local Node and the OBU and the Local Node and the Control Centre is really quick.

Finally, the overall time taken from the moment the tracking messages were sent by the OBU to the Control Centre until the time the OBU received the response from the Control Centre, was about 3 sec., whereas for the alarm messages, the overall process took about 1.4 minutes (this refers to the emergency scenario),
where third parties needed to be notified. According to the remarks noted in the QoS questionnaire, the system seems to work fine, and when there was an adequate service level, the requests were processed and responded as expected. The system did not crash in any case.

To sum up, the Swiss Pilots were conducted with no major problems. However, the extreme weather conditions (November 2008) led to reduced quality in wireless service levels performance. All modules worked fine and their communication as well. Only once, the Client lost the connection due to bad wireless service level in a special sector of the track. It should be underlined however, that the system when it is being used in an area with a good GPRS/UMTS service level, is very stable. The DSRC communication between the Local Node and the OBU worked also fine.

\textit{Table 4.4}: Mean values for enforcement scenario-Swiss Pilots

<table>
<thead>
<tr>
<th></th>
<th>Communication time between LN and OBU</th>
<th>Communication time between LN and CC</th>
<th>Overall time for enforcement scenario accomplishment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.83 sec.</td>
<td>1.88 sec.</td>
<td>9.25 sec</td>
</tr>
</tbody>
</table>

\textbf{4.4.6 Human Factors Assessment Results}

As already mentioned, the user group that tested the system functions consisted of 50 users in total in all pilot sites. The user group consisted of Dangerous Goods Drivers, Control Centre Operators, Consignees, local Enforcement authorities, Emergency bodies and Dispatchers. In this section, indicative results are being provided (on human factor aspects) concerning only the Dangerous Goods drivers (Bekiaris, Gemou et al., 2009).

Figure 4.16 below presents some indicative results of the usability assessment of the system.

The rating scale used for the system usability assessment across several aspects extends from “-2” (strongly disagree) to “+2” (strongly agree). \textit{It should be noted that in the relevant questions of the questionnaires, “-2” and “+2” did not always correspond to the most positive and the most negative edge respectively (this is a usual practice in surveys for counterbalancing bias). Thus, in the context of the questionnaires, there are some answers that even though having a negative range, they have a positive meaning. For the sake of the analysis and the}
For example in the following figure, the question “The screen layout is confusing” has got an average mean rating equal to 1.27. This is a positive result and not a negative one. In addition to the mean ratings, standard deviations have been also estimated in each case to depict the reliability of the results. The main results corresponding to the Dangerous Goods (DG) drivers participating in the Pilots are briefly reflected in Figure 4.16.

As it can be seen in Figure 4.16, almost all aspects being interviewed were rated positively by the Dangerous Goods drivers. The most positively rated aspect seems to be that the users did understand the functionality of the system, whereas the only negative one, is that users were not exactly convinced of the usefulness of the system functions. However, one should not neglect that the standard deviations are rather big in some cases.

![System Usability Assessment](image)

**Figure 4.16:** System function usability assessment results (Scale -2, +2)-DG drivers.

In addition, the SUS scale was used, which consists of 10 questions and the rating extends from “-2” (strongly disagree) to “+2” (strongly agree). The results coming from the SUS scale strengthen the previous results. Lower scored items...
(i.e. confidence, need for technical help and previous experience with the system) are accompanied by big standard deviations; thus one should be rather cautious in interpreting that (see Figure 4.17). Comfort and integration aspects are positively rated, whereas drivers stated that would like to use the system frequently.

![Figure 4.17: System SUS scale results (Scale -2, +2)-DG drivers.](image)

In addition, overall user acceptance results have emerged via the use of the Van der Laan scale.

The rating scale for Van den Laan extends from “-2” (negative edge) to “+2” (positive edge) and the average scores on Usefulness and Satisfaction imply rather equally positive results for both main aspects, just above 0.50. The standard deviations for “Usefulness” and “Satisfaction” are 0.31 and 0.34, respectively, and support the findings emerged.

In addition to the above, all drivers stated that they would like to have the system. In order to install the system the drivers stated that they would be willing to pay from 500€ to 1500€ and for maintenance up to 75€, while 2 of them believed that the maintenance should be free of charge.

About improving the system most of the DG Drivers expressed their belief that the actual maps should be more detailed than those used in the trial case and some also think that a smart key could replace the several clicks needed for an action.
Main advantages of the system, according to the users, relate to safety, security and time aspects as well as to the potential given by the system to avoid traffic and possible accidents. Finally, some drivers, referred to the communication problems occurring in some cases during the Pilots.
5 System Impact Assessment Study: Indicative Results

5.1 General View

The integrated system being developed is expected to have major strategic impact in the area of Dangerous Goods transport, through:

- Meeting social demand for acceptable risk levels and safety maximization in the transportation of dangerous goods.
- The creation of a decision support and routing procedure commonly concerted by the very large and very small enterprises, taking into account equity schemes.
- The provision of real time and dynamic data to the dangerous goods logistic chain, thus maximizing the efficiency of transportation and reducing its cost.
- The establishment of a low-cost and high-reliability monitoring and enforcement system for dangerous goods vehicles.
- The establishment of pan-European cooperation in monitoring and controlling dangerous goods movements.
- The reduction of congestion and other problems due to dangerous goods vehicles by controlling their numbers and types at any given part of the network at any moment.
- The creation of a standardized ontological framework for dangerous goods classification, monitoring and control, that optimises the use of the network by such goods carrying vehicles, while always, protecting public safety.
- The application guidelines and training schemes developed in its context that will rationalize and optimize dangerous goods transportation.

The impact is expected to be significant, given that the problem of Dangerous Good’s safe transportation is not a local one, but one that goes beyond national boundaries and requires pan-European actions, since:

- Only through pan-European common ontologies can the movement and cargo of such vehicles be monitored and enforced.
- OEMs and sensor/telecom suppliers may provide viably the necessary solutions only within the range of the European Market.
As the PRESTIGE accident has shown, such catastrophes may happen at any moment, anywhere in Europe and pro-active action is required to guarantee citizens’ safety and security throughout Europe.

Finally, the close collaboration of OEMs, sensor/telecom providers and operators, Dangerous Goods companies, infrastructure operators and other key stakeholders from 6 EC countries, ranging from North (Finland), to Central (Germany, Switzerland) and South (Spain, Italy, Greece) guaranteed the pan-European dimension of the project.

The intentions of the GOOD ROUTE Consortium for further exploitation of the project results are reflected in the Exploitation and Business Plans of the Consortium (Gemou and Bekiaris, 2009).

5.2 Insight in System Expected Impacts

After the conduct of the Pilots, a short but revealing impact assessment was performed in the project (Bekiaris, Gemou et al., 2009; Landwehr, Krietsch et al., 2009). The basic interrelated impacts of the system are being reflected in the following figure.

This Chapter summarises the outcomes of the different assessment studies in terms of safety, transport operation efficiency (and inherent costs) and, involved actors comfort and Quality of Life.
**Figure 5.1:** Hierarchical decision tree for system Socioeconomic impacts.
5.2.1 Safety Impacts

Since it was not possible to objectively assess the system through the Pilot trials (obviously no accidents and injuries could be provoked), an indicative safety impact assessment has been performed on theoretical level, with the assistance of the DSS simulator (developed in addition to the real prototype) and the inherent risk assessment methodology applied.

The scenario of the assessment dealt with a BLEVE explosion occurring in a DG transport operation. The percentage (%) of fatalities, injuries as well as range of them around the spot of the accident have been used as entry points for the analysis.

In this case study, there were two route alternatives (for the same origin and destination): a short one through an urban centre of Thessaloniki and a longer one through inhabited suburb. For the safety risk assessment, the safety related consequences of accidents were quantified first of all in terms of provoked fatalities and then in terms of 1st and 2nd degree injuries.

According to the study, which was conducted on the basis of the minimum safety risk assessment methodology, the minimum safety risk route emerging would be in the day to go through the suburb and in the night through the city centre and would result in 82.8% reduction in fatalities (if the route was performed during the day), 92.3% reduction in 2nd degree injuries (if the route was performed during the day), 82.8% reduction in fatalities (if the route was performed during the day), 92.7% reduction in 1st degree injuries (if the route was performed during the day), 66.66% reduction in fatalities (if the route was performed during the night), 75% in 2nd degree injuries (if the route was performed during the night) and 70% in 1st degree injuries (if the route was performed during the night). It is evident from the above that the safety impact of the system can be enormous.

In addition to the above theoretical analysis, the technical validation of the system in the Pilots made evident that, besides, the positive safety impacts coming from the routing/re-routing functionalities of the system, the emergency functionality should be also not neglected. As test results have shown, emergency (with notification of all the corresponding actors
through the portal) is accomplished within 1.8 minutes (mean value of the respective test results), which means that in hardly 2 minutes, all emergency actors are notified of any accident/incident happening; the safety impacts are self-evident.

5.2.2 Impacts on Transport Operation Efficiency

5.2.2.1 Impacts on own Transport Operation

In the context of a socioeconomic analysis conducted (Landwehr, Krietsch et al., 2009), there were three alternative routes compared in terms of distance, travel time, cost and risk, namely the minimum cost route, the minimum risk route and the combined route minimising at the same time cost and risk.

Thus, for the sake of the study, the developed DSS simulator provided for the same transport request the following alternatives:

i) the minimum economic cost route,

ii) the minimum (safety) risk route or

iii) the minimum combined cost route.

The impact of each of the aforementioned routes had on the route length, the route duration, the overall economic cost and the overall risk of the route was examined.

In the table below, we can see the total distance, travel time, economic cost and risk for each of the three routes, as well as the deviation of those values when compared with the corresponding values of the first route (minimum economic cost route).

**Table 5.1: Total distance, travel time, economic cost and risk for three alternative routes**

<table>
<thead>
<tr>
<th></th>
<th>Minimum Cost</th>
<th>Minimum Risk</th>
<th>Deviation</th>
<th>Minimum Combined Cost</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>53.84</td>
<td>96.449</td>
<td>79.14%</td>
<td>57.07</td>
<td>6.01%</td>
</tr>
<tr>
<td>Travel Time</td>
<td>1:46:59</td>
<td>2:17:29</td>
<td>28.51%</td>
<td>1:52:32</td>
<td>5.19%</td>
</tr>
<tr>
<td>Cost</td>
<td>36.21</td>
<td>58.629746</td>
<td>61.91%</td>
<td>37.95</td>
<td>4.81%</td>
</tr>
<tr>
<td>Risk</td>
<td>49.02</td>
<td>10.061643</td>
<td>-79.48%</td>
<td>15.86</td>
<td>-67.65%</td>
</tr>
</tbody>
</table>

---

Minimum cost is expressed in km and cost in €. Risk is dimensionless (0-100 or 0-1 if normalised).
In the case of the minimum risk route, the overall distance and the total economic cost are greatly increased (79.14% and 61.91%), while the total risk is almost equally decreased (79.48%). The travel time is also increased (28.51%) but not so much as the aforementioned values. Thus, the minimum risk route achieves the minimisation of the risk with the price of an equally big increment of the cost.

In the case of the minimum combined cost route, however, we experience a similarly big reduction of the total risk (67.65) with only a slight increment of the overall distance (6.01%), travel time (5.19%) and economic cost (4.81).

Therefore, we conclude that the combined route, which minimises cost and risk in the best possible way in each case and which is the one that the system has been based upon, is the optimal one, when we take into account the overall risk as well as the business needs. It is also easier to be adopted by the interested parties than the more costly minimum risk route.

In addition to the above, another analysis was also conducted, in order to assess the impacts when a DG vehicle is not allowed to pass through a restricted tunnel, while those restrictions wouldn’t apply to a similar DG vehicle that makes use of the system (passport functionality).

As has been aforementioned, nowadays, most DGV’s are not allowed to pass through sensitive parts of the infrastructure, such as tunnels and bridges. In those cases, they are forced to follow big deviations, greatly increasing the cost of route, pollution and maybe even the overall risk. The system adoption allows the passage of equipped vehicles through special infrastructures. These two cases have been compared in terms of the total distance, travel time, economic cost and risk of each of the two alternative routes.

In the study example, two DGVs carrying ammonia start their journey at the same time. The first one does not use the system, while the second does. The equipped DGV is allowed to pass through the Gotthard Tunnel (test site of GOOD ROUTE used as a case study here), while the other one is not.
The minimum cost route of the non-equipped DGV was compared to the minimum combined cost route of the equipped DGV. Due to the area being underpopulated, the two routes differed only in the restricted tunnel, which is part of the latter only, while the former follows a deviation around it.

In the table below, we can see the total distance, travel time, economic cost and risk of each of the two routes, as well as the deviation of those values when compared with the corresponding values of the first route (minimum combined cost route of the equipped DGV).

\textbf{Table 5.2: Total distance, travel time, economic cost and risk for equipped and non-equipped DGV (allowed/not allowed to pass through the infrastructure)}

<table>
<thead>
<tr>
<th></th>
<th>Equipped DGV</th>
<th>Non-equipped DGV</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>44.28</td>
<td>56.94</td>
<td>28.58%</td>
</tr>
<tr>
<td>Travel Time</td>
<td>0:50:58</td>
<td>1:24:29</td>
<td>65.76%</td>
</tr>
<tr>
<td>Cost</td>
<td>26.39</td>
<td>37.13</td>
<td>40.64%</td>
</tr>
<tr>
<td>Risk</td>
<td>0.21</td>
<td>0.62</td>
<td>189.49%</td>
</tr>
</tbody>
</table>

It is obvious that the deviation which the non-equipped DGV is forced to follow has a very negative impact to all the observed values. The distance increases by 28.58%, the travel time by 65.76%, the total economic cost by 40.64% and the total risk by 189.49%. From the above, we conclude that the use of the system cannot only reduce the overall risk, but the total economic cost as well, when sensitive parts of the infrastructure are concerned.

Finally, according to the socioeconomic study held (Landwehr, Krietsch et al., 2009), on one hand, the system itself takes a minimum investment of 2.66 Mio. € for one year operation in one site. Within a time horizon of five years, the system costs reach a total of +27 Mio. € for one site. The main reason for this economic fact is the massive investment and operational cost related to the OBUs of the DG vehicle fleet, which can be hardly justified for a single infrastructure object (one site).

\footnote{Minimum cost is expressed in km and cost in €. Risk is dimensionless (0-100 or 0-1 if normalized; here normalised).}
Thus, although even one site can be theoretically operated with overall benefits under certain assumptions, nevertheless, it is recommended, for both economic and safety reasons, that the system is being introduced for all/most critical infrastructures in a region (at least two sites).

Finally, as made evident from the analysis of the technical validation, the system does not create any additional delays in the transport pre-trip and on-trip phases. The operation time between the Control Centre and the DSS, which encompasses both the communication time and the processing time of the DSS and the Control Centre is negligible, while the DSS does not also seem to affect at all the overall time required for the accomplishment of the routing/re-routing scenarios (in comparison to the existing route guidance systems), although one should take into consideration the fact that the DSS is still a prototype, which by default does not incorporate all those, frequently “heavy” features, that a commercial product does.

As also shown from the Pilots, efficient enforcement is also enabled through the system. Nowadays, several dangerous goods vehicles pass through a toll station of a highway, soon after which a long bridge or tunnel starts. The vehicles either pass through the bridge/tunnel or are sent by a RO-RO ferry to the other side, loosing far too much time. If the police decides to make checks, it needs to stop all heavy trucks, to check their speed (through the speedometer on-board) and pass them through a specific infrastructure to measure the load per axle. It should also check the type of load carried, etc. The overall check time per vehicle is 10-30 minutes, while the expected rate of rules violation is roughly 7-10%. The technical validation results showed that for the accomplishment of the enforcement task (where both the driver and the respective enforcement units are being notified) less than 1.5 minutes are required (mean value according to the test results) for all vehicles in the area. This reveals the great economic, traffic efficiency but also safety impact the system enforcement could bring about. Time delays related to enforcement are minimised, automation inevitably prevents from unnoticed violations, which could result in great safety risks, whereas the enforcement personnel effort is minimised.
5.2.2.2 Impacts on Other Road Users

In addition to the above work, the impact of the Dangerous Goods Vehicles traffic on other road users was also investigated, through another impact assessment study.

The minimum risk methodology gave as a result the DGV paths that minimize the environmental and human risks, without taking into consideration the traffic conditions of the network and the problems that this volume may add. The road users’ impact analysis added the parameter of traffic volume restrains in the above methodology. To succeed that, the network and its conditions were simulated and running the traffic assignment procedure, different minimum time paths were resulted.

These paths were compared with the minimum risk ones and data such as the volumes of the network, while the travel time and the v/c were also analyzed. Furthermore a conflict resolution methodology was simulated giving optimized paths for the DGV volumes. In depth analysis of the above results was developed. The main results from the analysis are the following (Kauber, Emmanouilidis et al., 2009):

- The routing of DGV based on shortest time & distance paths and traffic conditions gives longer distance paths but utilises higher capacity and free capacity links of the network.
- The minimum risk routing methodology results to paths that utilise congested links (minor free capacity) of high hierarchy since the avoidance of dense population areas is dominant criterion for route selection.
- Negative impact to the traffic conditions in the links involved to the minimum risk route and therefore negative impact to the other users of the road network.
- Reduction of vehicle kms for the examined area (by 33%).
- Reduction of average speed for auto vehicles (by 14%).
- Increase of V/C ratio for the specific utilized links (by 24%).
- The conflict resolution approach seems to result to better traffic conditions for the DGV and the other users of the network and decreases negative impacts.
- A more in depth analysis in the way that the heavy vehicle volumes should be assigned in the network must be implemented according to the methodology followed. The final methodology should take into account the safety parameters but also the network conditions, the capacity of the roads, the
equable assigned of the volume and the minor extension of the travel time.

5.2.3 Impacts on Comfort and Quality of Life

Besides the aforementioned estimated impacts, one should not neglect the impact the system would have in terms of comfort and general Quality of Life (QoL) of all involved actors.

The results coming from the Human Factors assessment make evident that according to all actors, the system, besides safety and transport operation efficiency enhancement, is envisaged to enhance the daily routines of all involved actors (drivers, operators, emergency/enforcement bodies, consignees, dispatchers), and despite the fact that in some cases, some of them might found it complex, not intuitive enough, etc., the overall usefulness and satisfaction of the system is always positive for all types of actors.

As can be seen in the following figure, besides the fact that the system adoption in daily routines has been considered time consuming, safety, reliability and cost-effectiveness aspects are always rated positively, whereas with the exemption of the operators, the system is considered by all actors to enhance a lot the controllability of the transport operation.
Figure 5.2: Overview of system envisaged impacts according to Pilot participants interviewed.
6 System Deployment

6.1 Comparison with State of the Art

Before we present the anticipated deployment of the system, it is beneficial to summarise the relation of the prototype integrated system (presented in Chapter 4) to the overall market context that is being placed within.

Starting from the needs and system requirements phase, and in order to define the most representative Use Cases for the intended system together with the associated parameters/restrictions, a series of accident data sources which deal with the DG transportation in national, European and International level (i.e. FARS, MHIDAS, BP, GUNDI databases, INFORMED LdV project reported studies, etc.) has been taken into consideration. It has managed to re-classify the available data in a way that enabled the identification of those conditional parameters that are considered significant for the envisaged system implementation and evaluation, creating in this way a knowledge database around accidents and relevant information for the accidents and the status of traffic safety in the DG haulage sector. In addition, through the surveys and the workshops that were realised, it was made feasible to go one step further and detect the specific needs of all actors involved in the DG transportation chain, with regard to systems like the one being developed. The Use Cases identified is the most significant outcome of this work and can be used as a reference for other systems and for further research.

On the other hand, existing classification systems that support the current transportation schemes all around Europe, most of them ADR-based, but applied in a very specific way (according to local infrastructures and regulations requirements), have been investigated. The ontology developed (Bekiaris and Gemou, 2006) is considered to be the first most innovative outcome of the project, since there is no relevant ontology known, which addresses the special conditions existing in DG transportation and has classified a series of info about the driver, the cargo, the company, the environmental conditions, the vehicle and the logistic chain, so that the needs of all interested actors (i.e. infrastructure, drivers, customers, companies, etc.) are being addressed. Its main benefits lie in the fact that the ontology is open, easily interfaced and also amenable to further enrichment and editing.
Furthermore, the Route Guidance System and its embedded DSS is the first and only (so far) system that optimises routing by taking into account the risk associated with the road transport of dangerous goods in addition to the usual economic factors, such as time, distance and/or fuel consumed. Systems relevant to this can be separated into two broad categories, with no significant overlap between them. The first category encompasses systems dealing with Quantitative Risk Assessment whereas as the second deals with Vehicle Route Guidance and Optimization.

Quantitative Risk Assessment tools are based on a set of procedures, aimed at the quantitative assessment of the risks connected with processing, storage and transportation of dangerous substances in industrial areas. The risk quantification procedure is developed through the evaluation, for all risk sources, of the accidents occurrence frequency and of the magnitude of casualties caused by such events. Such tools include integrated modules for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. The main objective of all Quantitative Risk Assessment Systems is the location planning of industrial installations and/or of static transportation routes, by taking into account economic and societal factors (e.g. safety).

On the other hand, Vehicle Route Guidance and Optimization is a quickly expanding field that uses the latest advances in telematics and computing to combine real time location information with detailed knowledge of terrains, in order to provide detailed routing instructions to vehicles on the road. All commercial fleet management systems offer a core of common features, such as:

- Multiple commodity, multiple vehicle routing optimization, that takes into account delivery time windows. Parameters optimized are of a financial nature, such as fuel cost or time, distance, etc.
- Integration with enterprise logistics systems.
- Wireless, real time (satellite and mobile carrier based) monitoring, and control of vehicles to various extents.
- Real time re-routing capabilities in the case of unforeseen events or changes in business requirements.
- Logging of vehicle status.
- Advanced systems, that offer a “hazmat” routing option, that takes into account relevant accessibility regulations and restrictions for the different classes of transported goods when doing routing optimization.
From the analysis of available offerings in both sectors, it has been made clear that existing Quantitative Risk Assessment tools do not include facilities for dynamic vehicle routing, whereas Route Guidance systems do not take into account transport risk related factors.

The DSS is a system that integrates and builds on the most recent research efforts, combining methodologies from the area of Quantitative Risk Assessment and Vehicle Routing Optimization under real time conditions and local information. Even though other existing systems overlap with particular areas covered by this system and most of the relevant technologies and know-how deployed are available, the integrated functionality offered by this system DSS is truly unique and novel. The following table presents a comparison of the characteristics of our system DSS in relation to other existing systems.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>GoodRoute DSS</th>
<th>Quantitative Risk Analysis Tools</th>
<th>Route Guidance Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS back-end</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Quantitative Risk Assessment</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Evaluation of Risk measures (Individual &amp; societal risks, F/N curves etc.)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vehicle Routing Optimization</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Minimum Risk Routing</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of real time traffic data</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Use of local road characteristics</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Use of local weather statistical</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Use of real time weather data</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consideration of broader needs of society</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Even though there are significant challenges to be met before the system can be implemented to its fullest extent, significant gains can be expected from even an incomplete initial realisation, thereby making the existence of a critical market mass for profitable implementation unnecessary. Challenges to overcome relate mostly to the lack of detailed data from which accurate Quantitative Risk Assessment calculations can be made. However, even when using data with low time and space granularity, useful decisions can be made with regard to the routing of DGVs. Another significant challenge, that is being currently overcome, is the necessity of performing the numerically very intensive calculations, related to the calculation of transport risks over an entire road network in real or almost real time.
Considering the given total lack of commercial systems similar to this one, in combination with the vigorous research interest apparent in the recent literature and the obvious benefits to society, it becomes clear that there should be significant commercialization opportunities for the developed system DSS and Route Guidance system. However, much concerted work remains to be done in terms of building the necessary information infrastructure, by the private as well as by the public sector, for sustainable real world implementation. The effort is certainly worthwhile, given the opportunities involved.

Another important module developed and is part of its integrated configuration is the one dedicated to enforcement. Studies performed in the EU Member States showed that good enforcement practices could avoid many road fatalities resulting from speeding, not wearing seat belts or driving while intoxicated; moreover non compliance with rules relating to professional road transport activities, such as driving and resting times or weight and dimensions, for trucks and buses, is an important cause of fatal accidents. According to the Directive 2006/22/EC on social legislation relating to “Road transport activities”, the introduction of digital tachographs (DTCO) has become mandatory in all EU Member States commercial vehicles. The Directive defines checks to be undertaken, resting times and the proper operation of the tachograph and associated equipment. Some constraints have been introduced on storage duty of diagram charts in the vehicle, manual recordings and printout and their safekeeping period has been prolonged. Drivers, on request, must be able to present diagram charts, manual recordings and printouts for the current week plus the preceding 15 days.

Our case study refers in particular to vehicles transporting goods that, in case of accident, are dangerous for the environment and people’s health. The enforcement module developed is connected to DTCO and anticipates the capability to transmit through wireless communication links driver and vehicle information to control centres and infrastructure nodes.

6.2 Position in the Competitive Market

The success of system penetration is dependent on two market factors, namely overall growth of the relevant market segments and technological trends/evolution that may favour the uptake of the relevant services provided.

The main market segments that are relevant are namely the personal navigations systems market and the fleet management systems/services sectors.
This section presents in short how the integrated solution is placed within these market segments in order to delineate the context within which different implementation scenarios (presented in a following section) will be applied.

6.2.1 Mobile Data Services and the Personal Navigation Market

The most promising trend is the envisaged increase in the usage of mobile data services and their future role in the business planning of the MNOs (Mobile Network Operators).

![Figure 6.1: Voice and Data APRU Trends 2009-2014](source)

In this framework, the mobile market requires attractive services, such as the ones proposed herein.

Main ingredients of growth for mobile services are: a) Colour display terminals with user friendly icon based menus, b) Increased access speed with GPRS/UMTS, and c) Diversity and growth in available content services.

The faster and broadband networks especially, expect to further stimulate usage of data services, specifically those including multi-media objects, such as maps. 3G / UMTS is already a commercial reality, with more than 33 million

3G / UMTS uses globally harmonised spectrum and builds on economies of scale of global GSM market (>1.3 billion customers). IEEE technologies, such as WiFi & WiMAX, present a valuable complement to operators’ pure cellular portfolios. Spectrum is the most critical resource in wireless communication, worldwide roaming and economies of scale demand harmonization. The development of common wireless platforms, able to facilitate interchangeably various communication networks, will further enhance the possibilities of interoperable indoor-outdoor-in-vehicle applications, such as the system discussed herein. For example, UMTS - WiFi handover is still under development, but will be a potential starting point for further expansion of 3G services.

While mobile services on mobile handsets seem to have the necessary market boost, in-vehicle connectivity and applications are slowly reaching maturity, but are still not a huge success. Berg Insight, in a market research paper of 2005, identifies low number of equipped cars and low numbers of cars with GPRS connectivity; biggest problem for consumers’ adoption is “Lack of awareness by consumers of the services offered” (Berg Insight, 2005).

Another important characteristic of the system services is their location-based nature. Mobile location services have not taken off as rapidly as many observers expected a few years ago. Total LBS service revenue in the EU 27+2 was €214 million in 2008 and Berg Insight forecasts LBS revenues to grow to about €580 million in 2014. Including location-based tariffs for data and voice calls, total revenues are estimated to exceed €1.430 million.
Figure 6.2: LBS revenue forecast (2008-2014)

Source: Enterprise Mobility Experts, Location Based Services Market and Trend Analysis, 2011

Figure 6.3: Location Based Service Revenue by region 2005 and 2010

Source: Enterprise Mobility Experts, Location Based Services Market and Trend Analysis, 2011
There are some clear operator trends today in Europe, that are very positive for LBS, such as:

- Growing competition among the operators on more mature markets.
- e-launch campaigns of LBS.
- Increasing interest in high accuracy technologies.
- Position wholesale on a larger scale.
- Emergency call implementation within EU. There are still possibilities for mandates, pushing the operators to invest in location-based services.
- New handsets offer new possibilities. More attractive LBS, thanks to larger storage memory, colour screens, Java, megapixel cameras and MMS.

There are several important drivers identified, which will bring about a mass market breakthrough for LBS at long last. These include increasingly user friendly handsets, accelerated implementation of high accuracy, high performance positioning technology and an increasing emphasis among operators on data services, to compensate for lower voice revenues. E112 directives from the EU have driven to the quicker implementation of high accuracy positioning technology among mobile operators in Europe.

Once the European LBS market takes off, the key market segments will be navigation, tracking and location-enhanced instant messaging. According to a market study, undertaken by Ericsson Consumer and Enterprise Lab, potential users ranked location-based services supporting cost control, safety and navigation as the most interesting.
Premium LBS applications such as in **car navigation** will contribute a significant 36% share of total LBS revenues by 2013. In total maps, routing, car and pedestrian navigation solutions will generate just over $3 billion by the end of this period. In specific, in year 2011, navigation ranked first as the most profitable service (Enterprise Mobility Experts, 2011).

According to Berg Insight’s new report (November 2010), “Personal Navigation Devices – 4th Edition”: “There are now over 200 million turn-by-turn navigation systems in use worldwide, including about 40 million factory installed and aftermarket in-dash navigation systems, more than 120 million Personal Navigation Devices (PNDs) and an estimated 44 million navigation-enabled mobile phones”.

PNDs are still dominating the personal navigation market, especially in Europe and North America, but more and more handset owners are discovering navigation software and services for mobile phones. Shipments in Europe declined to about 15.5 million units in 2009 while shipments in North America increased to 18 million units. In the rest of the world, shipments grew by one million to an estimated 6.5 million units in 2009.

Especially in Europe and North America, the PND as a device category is facing increasing competition from handset-based navigation services and greater...
availability of low cost in-dash car navigation systems. Berg Insight estimates that PND shipments in Europe and North America have peaked and will gradually decline to about 10 and 14 million units annually respectively in 2015. Worldwide shipments of PNDs are forecasted to peak at around 42 million devices annually in 2011-2012 and gradually decline to 34 million units in 2015.

The operators in Europe are now launching off-board navigation on a broad scale, hoping that this will be a successful service, driving new traffic in their networks. Berg Insight estimates that smartphone navigation will ultimately become the largest of the three segments.

There are today many players in the market place and portable navigation suppliers are finding it more difficult to differentiate their products. Advanced features, such as traffic information services (both RDS-TMC and GPRS based) are now becoming standard, across all forms of portable navigation. Another interesting trend is the move away from simple, dedicated PND systems, towards multi-function devices, with hands-free kit and MP3 player features.

At the moment, off-board navigation is way behind more traditional on-board solutions. However, off-board navigation is gaining a significant market share in the area of smartphone navigation solutions.

Currently, LBS is mostly based on Cell-id positioning, however other options seem more appealing. According to Berg Insight (2008) the majority of those asked regarding which positioning technology they think will be the most important the coming years, 65%, replied a combination of two or more technologies, while 35 percent said A-GPS. It is obvious that satellite positioning is a coming preferred technology among operators in Europe and preferably in combination with other technologies, such as enhanced-cell id and terminal-based positioning technologies.

The last question asked to the operators in the same survey was: what are the most important factors to get the LBS market to boom. Built in GPS/Galileo-chips was the most common reply, coming from 75% of the respondents. About 50% replied that more visibility and marketing of LBS is important, to make the end-users aware of the services. The operators are also looking for more innovative LBS, that can really catch the needs of the end-users, which was answered by 35% of the respondents.

Sales of GPS-enabled GSM/WCDMA handsets grew to an estimated 150 million units in 2009, up from 78 million devices in 2008 (Berg Insight, GPS AND
MOBILE HANDSETS). Berg Insight forecasts that shipments of GPS-enabled GSM/WCDMA/LTE handsets will grow to 770 million units in 2014, representing an attach rate of 55%. Including handsets based on other air interface standards such as CDMA and TD-SCDMA, GPS-enabled handsets sales are estimated to reach about 960 million, or 60% of total handset shipments in 2014.

An overview of the personal navigation systems value chain is shown in the following figure. As shown below, the personal navigation value chain is comprised of three principal categories of players (Figure 6.5). These are map data providers, navigation solution providers and device manufacturers. In many cases, dynamic content providers and mobile operators are also involved. Digital map data for the personal navigation market are today available from two dominant players.

Navigation software is available from numerous providers, developing products for several hardware platforms. Some software providers develop software for all platforms and operating systems, both on-board and off-board systems. However, only a few players design and manufacture PNDs, as well as develop navigation software in-house. Most PND providers outsource the hardware manufacturing and navigation software development and focus on providing competitively priced and customised bundles to end users.

Off-board solution providers offer their client applications either directly to end users, for download via the internet, or as white label solutions for network operators.

Network operators can choose to provide off-board navigation solutions by licensing software platforms or by relying on complete hosted solutions.

End users can get access to dynamic content, using RDS-TMC receivers or via GPRS. In off-board solutions the dynamic content is usually integrated on the server side and sent together with the map data to the end user’s navigation device, using a wireless network.
In that sense, there is potential for the effective promotion and adoption of the “Minimum Risk Guidance System”, which constitutes one of the core products of the integrated system.

The key advantage of the module is that it will be based on existing platforms and technologies, providing though the “safest route” option, which is an innovation in transport navigation and, in this way, the already established navigation market can be targeted without any technical or other barriers.

It will thus be possible to seamlessly exchange navigation relevant data between the mobile client, based on JAVA/OSGi, and the back-end platform, based on JAVA and SOAP Web services. Always under the condition of feasibility, the user will have the option to plan and calculate a route on the back-end system and navigate with it on the mobile device. Routes calculated on the mobile device will be usable in the back-end system. The mobile navigation will run on several navigation clients (tablet PC’s, PDAs and PDA-like smartphones), selected upon
certain requirements regarding processing power. Depending on the available device, UMTS may be used for data transfer instead of GPRS.

In addition, the Decision Support System (DSS) and the Conflict Resolution (CR) module provide the central functionality of the integrated system. In particular, both systems are integral to the Minimum Risk Guidance Module described above, so everything concerning the exploitation of that module also applies to the DSS and the CR module.

However, these modules are architected to stand on their own, as independent units, and as such can be made available to other on- and off-board route guidance system manufacturers as well.

Concerning the DSS, a stand-alone version or fall-back option provision, that would not rely on a back-end system, control centre or conflict resolution scheme, could be developed and marketed as an option, targeting an even wider DGV operator market segment. Such a system would use ADR-class dependent risk maps, that would provide pre-calculated and normalized (with respect to quantity of material transported) risk contours (similar to elevation contours), that the routing system would utilise, in order to calculate optimal routes with respect to risks and transport costs. Such a system could be developed irrespective of any (obviously more accurate) Control Centre-based system and can be useful in areas where no such control systems exist.

The Conflict Resolution system, on the other hand, would, under normal circumstances, be accompanied by the DSS, however it can also be exploited independently of it, assuming another provider of candidate routes is available. Therefore, the conflict resolution services provided by it can also apply to situations where a variety of possibly conflicting routes are available, besides minimum risk ones. As such, it may be of interest to infrastructure Control Centres in the more general sense.

On the other hand, the “Data Fusion and Integration Module” is located in the back-end system of the service platform. The module will be linked by SOAP Web services to other servers within the system, in order to be able to aggregate data from various distributed sources.

In addition, the module will have a data exchange link (probably also SOAP) to the hybrid navigation application described earlier. The task of the data fusion module is to aggregate relevant information from different sources and combine it to new information, that is valuable for the actors in the value chain. This
could be for example the combination of traffic information with weather
information/road conditions or the combination of remaining travel time with
pre-defined time slots, introduced by Traffic Management Centres. Through
SOAP interfaces and the navigation application this information is also available
to third parties. In this case, around 10,000 end-users are targeted.

Finally, the Logistics module may be considered as the communication tool of the
user-client with the operator of the system and will provide information on the
routing (minimum risk path) and notification on the approval of passage for the
critical infrastructure segments. This module would be primarily interconnected
with the Control Centre, the DSS and the Conflict Resolution Module; therefore
could be deployed in a single package configuration.

However, when considering individually this component of the system, this will
also have a significant usability and market penetration, if considered as a
routing tool (even if concerning the minimum risk route) for the companies that
do not have routing systems and organize their routing on a planning level
manually and empirically.

6.2.2 The Fleet Management and Automotive Market

The system being developed is intended to be as a whole an advanced (integrated
and cooperative) fleet management service. Fleet management services enable
the management, tracking, maintenance and accounting of vehicles and fleets of
all sizes, from transport and vehicle management to driver support services, in
order to support customer in the day-to-day running of their core business.

Advantages are in costs reduction for routine activities; better service and more
customer satisfaction, delivering on time and keeping customer appointments
much better; improved planning following each status change for vehicle, order
or driver; better overview, for example vehicle positions; complete clarity of
transport services; and so on.

The relevant market growth seems to work for the benefit of fleet management
services, since the number of vehicle registrations in key target groups is
increasing in most of the cases. However, in parallel, the transportation industry
operates at very low margins, which makes cost savings opportunities a must.

The increased market activity is considered capable of creating the need of
emerging integrated telematic solutions. At the same time, the rapidly
increasing competition and emerging opportunities in the Eastern Europe forces the establishment of enhanced logistic management.

In parallel, the truck size is increasing, creating the need for more and more accuracy and efficiency in guidance. Integrated systems, that will improve and will provide integrated services for trucks monitoring and guidance, seem to be a necessity for public safety and industry as well (see Figure 6.6).
data obtained from receivers and sensors. Key market participants in this category include AMD, IBM, Intel and Motorola.

- **System Suppliers** provide complete or part finished systems that are manufactured using component parts. Key market participants in this category include Alpine, Aplicom, Datafactory and Gedas.

- **Firmware** (Software Platform) provide operating platforms or firmware for hardware that allow components within a telematics system to communicate with each other for functioning as a complete unit. Key market participants in this category include IBM, Microsoft and Sun Microsystems.

- **Services** (inc. Airtime) companies provide services and airtime for telematics systems. This includes both service centres and web based service providers. Key market participants in this category include Cybit, O2, Sateltrack and Vodafone.

- **System Integrators** integrate complete telematics systems ready for both pre-delivery and retrofit. Key market participants in this category include Actia, DynaFleet, FleetBoard and Infotronics.

An overview of the OEM market for commercial vehicles is shown in the following figure.
### Table 6.2: OEM market for commercial vehicles

*Source: Bekiaris et al, 2006*

<table>
<thead>
<tr>
<th>Functionality / Competitor</th>
<th>Dynafleet (VOLVO Trucks)</th>
<th>Infom@x Web (Renault Trucks)</th>
<th>MAN-ERF Telematics (MAN)</th>
<th>Fleetboard (Daimler/Chrysler)</th>
<th>SCANA Fleet Management (Scania)</th>
<th>DAF telematics (DAF)</th>
<th>Blue &amp; ME Fleet (IVECO)</th>
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<td>Messaging</td>
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<td>Maintenance plan management</td>
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<td>Mission / order management</td>
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<td>Operating driver management (Reporting)</td>
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<td>Vehicle data analysis and reporting</td>
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<td>Escalenting</td>
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<td>Fleet maintenance plan management (Analysis of operating data)</td>
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<td>Freight data analysis and reporting</td>
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<td>Insurance service based on vehicle use</td>
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<td>Telediagnosis (Analysis of DTCs)</td>
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The current vision, according to key stakeholders, is to create a portfolio of content that serves both management and the truck driver—moving from static to dynamic content over time and creating a location-based trucking system. The operating efficiency will be improved (cost will be reduced), together with the customer satisfaction (delivery will be achieved in time), while driving will be safer and more comfortable.

It is important to highlight that some trends coming from a comparative analysis of competitors’ offer show a rising role for services affecting key issues like security, safety, reliability and regulatory compliance. They include:

- Over the air software maintenance (Volvo and Mercedes);
- Telediagnosis (Mercedes);
- Use of smart cards for driver identification (Mercedes, Renault);
• Management of driving time (Scania, Renault);
• Integration of PDAs for a more flexible mission management (Mercedes).

Services within the red area in Table 6.2 will be, of course, a part of the telematic platforms in the next future. The capability to offer these services could be the key that will keep a company one step ahead of its competitors.

Whether or not consumers are willing to pay initial or ongoing fees for GOOD-ROUTE-like services, vehicle manufacturers still need to consider the following issues:

• Cost of hardware ~ A Telematics Control Unit of the future will typically cost upward of €100.
• Cost of communications ~ Vehicle manufacturers must consider the ongoing costs of sending data over a GSM/GPRS network.
• Cost of infrastructure ~ Once being sent, the cost of the infrastructure required to process, store and re-route the data can be extremely high.

One opportunity for vehicle manufacturers to cover part of the costs could be the European Commission’s target of fitting E-call systems into new cars by 2015. This could potentially cover the initial cost of fitting communication hardware in each vehicle.

Next to that, vehicle manufacturers have a careful relationship with their dealerships and are generally unable to force dealers to adopt particular services. The difficulty for vehicle manufacturers will be in convincing dealerships to invest in new in-dealer infrastructure, required to support remote diagnostic applications.

Dealerships may see such services as a threat to their independence and revenues. Therefore, vehicle manufacturers must find non-intrusive methods of linking them in order to attract a high proportion of dealers.

**From the above synopsis, it is evident that the market is mature enough to host applications like the ones being developed and presented here.**

**Furthermore, accident statistics (see Chapter 2), according to which, trucks are involved in a high percentage of accidents (55% of total accidents according to GES, 52% according to FARS, etc.), make evident that, from the users’ needs**
perspective, there is an emerging need for the prompt adoption in the market of services similar to the ones developed and presented herein.

6.3 Value Chain

The market survey conducted (Bekiaris, Gemou et al., 2006) has assisted to identify the competitive reference market for the developed solutions and has constituted the basis for their business and exploitation plans.

The system value chain, that has constituted the basis for the exploitation approach to be followed for the products of the project, is shown in the following picture. The “Service chain” and the “System development chain” are distinguished, whereas the nature of the depicted interactions throughout the value chain are being characterised either as (Business to Business) B2B or as B2C (Business to Customer) relations.

The data needed (traffic info, etc.) are provided by the TMC’s (incorporated or linked to the Pilot sites in the following diagram), and are used to feed the system modules and services. The system services are linked to allied services (e.g. police, etc.) and in their integrated form, they constitute part of the final application, which is incorporated partially in DG vehicles fleets and in TMC’s, whereas the main end-customer of that are the DG transportation companies (e.g. BP). Besides the services, the s/w and system modules constitute the “system part” and are also integrated in the final application, to support the services finally provided.

Each identified exploitable product is related to a respective role, defined in the value chain of the following figure. All identified exploitable products are considered as main products, meaning that all of them are products that are needed for the overall system’s deployment, and should be considered as “core” in the marketing approach.

As shown below, the individual products can be s/w, h/w or services. Finally, the integrated final Product will be a combination of software license set up and services.
6.4 System Implementation Scenarios

6.4.1 Application Scenarios

The following application scenarios constitute the basic real-life case studies of the system embedding its core functionalities (minimum risk route planning, guidance, monitoring, re-routing, incidents notification, priority passage and enforcement/emergency) (Landwehr, Krietsch et al., 2009).

There are three application scenarios analysed below, aiming to clarify basic operational conditions and modalities of the system:

- **Application Scenario 1**: Minimum Risk Routing & Monitoring
- **Application Scenario 2**: Passport for Infrastructure Passage
- **Application Scenario 3**: Efficient enforcement of legal compliance

\[
\text{Figure 6.7: Value chain.}
\]
After the presentation of the above application scenarios, the potential of their deployment according to the standing business cases (hereby called deployment scenarios) is discussed in section 6.4.2.

6.4.1.1 Application Scenario 1: Minimum Risk Routing & Monitoring

**Current flow:** A logistics company of a dangerous goods (DG) vehicle is planning and operating its trip. Depending on its characteristics it is not allowed to pass certain areas and infrastructure objects. It therefore plans its route depending on the operators’ knowledge of accessibility and/or refers to police/road authority support for trip planning. Once the route is planned, the driver operates the tour on the chosen route. If any events (e.g. traffic jam) occur, the vehicle driver is either stuck in the event, or has to deviate onto other roads, which may not be allowable or foreseen for such use.

**Developed System flow:** The Logistics Company uses the GOOD ROUTE Portal for route planning for a specific vehicle/load and trip. It thereby receives a route planning in compliance with public authority/infrastructure operator restrictions for DG\(^{13}\). The vehicle/load and the route are therefore known to the infrastructure operator in advance.

With the start of the trip, the driver starts its route guidance system and thereby activates the route for monitoring at the service centre. The trip is recalculated with the current traffic information and an up-to-date time of arrival is calculated. The driver is guided along the minimum risk route. In case of an event, the Control Centre (CC) logic monitoring the trip, can alert the vehicle/driver and directly propose a routing alternative in line with DG restrictions and minimal risk. A recalculated time of arrival is provided. The Logistic Company (LC) is informed and can reschedule the tour if necessary.

**Functions**

Following functions are operated by the System in this scenario:

- minimum risk route planning (pretrip) (LC, CC)
- route guidance (on-trip) (Driver)
- route monitoring and alert (CC, LC)
- minimum risk route re-routing (due to event and/or tour rescheduling) (LC)

\(^{13}\) We thereby assume, that not only risk but also legal restrictions are included in the DSS route optimisation process.
The IO (Infrastructure Operator) would not directly be involved in this scenario. This scenario would usually be combined with the infrastructure passport scenario and/or enforcement scenario, where the IO/Police could be directly involved during the supervision of the trip.

Components involved:
- **GOOD ROUTE** Control Centre, DSS-for trip planning
- OBU & routing client- for route guidance and monitoring

**Table 6.3: Application scenario 1 – Minimum Risk Routing & Monitoring (outside specific infrastructure)**

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relevant Costs</th>
<th>Relevant Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>• Investment costs (related to routing client and OBU and subscription to service, if own contractors).</td>
<td>• Lower accident risk.</td>
</tr>
<tr>
<td></td>
<td>• • Increased comfort (much less unexpected events and delays).</td>
<td>• Increased operational security of the trip (routing and re-routing, as provided by the Logistics Company, will ensure more adequate parking places and itineraries).</td>
</tr>
<tr>
<td></td>
<td>• • Increased overall security of the trip (routing and re-routing, as provided by the Logistics Company, will ensure more adequate parking places and itineraries).</td>
<td>• Reduced stress: transit of responsibilities to the Logistic Company.</td>
</tr>
<tr>
<td>LC</td>
<td>• Control Centre subscription and maintenance costs (for the service, the maps, ...).</td>
<td>• More reliable tour planning and Estimated Time of Arrival (ETA), which implies better planning of the overall logistic chain and strengthening of the company profile (higher reliability).</td>
</tr>
<tr>
<td></td>
<td>• Vehicles’ OBU’s and routing clients.</td>
<td>• Early information on any type of obstacles ahead (monitoring &amp; alert).</td>
</tr>
<tr>
<td></td>
<td>• Higher operational costs and time delays (since there is possibility for prolonged route).</td>
<td>• Continuous monitoring or the trip and increased compliance with law/rules: reduced fines, reduced drivers’ misbehaviour.</td>
</tr>
</tbody>
</table>
### 6.4.1.2 Application Scenario 2: Passport for Infrastructure Passage

**Current Flow:** A LC plans a route for its DG vehicle/load, which would pass a critical infrastructure (tunnel, bridge) with restricted access.

- **Option 1:** passage not allowed: the LC has to plan alternative routes, usually involving significantly longer routes.
- **Option 2:** passage allowed, but only with special precautionary measures (escorting), taking significantly more time than usual.

**Developed System Flow:** The DG vehicle (or the Logistic Company) plans the route via the *GOOD ROUTE* portal and, if applicable (according to the results of the Minimum Risk Route Guidance), requests for approval for passage through the critical infrastructure (i.e. tunnel, bridge, etc.). The IO either denies passage (leading to option 1 normal flow) or grants passage through the *GOOD ROUTE* portal (authorised part for the IO), leading to a conform workflow for infrastructure passage.

In the first case, the minimum risk route guidance for the planned route is activated (identical to Application Scenario 1). In the second case, the IO is able to identify in due time the vehicle, that has obtained passage approval and provide priority.

The most of the characteristics of each transport operation are verified in advance, from the time of passage request, and the approval is provided upon the approval from the IO. However, as soon as the vehicle enters the control area of the enforcement node (local node is the specific case study herein), which covers the critical infrastructure surrounding area, the vehicle/load status is once again automatically verified (though the enforcement system) upon the thresholds defined for the specific infrastructure (thresholds are regulated upon the local policies in each case); thus, there is no need for escorting measures as in normal flow. Vehicles with alarms are separated for further check and vehicle without alarms can pass without disturbance, as scheduled, according to the priority rules set for this case by the IO. Further functionality is detailed in the following enforcement scenario.
Given the above, the passage through the infrastructure itself is expected to take less time and to be safer than without the system.

**Functions**
Following functions are operated by the System in this scenario in addition to Application Scenario 1:

- passport for infrastructure passage – LC, IO, (CC)
- Control Centre (Portal) – vehicle status monitoring (by police)
- automatic control (of vehicle compliance with rules) and enforcement – enforcement entity
- prompt/safe infrastructure passage - IO

**Components involved:**
- GOOD ROUTE Control Centre, DSS – for trip planning, passport
- Enforcement nodes, OBU & on-board driver HMI – for enforcement check
- OBU & routing client – for route guidance and monitoring

In addition to the relevant costs and benefits of Table 6.3 Table 6.4 which apply also here with regard to the part of route planning, guidance and monitoring, the following table presents the additional costs and benefits related to the passport functionality in specific.

**Table 6.4: Application scenario 2 - Secured Infrastructure Passage.**

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relevant Costs</th>
<th>Relevant Benefits</th>
</tr>
</thead>
</table>
| Driver | As in Table 6.3 & upgrade of sensorial system if own contractor (for the enforcement functionality, which applies mainly for the following scenario). | • Additional reduction in unexpected delays due to the priority asset of the “passport” functionality.  
  • Lower possibility for penalties for noticed violations (due to the in-advance check on planning phase pending the issue of “passport”).  
  • Shorter, safer and more comfortable trips (in case wide deviation around special infrastructure is not necessary). |
| LC | As in Table 6.3 & upgrade of sensorial system of the truck fleet (for the enforcement functionality, which applies mainly for the following scenario). | • Shorter, safer and more comfortable trips (in case wide deviation around special infrastructure is not necessary), which imply less accidents (fatigue related), less operational costs (shorter trips |
### Application Scenario 3: Efficient enforcement of legal compliance

**Current Flow:** Several dangerous goods vehicles pass through a toll station of a highway, soon after which a long bridge or tunnel starts. The vehicles either pass through the bridge/tunnel or are sent by a RO-RO ferry to the other side, losing far too much time. If the police decides to make checks, it needs to stop all heavy trucks to check their speed (through the speedometer on-board) and pass them through a specific infrastructure to measure the load per axle. It should also check the type of load carried, etc. The overall check time per vehicle is from 10-30 minutes. The expected rate of rules violation is roughly 7-10%.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relevant Costs</th>
<th>Relevant Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>System investment costs (subscription to the service).</td>
<td>implying fuel and time savings), more attractive profile (less accidents; less delays; IT systems adopter), less costs due to penalties (in-advance enforcement).</td>
</tr>
<tr>
<td></td>
<td>Enforcement costs (for enforcement nodes).</td>
<td>• Less resources spent for vehicles “escorting”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lower possibility for damage to the infrastructure (due to the in-advance check on planning phase pending the issue of “passport” and also the real-time enforcement check before entering the infrastructure).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Better planning, both on overall operation terms and emergency reaction plans (since they know in advance how many vehicles are expected and what they carry).</td>
</tr>
<tr>
<td>External effects (Society)</td>
<td>It depends which is the actor that pays for the subscription to the GOOD ROUTE service (both for passport and enforcement). The relevant costs could be societal costs.</td>
<td>Lower accident/incident risk which may lead to deaths, injuries, environmental and infrastructure damage (due to the in-advance check on planning phase pending the issue of “passport” and also the real-time enforcement check before entering the infrastructure).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Also, depending on deployment scenario: higher compliance rate /less rules violation and hence lower risk.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less traffic side effects (due to avoidance of deviation routes).</td>
</tr>
</tbody>
</table>
Developed System Flow: A police car is parked just before the toll station and receives the signals sent by the enforcement data from OBU/local node module. All trucks that have a total weight and a weight per axle that is less than a threshold and carry dangerous goods that do not fall into certain types are allowed to cross the specific infrastructure, without the normal flow escorting measures. The rest few have to use the RO-RO ferry. The few ones for which a violation is self-reported are stopped at the toll station and fined. The necessary checks are less than 1/10 than before and every stopped vehicle is fined.

As aforementioned, the thresholds defined for each specific infrastructure are being regulated upon the local policies in each case.

The following functions are operated by the System in this scenario:

- automatic control (of vehicle compliance with rules) and enforcement – enforcement entity

Components involved:

- Control Centre (Portal) – vehicle status monitoring (by police and by I/O)
- Enforcement nodes, OBU & on-board driver HMI – for enforcement functionality

The following table presents the additional costs and benefits related to the automatic enforcement functionality.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relevant Costs</th>
<th>Relevant Benefits</th>
</tr>
</thead>
</table>
| Driver | As in Table 6.3 & upgrade of sensorial system if own contractor for the enforcement functionality. | • Passage through infrastructure (if approved to pass), leading to shorter, safer and more comfortable trips.  
• Lower time for passage, since there are fewer possibilities for enforcement control, and if there are any, are more targeted; in any other case, passage is automatic.  
• Compliance with rules; reduced stress for penalties. |
| LC | As in Table 6.3 & upgrade of sensorial system of the truck fleet for the enforcement functionality. | • Higher potential for shorter, safer and more comfortable trips (in case wide deviation around special infrastructure is not necessary). |
### Relevant Costs and Benefits for DANGEROUS GOODS TRANSPORTATION

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relevant Costs</th>
<th>Relevant Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>which imply less accidents (fatigue related), less operational costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(shorter trips implying fuel and time savings), more attractive profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(less accidents; less delays; IT systems adopter), less costs due to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>penalties (awareness for automatic enforcement).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>which imply less accidents (fatigue related), less operational costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(shorter trips implying fuel and time savings), more attractive profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(less accidents; less delays; IT systems adopter), less costs due to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>penalties (awareness for automatic enforcement).</td>
<td></td>
</tr>
<tr>
<td>Police</td>
<td>System investment costs (subscription to the service).</td>
<td>More prompt and efficient enforcement on reduced number of vehicles.</td>
</tr>
<tr>
<td></td>
<td>Enforcement costs (for enforcement nodes), if this is the actor responsible</td>
<td>Smaller effort from enforcement personnel for performance of daily tasks; raised productivity.</td>
</tr>
<tr>
<td></td>
<td>for this.</td>
<td></td>
</tr>
<tr>
<td>IO</td>
<td>System investment costs (subscription to the service).</td>
<td>Fewer resources spent for vehicles “escorting”.</td>
</tr>
<tr>
<td></td>
<td>Enforcement costs (for enforcement nodes), if this is the actor responsible</td>
<td>Lower possibility for damage to the infrastructure (due to the real-time enforcement check before entering the infrastructure).</td>
</tr>
<tr>
<td></td>
<td>for this.</td>
<td>Increased gain, since the possibility of accepting more vehicles is increased.</td>
</tr>
<tr>
<td>External effects</td>
<td>Enforcement costs (for enforcement nodes), if this is the actor responsible</td>
<td>Lower accident/incident risk which may lead to deaths, injuries, environmental and infrastructure damage (due to the real-time enforcement check before entering the infrastructure).</td>
</tr>
<tr>
<td>(Society)</td>
<td>for this.</td>
<td>Also, depending on deployment scenario: higher compliance rate /less rules violation and hence lower risk.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less traffic side effects (due to avoidance of deviation routes).</td>
</tr>
</tbody>
</table>
6.4.2 Deployment Scenarios

There are three main Business Cases (hereby called deployment scenarios), envisaged for the system market penetration (Landwehr, Krietsch et al., 2009).

- **Deployment Scenario 1**: Operation for Logistic Company’s internal purposes
- **Deployment Scenario 2**: Operation by specific IO’s for voluntarily use by LCs
- **Deployment Scenario 3**: Mandatory use

6.4.2.1 Deployment Scenario 1: Operation for Logistic Company’s internal purposes

In this case, the system is implemented by a (group of) Logistic Company(ies) to facilitate planning and monitoring of dangerous goods transports. It is adopted (on a voluntary basis) as an enhanced safety measure, to improve the efficiency and reduce the cost of the operation.

The system can be conceived as a specialisation of client server systems for integrated tour planning, server guided truck navigation and monitoring, of which maps are extended for Dangerous Goods features and minimum risk evaluation algorithms.

Infrastructure operators have no or only a limited role in this scenario. Not being the prime initiator of the system, they might collaborate supplying up to date information on travel/passage times and events, as well as other details as far as in their interest and benefit from some knowledge on the specific trips of the DG vehicles monitored by the system.

Market penetration is expected to remain low (only large hauliers to be involved in otherwise private operation).

Application scenarios which may be deployed under this scenario:
- Minimal Risk routing & monitoring
- To a very limited extent: passport of infrastructure passage

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14 The route is determined in the service centre (equivalent to GOOD ROUTEs Control Centre) and transmitted to the navigation client.
6.4.2.2 Deployment Scenario 2: Operation by specific IO’s for voluntarily use by LCs

In this case, the system will be introduced by specific infrastructure operators in order to manage access or give priority of access or guarantee fast access (without escorting) or reduced fees, etc. The adoption of the system is voluntary and will be undertaken by selected transporters and dispatchers of high volumes. The more infrastructure operators adopt such a (harmonised) system the more attractive it will become for transporters/dispatchers to adopt such a system.

As for Deployment scenario 1, the system can be conceived as a specialisation of client server systems for integrated tour planning, server guided truck navigation and monitoring, of which maps are extended for Dangerous Goods features and minimum risk evaluation algorithms. In addition, OBUs (providing vehicle status information as well as billing functionalities) are supplied to DG LC as truck equipment and local node equipment are being implemented at the infrastructure for vehicle status monitoring and enforcement support.

A gradual market penetration is foreseen comparable e.g. to the introduction of automated tolling at Brenner or on French motorways, but focused on DG vehicles, which may choose to equip their vehicles and use the anticipated procedures (or continue without). The volume and growth is directly related with the number and the importance of the infrastructure operators involved.

Figure 6.8: Value chain for deployment scenario 1.
All application scenarios may be deployed in this case:
- Minimal Risk routing & monitoring
- Passport for infrastructure passage
- Efficient enforcement of legal compliance may only implemented in a limited way, i.e. those vehicles equipped with OBU’s may be exempt from manual controls and may be offered more rapid processing (as incentive for the system use).

Figure 6.9: Value chain for deployment scenario 2.

6.4.2.3 Deployment Scenario 3: Mandatory use
The system is introduced by specific infrastructure or for whole areas/countries as mandatory for all ADR vehicles or some classes of them. The system is equivalent to that in Deployment Scenario 2, though extended for enforcement features. Fast market penetration is expected in this case (from 50% to 100%, depending upon the type of law restrictions; i.e. local vs. national).

Scenarios/functions which may be deployed under this scenario:
- Minimal Risk routing & monitoring
- Passport for infrastructure passage
- Efficient enforcement of legal compliance

The value chain is very similar to Scenario 2.

Figure 6.10: Value chain for deployment scenario 3.

6.4.2.4 Subjective assessment of Deployment Scenarios
In addition to the CBA analysis conducted, a Multicriteria analysis with 10 experts coming from ELPA allowed the evaluation of the system effects and impacts, not easily quantifiable in order to be addressed by the CBA analysis (Landwehr, Krietsch et al., 2009).

The Multicriteria analysis was performed through cross-comparison tables formulated specifically for this purpose, following the analytical hierarchy process (AHP) (Saaty, 1982, 1988 and 1995), which is probably the most widely known and widely used MCA method in decision-making (Landwehr, Krietsch et al., 2009).
The focus was the assessment (in qualitative terms) of the socio-economic impacts of the system across its three different deployment scenarios. The deployment scenarios, aforementioned and described (see section 6.4.2), served as the “alternatives” and thus the basis of the analysis.

The criteria, upon which, these scenarios/business cases have been rated are as follows (see also Figure 5.1):

- Road Safety
- Environmental Safety
- Societal Safety
- Operational Costs
- Transport Operation efficiency
- Comfort and Quality of Life
- Jobs and revenue creation

The ranking of each system deployment scenario on each of the criteria reflecting the respective expected impact is shown in the following figure, whereas the overall ranking of the system deployment scenarios, incorporating the individual weight of the evaluation criteria, is shown in Figure 6.11.

![Figure 6.11: Deployment scenarios vs. evaluation criteria (expected impacts).](image)

The above figure demonstrates the level up to which each of the deployment scenarios is expected to influence road safety, environmental safety, societal safety, etc., always according to the decision makers. It should be noted that for
the extraction of the above figure, the decision makers in each case, were asked to evaluate the impact of the system if each of the deployment scenarios were applied, but always in comparison to the existing situation and not in comparison to another deployment scenario.

In more detail, when a decision maker was asked to evaluate the impacts of the mandatory use of the system, s/he was not supposed to imagine as pre-existing situation the one implied by the voluntary use of the system with additional benefits or by the voluntary use of the system for internal purposes. In each case, the reference situation was the current-without the system- situation.

As it is shown from the above figure, the mandatory adoption of the system is expected to influence more than any of the other deployment scenarios road safety, societal safety and environmental safety. This seems to be rather reasonable, since it is obvious that if the system is applied as a mandatory solution for all logistic companies and all infrastructures in the whole national traffic network, it will minimise at the maximum possible extent the risks inherent in Dangerous Goods transportation for the drivers and road users, for the third party populations, for the infrastructures and the environment, etc. In the same sense, the intermediate conditions (Deployment scenarios 2 and 3) are expected to influence less the road, societal and environmental safety.

On the other hand, it seems that the second deployment scenario (“Voluntary use with additional benefits”) is expected to bring about the most radical change (always in comparison to the existing situation) in terms of the transport operation efficiency.

This is considered a reasonable result, since the efficiency of the transport operations is considered to be well improved in Deployment Scenarios 1 and 2, however, in the context of the mandatory use of the system, a much more complex framework is created and further investigation should be held.

For example, the potential analyst should take into consideration what would happen if all logistic companies would have the right to book a passport for passage through infrastructures, or if their fleets (travelling on the same route) were all redirected to the safest route (which is always the same for any vehicle having the same or similar origin and destination...) (see the respective research results in section 5.2.2.2).

In this case, very careful business rules and conflict resolution schemes should be designed in order to allow the most efficient possible exploitation of the
system in a wide scale. Operational costs, on the other hand, are expected to be influenced more in the case of the voluntary use for internal purposes.

It is a fact that the operational costs of the company will increase in such a case, taking into account the investment costs on vehicle equipment, Control Centre services operation and maintenance (perhaps new personnel has to be employed for these purposes), which is counterbalanced, however, by the fact that less accident costs and less costs related to delays, etc. will most probably occur. Nevertheless, this is also valid in the other two Deployment Scenarios. The difference is that in the other two cases (in the second Deployment Scenario and much more in the third mandatory case), operational costs seem to have much less significance in relation to other criteria.

Finally, the following figure has emerged, which provides the overall ranking of the deployment scenarios, having incorporated, the individual weight of each criterion and the ranking of each deployment scenario upon each criterion). It seems that the mandatory use of the system seems to be the most desirable scenario in terms of expected impacts in comparison to the other two, whereas the voluntary use of the system for internal purposes for the company is the last one in the ranking, expected to bring about the less significant impacts.

![GOOD ROUTE Deployment Scenarios Overall Ranking](image)

**Figure 6.12:** Deployment scenarios overall ranking.

6.4.2.5 Major remarks

As resulted from the socioeconomic studies (Landwehr, Krietsch et al., 2009), the major innovation and strength of the system is the fact that, in comparison to existing conventional fleet management systems, which are operating on the basis of the fastest or shortest route, this one calculates the minimum risk route.
In addition to the estimation of the **minimum risk route**, the **minimum risk re-routing** is also enabled through the system.

All conditions (business reasons, traffic jam or accident, weather conditions, other) are automatically identified by the system and the minimum risk re-routing is directly estimated, according to the rules set behind (depending upon the deployment scenario, it could be the company, the infrastructure operator or other entities that set these rules) and acknowledged to all actors of the logistic chain.

This offers each user group a very **high process automation and guidance level in terms of daily operations and decision making**. Taking into account that the system constitutes a win-win business proposition to all involved stakeholders, everyone involved benefits in terms of safety, comfort and even operational costs.

There is also a noticeable potential for **added value services to which this system can be extended**, e.g. (security, overall environmental safety). This creates the opportunity to further improve the system and to keep it as state of the art for the next years. Besides investment costs, the **driver acceptance, in specific, has been identified as critical parameter for the system adoption**. In a possible roll out scenario, driver training can minimise acceptance discrepancies.

It is also implied that a **system implementation to less than 3 sites would imply high investment costs for a basic setup and lower benefits due to a reduced area of effectiveness.**
7 SWOT ANALYSIS

Finally, the major Strengths, Weaknesses, Opportunities and Threats of the system are summarised below (Landwehr, Krietsch et al., 2009).

7.1 Strengths

- **Minimum Risk Route Guidance**
The major innovation and strength of the system is the fact that calculates the minimum risk route (route with the minimum cost, with the maximum safety, combined route with minimum cost and maximum safety) in opposition to existing conventional fleet management systems, which are operating on the basis of the fastest or shortest route. In this way, it is the first time that a system, placed actually in the fleet management segment, does take into consideration the safety aspects of the drivers all road users, as well of the 3rd party populations.

- **Automatic Minimum Risk Re-routing**
In addition to the estimation of the minimum risk route, the minimum risk re-routing is also enabled through the system. All conditions (business reasons, traffic jam or accident, weather conditions, other) are automatically identified by the system and the minimum risk re-routing is directly estimated, according to the rules set behind (depending upon the deployment scenario –see section 6.4.2-, it could be the company, the infrastructure operator or other entities that set these rules) and acknowledged to all actors of the logistic chain. All the decision and execution burden related to the change of route is taken off the driver, who is assisted with an easy to use navigation system, easily installed in his/her vehicle.

- **Passport for infrastructure passage**
The “passport” for passage function, through several infrastructures, is another major strength of the system. Time delays, related also to additional costs for the company and the infrastructure, are being averted in this way, whereas the infrastructure achieves to have an overview of its traffic network and manage the transport operation much more efficiently. The same is valid also for the company, that is enabled to plan the itineraries of the vehicles in advance and estimate a very close to reality time of arrival to destinations, which enhances
the flow of the overall logistic chain. Finally, the driver is very much enhanced in his/her daily employment tasks, since s/he knows in advance the schedule of the day and may plan his/her trip in the most convenient for him/her way.

- **Enforcement/emergency**

Automatic enforcement and emergency support are also considered as strengths of the system. Automatic enforcement comes to replace conventional escorting held in infrastructures nowadays and to achieve higher level of compliance to the valid in each case regulations. The operators of the infrastructure know in advance what is transferred in their site, which also enables them to allow the passage of more vehicles through it, since they will be assured that it is safe and since they will be prepared on how to mitigate potential risks (enforcement functionality). This will enhance also the transport operation as a whole, since unnecessary deviations, leading to longer and thus more costly trips, will be averted, which is beneficial for both the companies and the drivers. Finally, this comes to be also beneficial for the society as a whole, since routes through densely population areas will be avoided. The emergency functionality in specific will allow prompt detection of malfunctions and failures of any type and respective reaction by the corresponding entities. In this way, loss of human lives and large scale damages to the infrastructure are being prevented.

- **Control Centre: an info point for the whole logistic chain**

The feasibility of all the above use cases, which require the involvement of all parties related to the transport operation, is achieved through the *GOOD ROUTE* Control Centre. All actors with different accreditation rights are enabled to monitor the transport operation of the equipped fleets and any changes occurring to that through a portal, which notifies them on the interesting and significant for them events in real-time. Thus, depending on the emerging situation, quick decisions are made from the side of the infrastructure operators and the companies and prompt reaction is enabled from the respective entities in case of problems (reasons for enforcement or emergency). In this way, even customers benefit directly, since they are also authorised to monitor the operation status of their own goods.

- **Driver always in the loop**

The driver, from his/her side, is also enabled in his/her daily tasks, through the navigation client, via which s/he is notified automatically for any changes in his/her route, as well as through the in-vehicle display, through which s/he is notified for any violations made (regarding his/her vehicle and its cargo). The on-board unit also enables the communication in emergency cases. In this way, the driver is always kept in the loop.
• **Instantiation of system Decision Making according to local rules and stakeholders weighting factors**

The local rules imposed by each infrastructure in normal flow constitute the framework, upon which the Decision Support System operates and provides the minimum risk route. A great flexibility of the system is the fact that any change in the local rules or addition of new ones, corresponding to new infrastructures subscribed, is easily followed by the framework set behind the decision process of the system. In a similar manner, the weights imposed to each contributing factor for the estimation of the combined minimum risk route (minimum cost and maximum safety for drivers and third parties) can be also modified, depending upon the priorities in each case. Thus, a different weighting system may be applied, following the deployment context of the system (local, national, European context), the main actor behind the system (dispatcher, infrastructure, contractor, public entity), the current governmental priorities, etc.

• **Common Ontological Framework**

The basis for the communication principles has been set in the ontological framework, developed from its early beginning. The ontological framework is developed in such a way, so as to include, if needed, more attributes corresponding to more parameters (related to vehicle, cargo, transport operation as a whole) as well as to more context of use, beyond road transport. It is open to be interfaced by other ontologies, enabling the connection of the current system to other ones. It is the main asset of the system that will allow its wide scale adoption and its compliance to the existing systems, raising in this way its penetration potential and viability.

• **Compliance with emerging technologies**

As has been evident in the research conducted in the project (Source: Negkas, Ayeridis et al., 2009), the system complies with all standards relevant to it, which strengthens its penetration potential. It is well placed in the context of the European Directives for Dangerous Goods transportation; it complies with C2C, I2C, C2I and TMC standards, security standards, etc.

• **Benefits for all**

The developed service constitutes win-win business proposition to all involved stakeholders. The company, the drivers, the infrastructure, the customers, the enforcement and the emergency units and, above all, the whole society, can benefit in terms of safety, comfort and operational costs.
• **Vast potential for added value services**

The context of use may be easily extended in many aspects. The decision making may anticipate more dimensions than the ones already considered (i.e. security, environmental safety), the telematic system could include more functionalities (like driver monitoring systems and other Advanced Driver Assistance Systems), more actors, if applicable, could be involved and access the Control Centre, whereas the context of use could be enlarged, including other transportation segments, besides the Dangerous Goods transportation, as well as other transportation modes, besides road transport. The cooperative principles embedded in the system architecture would allow more advanced communication potentials, which have not been demonstrated in the context of *GOOD ROUTE*, like communication with other vehicles or other infrastructure items (VMS, beacons, V2V, etc.).

### 7.2 Weaknesses

• **Need for instantiation/update of map data**

The map data utilised by the Decision Support System need to be constantly updated, whereas each time a new infrastructure is subscribed to the service, the population and safety related map data of the region needs to be constructed and added in the back-end.

• **Missing real time accident and updated population data**

The Decision Support System, among other data, utilises accident and population data in order to calculate its indices. In case such data is missing, historic data need to be utilized instead, which are, however, not always representative of the recent reality.

• **Need for medium to large scale deployment of the system**

As it is evident from the socio-economic studies results (Landwehr, Krietsch et al., 2009), the more infrastructures do subscribe in the system the more beneficial the system proves to be for the Logistic Company. Otherwise, the system, at least from in monetary aspects, does not pay off the investment required on behalf of the company, which may constitute a barrier for its initial penetration in the market.

• **Need for scope widening**

The Minimum Risk Route Guidance takes currently into account the minimum risk route in terms of costs and safety (on individual and on combined basis). Although, in this way, it already addresses a great share of risks related to transport operations, aspects like security, overall environmental protection, etc.
are factors that are not at the moment anticipated in the decision making process and comprise a recommendation for further enrichment of the system. A further enrichment would be also related to the application of the service in a wider segment of the transport operations, dealing with the transportation of other types of goods (i.e. high value goods) or even public transport. In this way, the target market would be enlarged significantly.

7.3 Opportunities

- **High societal and business risk**
  In the last 10 years more than 200 people have died in Europe’s tunnels and the direct cost of these accidents were about 210 million Euros per year. Meanwhile, 0,5% of total accidents occur in bridges, 3% of which are fatal ones. And the number of such critical infrastructures (i.e. urban tunnels, highway tunnels, long bridges, etc.) is expected to increase by 35% until 2010. The societal and business risk is evident and constitutes the main rational for research and deployment of systems like the one being developed.

- **ERA-NET Transport Action Group, ITS Action Plan, UNECE, relevant Directives and initiatives**
  There is a series of Directives and Action Plans that constitute the appropriate regulatory framework for the developed solutions, to fit in and comply with. The most outstanding and relevant, which proves that the conceptualization and development of the system has been in line with the European and international trends and priorities in the area, are outlined below.

The ERA-NET TRANSPORT Action Groups are aiming at coordinating national research policies in the field of transport. Fifteen partners (mainly ministries) from twelve countries are working together towards this coordination. The final objective is to create a strong and unified European Research Area in the field of transport. Therefore, various European countries are searching the ways and means to launch a common research project to find out what would be the requirements for a European system, which would make interoperable different local, national and regional systems.

In specific, the Action Group 12 (ENT12) is trying to coordinate national policies of research in the specific field of the transport of dangerous goods. In addition, within the framework of this Activity, an inventory of the norms used by different actors for the collection and exchange of data are drawn. Relevant norms identified include: ISO 17687 concerning “Transport Information and Control Systems (TICS); General Fleet Management and Commercial Freight
Operations: Data Dictionary and Message sets for electronic identification; Monitoring of Hazardous Materials/Dangerous goods transportation; and DATEX2. The final list of standards will be composed within this activity.

Furthermore, the ITS Action Plan, entitled “An Action Plan for the Deployment of Intelligent Road Transport Systems for More Efficient, Safer and Cleaner Transport” is meant to identify the contribution which ITS can make for improving road transport efficiency, safety and security, and for reducing the negative impacts of transport on the environment and is in line with our priorities.

Finally, the Directive 2004/54/EC, on minimum safety requirements for tunnels in the trans-European road network creates a comprehensive regulatory framework addressing both administrative practices and infrastructure and technical standards. 512 tunnels were affected in the European Union, mostly in Austria and Italy.

In addition, the United Nations Economic Commission for Europe (UNECE), the major international forum regarding tunnel safety should be mentioned. 55 international agreements and conventions have been elaborated (ADR signed in Geneva in 1957, UN Convention on Road Traffic-Geneva 1949, …).

Another initiative has emerged by the UNECE Working Party on Road Traffic Safety in 1999 (a group of experts developed “recommendations for minimum requirements concerning safety in tunnels of various types and lengths”). In addition, an Ad-hoc Interdisciplinary Group of Experts on Safety in Tunnels under the aegis of UNECE Inland Transport Committee (2000) has been established. In December 2001, the UNECE group presented 43 recommendations concerning road users, tunnel operation, infrastructure and vehicles.

Finally, the study by the OECD and PIARC (World Road Association) produced in 2001 on the transport of dangerous goods through road tunnels, is actually picturing the work being held. It is reviewing past tunnel accidents and national legislations, and proposing three tools for a better management of risks: harmonised groupings of dangerous good loadings, a risk quantification model, and a decision support model.

Thus, the developed solution provides the answer and an enabling platform to many different policy initiatives and legislative actions.
7.4 Threats

- Dangerous Goods Vehicles Drivers Acceptance
It is common knowledge that the drivers of heavy vehicles do not always respond in the most eager way to the adoption of new, innovative technologies and services that would change their daily business routine and thinking. The concept of continuous monitoring and, even more, of enforcement, may not be well accepted, especially by drivers with long experience in the field. Before the system commercialisation, a deeper investigation on the User Interface aspects, especially those ones concerning the drivers, should be realised, to assure intuitiveness and user acceptance.

In the meanwhile, and as stated in the Pan-European workshop of GOOD ROUTE-EURIDICE in Lucerne, it will be difficult to approach the drivers that work for themselves (and not on behalf of a company), which, however, comprise a considerable share of this market.

- Research focus on European and international level shifting from safety to the environmental protection
Due to the large scale environmental damage of the last decade and the multiple impacts for the quality of all kinds of life, research and business interest has been shifted from safety and the “0 accidents” vision to environmental protection and the “0 emissions” vision. The developed system, as it currently stands, does not yet focus on environmental issues, despite the fact that any DG accident may have extremely negative environmental impacts. However, the possibility of widening its scope, to take into account environmental aspects as contributing factors for the estimation of the (combined) minimum risk route, is a promising asset of the system.

- Economic recession
Economic recession will reduce the available social and private funds that could be used for setting up and maintaining services like the ones being delivered. On the other hand though, it will enhance the need for reducing the costs related to transport operation delays, fuel consumption, loss of human lives and infrastructure damage, thus it may also constitute an opportunity for systems like that.

- Competition
There are several other competing platforms in the cooperative safety systems area, even if they do not address the exact same targets (i.e. those of CVIS, SAFETUNNEL), while some Fleet Management Systems may provide part of the
herein discussed solutions, thus good consolidation, synergies and common interfaces rather than fierce antagonism and further market fractionisation are required.
8 POLICY AND TRAINING RECOMMENDATIONS

8.1 Introduction

Dangerous goods transportation implies important risks for road users, as well as for people living around. Moreover, the environmental implications resulted by a road accident involving dangerous goods, might seriously affect a wider area than the directly adjacent to the incident.

The local enforcement authorities and the infrastructure managers, provided that the dangerous goods transit is permitted, have to take all the necessary precautions for a safe and with a minimum possible time delay transportation, giving the proper information about the measures and the procedures that have to be followed.

The European Union through a series of enactments has defined the proper procedures and has set the minimum requirements that have to be followed in every stage of the dangerous goods transportation. Furthermore, the construction and testing specifications of the transportation measures are defined, as well as the minimum training requirements for the people involved in dangerous goods loading, transportation and unloading or for the personnel facing unexpected events connected to these stages.

The developed system aims to contribute to increased safe dangerous goods transportation basically by:

1. Informing the truck driver on potential dangers on the defined route and proposing alternative re-routings. It is stressed that the potential dangers includes the truck stop due to any problem on the route, since this stop is a risk reason to other vehicles or to adjacent non transporting activities.
2. Informing infrastructure management on an approaching dangerous goods truck, in order the defined transit procedure to be treated on the safer and less time consuming way.
3. Informing enforcement and other authorities (i.e. emergency units) about any unexpected event, giving opportunities for an in time application of prevention measures, that would avoid any dangerous condition or would minimize the magnitude and the consequences of events already in progress.
These system advantages can also be exploited by insurance companies specialized to dangerous goods transportation. The increased safety offered by the system, the faster treatment of transit infrastructure procedures and the increased control possibilities to the enforcement authorities could decrease the insurance company risks, leading to minimum debt to be insured and resulted to minimum insurance rate.

The European legislation on the dangerous goods transportation could be divided in two main parts:

- The first one is derived from the European Union administration and is setting the minimum safety requirements:
  - On training procedure of the drivers, the loading – unloading personnel, the safety advisers and the teams involving in unexpected events due to road accidents;
  - On vehicle construction, testing and signing;
  - On routing determination and in advance permission by national or local authorities;
  - On safety measures and transit procedures to be followed in the infrastructures of the Trans European Road Network.
- The second one contains national legislations and is setting additional safety measures taking into consideration the construction and the traffic conditions of national roads, the local climate conditions, the required protection conditions of the wider area around roads (inhabited area, environmental sensitive or protected area, archeological sites, etc.). In this category the specific procedures and safety rules imposed by road tunnels managers are incorporated.

The potentials of this system applications are resulted from its use cases (see section 4.2). Moreover, in the following section, the Use Cases compliance to the European legislation and the relevant national/local rules, if any, applied already in the dangerous goods transportation, is being described. In some cases, such a compliance is leading to the actual merging of more than one use cases, as it happens in a no transit permission through a road tunnel (UC1) because of any specific conditions or of the policy applied by the infrastructure management, the re-routing (UC3) for continuing the transportation and the enforcement of additional constraints or rules by traffic police or local authorities (UC5) according to national or local limitations to transportation of dangerous goods.
Thereupon, after the use cases analysis of the system, the investigation of the European legislation and taking into account that there are national and local dangerous goods transit rules, the system exploitation/adoption in any level could follow two ways:

- Either to be incorporated in the dangerous goods legislation, as supplementary to or amending existing clauses describing compulsory procedures. This case is concerning the European legislation or potentially the general framework of the national legislations harmonized to the European one.
- To be applied by the relevant actors (could be different according to the business cases; please refer to section 0) involved in the dangerous goods transportation in a way that without any violation of the legislation in action, to facilitate the application of the enforced procedures. In this case the involvement of local agents (infrastructure management, local traffic police, etc.) is excluded or reduced, and the necessary procedures should be implemented by some central nodes of the system, such as the expedition companies or national or regional system centres (Negkas, Ayeridis et al., 2009).

### 8.2 Input into Standardisation and Policies

#### 8.2.1 European legislation for Dangerous Goods Transportation – safety requirements and proposals to standards

The dangerous goods transportation in the European Union territory is regulated by:

- the ADR Directive «Agreement concerning the international carriage of Dangerous Goods by road»,
- the Directive 2004/54/EC «on minimum safety requirements for tunnels in the trans-European road network», and
- the Directive 95/50/EC «on uniform procedures for checks on the transport of dangerous goods by road».

Taking into consideration that the rest of the relevant legislation (personnel training, development and construction of vehicles, tanks and packing systems, inspections, measures to treat unexpected events, etc.) is supportive to the transportation procedure, the aforementioned Directives constitute the main European regulatory framework for the dangerous goods transportation.
The ADR Directive describes a series of minimum safety measures to be taken in all the stages of dangerous goods transportation, such as packing, filling, loading, transportation, personnel training, vehicle specifications, freight and vehicle signing, safety adviser responsibilities, and a series of local measures that potentially should be taken into consideration in transit through European regions or countries.

The Directive 2004/54/EK mentions the minimum measures to be taken for the safe transit of vehicles carrying dangerous goods through road tunnels on the Trans European Road Network longer than 500m.

The Directive 95/50/EK describes the check procedure that should be implemented by the States Member of the European Union on vehicles traveling on their territory and transporting dangerous goods. The checks will be sample and their objective is to ascertain the resulting implementation of the safety rules. However, it is necessary for limited vehicle checks, excluding multiple inspections, in accordance to a commonly accepted check list. During the check a standard check list should be used and after the procedure completion a copy is delivered to the vehicle driver.

In the table of Appendix B, the safety requirements of the ADR, 2004/54 and 95/50 Directives to which the system being developed is considered to contribute are isolated. This contribution consists of supplementary actions to the standard procedures, aiming at facilitating the enforcement authorities, the infrastructure management, the truck drivers and in general the people in-charge for dangerous goods transportation.

### 8.2.2 Towards ontologies standardisation

The established ontological framework is previously presented in section 4.2.4 of this document. The proposal of the GOOD ROUTE Consortium was towards a CEN/ISSSS Workshop on “Ontology integration and interoperability” in Dangerous Goods Transportation, together with the ERA-NET ENT12 (Working Group for “Hazardous Goods Tracking and Tracing”), UNECE, etc.

#### 8.2.2.1 Standardization issues

Especially domain ontologies (see section 4.2.4 for more info) are developed in eTravel, eSafety, eBusiness/eCommerce, eHealth, eLearning and other eApplication areas, in order to meet specific needs. In real life applications, the
short-comings of existing ontology approaches, which are largely due to deficits in standardization (gaps, under-specifying standards on the one hand, competing/contradicting standards on the other hand, primarily monolingual approaches, etc.), have led to new efforts in the world of open standards.

In 2006 the Management Group (MoU/MG) of the ITU-ISO-IEC-UN/ECE Memorandum of understanding concerning eCommerce standardization adopted a recommendation, which had been formulated by Infoterm on behalf of the technical committee ISO/TC 37 “Terminology and other language and content resources” of ISO (International Organization for Standardization). In 2005 they had been endorsed by CEN/ISSS (Information Society Standardization System of the European Standards Committee) and some of its Workshops, such as CEN/ISSS/WS/eCAT and CEN/ISSS/CDFG.

In fact, this recommendation geared towards the software engineering world anticipated the findings derived from recent discussions concerning the limitation of the concept “semantic interoperability”, which resulted in the broader concept of “content interoperability”, which can be defined as:

“the capability of **content items/content entities** (i.e. structured content at the level of lexical semantics)

- to be integrated into or combined with other (types of) content items / entities
- to be extensively re-used for other purposes (also sub-items /entities to be re-usable)
- to be searchable, retrievable, recombinalbe from different points-of-view”

The main goal of content interoperability is to arrive at content items/content entities (i.e. structured content at the level of lexical semantics), whose interoperability is measurable in the sense that the degree to which human intervention would be necessary becomes explicit. This fully applies to ontologies, too.

Within out system context, ontologies for Dangerous Goods Transportation have been developed ranging from planning, transport operation to emergencies handling and involving different stakeholders in the logistics chain. Thus, the developed ontology must be viewed as an upper ontology-still fundamental one-within the transport domain.
8.2.2.2 Various standardization approaches

Across all market sectors the need for interoperability of information and services is now considered a sine qua non of the modern information-based economy. Standardisation initiatives are already attacking the problem of making distinct representations and organisations of knowledge accessible to others. These initiatives are growing both out of the modeling requirements of individual or families of related applications, producing standards in particular areas, and out of more generic attempts to explicitly relate the models produces across broad applications areas by provision of metamodels and ontology definition standards.

Essential components of such models for long-term growth, such as versioning, networking, and other life-cycle considerations, are also beginning to be considered. The case for interoperable and sustainable ontology development is no longer open to debate and the goal of achieving interoperability is being aggressively pursued across e-Travel, e-Business, e-Health, e-Tourism, e-Government and virtually all other information-rich endeavours.

For the next generation of interoperable information services, however, there is a pressing need to develop one further aspect of interoperable and sustainable design in considerably more depth and to pursue early standardisation and application. This aspect relates to the decomposition of complex knowledge specifications into modular and possibly heterogeneously defined subcomponents. Existing practice, however, continues to produce ‘monolithic’ ontologies with poor decomposition properties. Such ontologies, even though they may be linked together via relation to common metamodels, are difficult to maintain and encourage modeling decisions that work against interoperability.

The crux of the problem to be resolved by appropriate standardisation is that existing metamodel specifications and ontology definition standards assume that the ontologies produced are essentially compatible down to exchanging of terms and filling in respective knowledge gaps. Merging and combining ontologies is then unproblematic. But this ‘charitable’ assumption of ontological compatibility frequently fails to hold. There are many distinct ‘views of reality’ and many distinct ‘universes of discourse’ for which ontologies must be provided and for which, subsequently, interoperability is to be achieved.

If these distinct views are broadly compatible ways of decomposing the domain to be modeled, then much can be achieved by conformance to a metamodel: this will allow composition. In the more common case that these views are not necessarily compatible, conformance to standardised modeling structures only assures
syntactic comparability. Merging or importing semantically incompatible information sources by following merely syntactic processes of composition produces inherently dysfunctional knowledge organisation. Moreover, if this is performed on large monolithic ontologies, the result is commonly so complex that it is no longer straightforward to see that the resulting conglomerate is deficient. In the worst case, apparent interoperability enforced by this method may even violate required quality measures in each of the domains combined by virtue of unforeseen ‘back-door’ knowledge combinations that are semantically invalid.

The GOOD ROUTE Partners involved in ontological framework decided that it is worthwhile to try to overcome the shortcomings of present standardization activities in the field of ontology interoperability. There are many examples, that it has been attempted ontologies to fit under a single ontology and thereby become interoperable. This can be called “weak heterogeneity”. However, there will be no single ontologies where everything fits. Therefore, “strong heterogeneity” is needed, where connections are achieved across differing ontologies/standards via formal structuring principles and not enforced consistency (Reinisch 2008).

8.2.2.3 Towards a CEN/ISSS Workshop on “Dangerous Goods Ontology integration and interoperability”

Ontology Interoperability is a key part of the Semantic Web and a significant long-standing challenge in its own right (e.g. Giunchiglia, 2005). There are standardization efforts going on in the frameworks of ISO/IEC-JTC 1/SC 32 “Metadata” (covering among others the ODM – Ontology Definition Metamodel, or MOF – Meta-Object Facility, etc.) ISO/TC 184/SC 4 “Industrial Data” (concerning product related data: content and transfer data), in eHealth and other eApplication areas.

The expert ontologies team wanted to go beyond more specific models such as those presented in the Giunchiglia/Pan/Serafini paper. It will also be restricting the domain of application with respect to a testbed in order to ensure that the proposal remains concrete. “Ontology interchange and interoperability: Basic Structuring Principles and Methodology Guidelines that support Ontology Interoperability” is proposed to be carried out within the framework of a new CEN/ISSS Workshop. This workshop can be based in the field of Dangerous Goods transportation.

For certain domains of application where interoperability is currently being pursued, the above-mentioned quality impairments are not acceptable and may
even be life-threatening. In the particular area of standardisation that is being proposed here, this is very much the case. Dangerous Goods transporation contexts, that provide services by combining services, devices and sensors across the complete transportation network, there is a crucial need for safe and secure interoperability at the semantic level. This level of quality assurance cannot be provided by syntactic interoperability. It is also unrealistic to assume that the manifold providers of components, ranging from TMIC operators, to AVL providers, to transportation companies and dispatchers will be producing both syntactically and semantically compatible models of their domains of concern. And, in fact, they should not even be being required to do this: placing modeling requirements from one domain (e.g. vehicle platforms) on the modeling requirements of another (e.g. infrastructure operators) will only impede development in each area and so impact negatively on the competitiveness of contributing providers.

To provide safe and secure interoperability, standardisation is required in the currently weakly addressed area of **ontological structuring and modularity** methods. In current ontology standardisation initiatives much has already been taken from established software engineering practice, but surprising little of what is known about modularity and structuring in software engineering has so far been applied. This workshop may target to bring together experts across the full spectrum of Dangerous Goods transportation.

Ontologies conforming to the structuring guidelines to be standardised within this Workshop are to provide a significantly improved capability for the much sought after goal of ‘seamless’ data interchange and Dangerous Goods operation. It will also be possible to formally guarantee the preservation of particular properties, such as consistency, in specifications so combined. The result will be a consolidated set of standardised guidelines which augment other standardisation initiatives, with particular respect to principles of semantically well-founded and implementable structuring and modularity.

The Workshop should try to liaise with ERA-NET, UNECE, TMIC standards as well as with national tunnel initiatives, in order to augment this list as required to ensure the broadest applicability and relevance. In each area included, existing ontological organisations and their requirements should be analysed with respect to necessary and beneficial structural decompositions and questions of modularity. The different use case related ontologies and their inter-module relationships can feed into illustrative scenarios, showing their actions sequence.
8.2.2.4 Workshop objectives and envisaged results
The major objective of this CEN/ISSS Workshop is proposed to move around the establishment of a first round of common agreement concerning the essential properties of structuring principles for interoperable ontologies within Dangerous Goods transportation domain, encompassing all modes of transport. The main deliverable should be targeted to be a CEN Workshop Agreement (CWA) on “Guidelines for reaching safe, secure and sustainable interoperability in the field of Dangerous Goods transportation”. The CWA should cover the following topics under a pan-European interoperability perspective:

a) analysis and identification of the needs of DG transportation stakeholders;

b) analysis of the gaps in the design of current interoperability approaches particularly with respect to structuring principles – in particular modularization requirements – and semantic heterogeneity;

c) description of the principles and requirements for structured heterogeneous ontologies;

d) analysis of business models and legal issues involved with DG transportation, over different transportation means and geographical areas (including IPRs15, personal data protection and privacy);

e) analysis of existing initiatives and approaches for flexible harmonization and global DG transportation (including process interoperability);

f) recommendations concerning a general framework for DG transportation-related information exchange that is appropriate for guiding subsequent implementation in inter-system interfaces and concrete device protocols (middleware solutions);

g) test bed for a best practice case.

The Workshop should not duplicate existing interoperability work in any of the current domains of interest, but, instead, provide an additional layer of standardised guidelines broadly applicable across other initiatives. Compatibility with established standards for ontology constructions, such as OWL, Common Logic, UML and their respective metamodels should be sought for. Wherever appropriate, terms already agreed in CEN, relevant ISO committees or other existing initiatives should be used.

8.3 Application Guidelines

The application guidelines provided in this section have derived from the knowledge gained throughout the system development, integration, technical

15 IPRs over contents of ontologies and product specifications.
verification and evaluation phases (Negkas, Ayeridis et al., 2009). These guidelines are of concern of all parties that wish to use/adopt and maintain the system being developed.

The guidelines are distinguished in technical guidelines, behavioural and legal/organizational guidelines. In each of them, it is indicated (upper right part) if they address the driver, the operator or the technical workforce (some of them are applicable for more than one type of users). In addition, it is indicated if they are existing guidelines (EG), if they are verified throughout the project (actually through the technical verification or the Pilots of the project-VG) or if they are new guidelines (not verified; but recommended based upon the overall gained know-how-NG).

### 8.3.1 Technical Guidelines

<table>
<thead>
<tr>
<th>GLD/ 1</th>
<th>The distance between the vehicle and the local node cannot exceed a range of 50 metres.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>Due to the short range wireless communication used and the low frequency, which implements 5.8 Ghz on the DSRC, the distance between the local node and the vehicle cannot exceed a prearranged value estimated to be around 50m. Beyond this distance, due to the air attenuation, sufficient communication cannot be assured.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in Gotthard.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 2</th>
<th>The connection between the Local Node and the truck require the complete visibility of the two corresponding antennas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>Due to the directional antennas used on each DSRC module, the enforcement node needs to be visible by the truck in order to start receiving and sending any data message.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in Gotthard and Turku.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 3</th>
<th>The speed of the vehicle should be maximum 110-120 km/h for the local node to be able to detect violation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>Even if the connection between the two DRSC modules is quite immediate, the enforcement module spends a few milliseconds to be synchronized with truck’s OBU in order to start receiving the values’ parameters of the truck. This process, together with the other requirements related to the quality of the communication, can seriously influence the integrity of the messages.</td>
</tr>
<tr>
<td>Rationale</td>
<td>Experience gained from <em>GOOD ROUTE</em> trials in Frejus tunnel in Italy.</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>GLD/ 4</td>
<td>For fast data transfer for the communication between Control Centre and Local Node, UMTS service should be preferred instead of GPRS.</td>
</tr>
<tr>
<td>Aetiology</td>
<td>GOOD ROUTE Pilots revealed a series of communication related problems.</td>
</tr>
<tr>
<td>Rationale</td>
<td>Experience gained from <em>GOOD ROUTE</em> trials in the three sites.</td>
</tr>
<tr>
<td>GLD/ 5</td>
<td>As the system currently stands, the GPS device applied to the Tablet PC needs to synchronize each time it is transported in offline mode (synchronization can take up to 10 minutes, driver / co-driver needs to be informed).</td>
</tr>
<tr>
<td>Aetiology</td>
<td>Relevant problems have been revealed in the <em>GOOD ROUTE</em> Pilots and technical verification phase.</td>
</tr>
<tr>
<td>Rationale</td>
<td>Experience gained from <em>GOOD ROUTE</em> trials and technical verification in the three sites.</td>
</tr>
<tr>
<td>GLD/ 6</td>
<td>The number of concurrent connections to the DSS web service cannot exceed 100 (in the current prototype).</td>
</tr>
<tr>
<td>Aetiology</td>
<td>It should be noticed that the above number is indicative and could be increased given that the PC has sufficient HW resources (like RAM, CPU). The selected value is optimal for best performance of the DSS module in terms of speed and efficiency. In addition, the DSS module has been designed so as to fully support multiple processor cores and thus achieve a speed up directly proportional to the number of cores.</td>
</tr>
<tr>
<td>Rationale</td>
<td>Experience gained from <em>GOOD ROUTE</em> trials in the three sites; specifications reported in D2.2: “Minimum Risk Route Guidance System” (Kauber, Emmanouilidis et al., 2009).</td>
</tr>
<tr>
<td>GLD/ 7</td>
<td>The optimal solution and therefore the best route estimation for a transport using the DSS module depends on the available real time information for specific regions/maps.</td>
</tr>
<tr>
<td>Aetiology</td>
<td>It should be noticed that the DSS module has been designed in such a way, so as to calculate the optimal route for a transport taking into account as much information available for each node in a region. Therefore, availability of information related to bridges, tunnels, slopes, etc. would be added value for the estimation of an optimal route based on the criteria of a specific transport (e.g. safest route, low-cost, etc).</td>
</tr>
</tbody>
</table>
### Rationale:
Experience gained from *GOOD ROUTE* trials in the three sites; Specifications reported in D2.2: “Minimum Risk Route Guidance System” (Kauber, Emmanouilidis et al., 2009).

### GLD/ 8
In order to obtain the optimal route for a given transport in real time, the system shall be able to connect to online systems that support online traffic data management as well as weather information.

### Aetiology:
Main purpose of the Decision Support System (DSS) module is to calculate the optimum route by taking into account the individual and societal risk-related cost, in addition to the economic cost. In order to achieve this, several real-time and statistical data are driven as input to the system, such as the road network, population distribution data, real-time as well as statistical traffic and weather data, historical accident data, road characteristics, real-time vehicle and cargo status.

### Rationale:
Experience gained from *GOOD ROUTE* trials in the three sites; Specifications reported in D2.2: “Minimum Risk Route Guidance System” (Kauber, Emmanouilidis et al., 2009).

### GLD/ 9
The number of via/intermediate nodes should not exceed 10 per route in order to get the optimal performance of the DSS module.

### Aetiology:
It should be noticed that if the number of via nodes increases, the time needed to estimate the optimal route could be higher. This is possible, given that for each via node point added to a route, an additional time is needed to reinitialize the routing algorithm.

### Rationale:
Experience gained from *GOOD ROUTE* trials in the three sites; Specifications reported in D2.2: “Minimum Risk Route Guidance System” (Kauber, Emmanouilidis et al., 2009).

### GLD/ 10
A mirroring system for the DSS web service should be available and if not possible, a backup solution should be considered.

### Aetiology:
The DSS system should be online without any interruption 24h per day. In order to avoid problems due to hardware or software failures, the DSS web service should be mirrored in an additional web server. If this is not possible, the operator should backup the web service every day in order to be able to restore it, if necessary. The above functionalities are available in the IIS web server, in which the DSS module is installed as an application module.

### Rationale:
Experience gained from *GOOD ROUTE* trials in the three sites.

### GLD/ 11
The borders of each region in a map should be correctly defined in order to avoid problems in the calculation of a route, in route segments near them.
### Aetiology:
The DSS web service uses the borders found in the map in order to estimate a route. Therefore, it is essential that the borders of the map are as accurate as possible in order to eliminate problems in estimating a route using the real coordinates taken from GPS hardware. However, the DSS module takes into account the cases in which the coordinates are out of bound in a map by giving a specific alert to the caller (e.g. an invalid input coordinate message is sent to the Control Centre of the system).

### Rationale:
Experience gained from GOOD ROUTE trials in the three sites.

### GLD/ 12
In order to release sensor positioning to communication issues between the nodes of the wireless network, it should be useful to take the antenna remotely from the node, by means of an extension. This could allow to avoid problematic communication also in very challenging environments that have to be monitored (i.e. container, metals, etc).

### Aetiology:
The communication link quality between nodes, considering different location inside the trailer, has to be assured.

### Rationale:
Experience gained from GOOD ROUTE trials in the three sites and prior technical verification phase.

### GLD/ 13
The Master Node (MN) of the wireless sensor network has to be placed in a position that might assure a clear LINE of SIGHT with all the other nodes of the network in order to avoid shielding, reflections and absorptions of the wireless signals.

### Aetiology:
The communication link quality between nodes, considering different location inside the trailer, has to be assured.

### Rationale:
D3.2: “OBU” (Bianconi, 2009).

### GLD/ 14
The installation of the wireless sensor network within the trailer has to consider the presence of other electronic devices and communication modules and any possible source of interference for the wireless signal.

### Aetiology:
Possible interferences with other electronic devices or communication modules. Problems related to the metallic wall of the trailer should be carefully evaluated.

### Rationale:

### GLD/ 15
In order to release DSRC module positioning to communication issues, it should be useful to take the antenna remotely from the module, by means of an extension. The antenna has to be placed somewhere in the vehicle in order to assure a perfect LINE of SIGHT.

### Aetiology:

### Rationale:

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<table>
<thead>
<tr>
<th>with the receiver when approaching the Local Node.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong> Considering different location of the DSRC module inside the truck, especially in respect to different models of truck, the communication link quality between DSRC transmitter and Local Node has to be assured.</td>
</tr>
<tr>
<td><strong>Rationale:</strong> Experience gained through technical verification phase and Pilots.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In respect to the applications and sensor modules workload, battery replacement has to be taken into account.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong> Until other ways to supply power to wireless modules will be provided, battery constraints have to be considered.</td>
</tr>
<tr>
<td><strong>Rationale:</strong> Requirements and specification provided at the beginning of the project.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Settings related to operational frequency, data rate, sensitivity, sampling rate, transmission power and sleep mode functioning have to be set in respect to the particular monitoring application, with a compromise between power budget and sensor lifetime.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong> Settings of wireless modules are application dependent.</td>
</tr>
<tr>
<td><strong>Rationale:</strong> Experience gained from GOOD ROUTE trials in Frejus tunnel in Italy.</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Providing sufficient energy to the mobile phone and the Tablet PC of the navigation system is essential, prior to actual use.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong> As the navigation system currently is, this is a sufficient precaution for smooth operation.</td>
</tr>
<tr>
<td><strong>Rationale:</strong> Experience gained from GOOD ROUTE trials in all three sites.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Usage of a foreign SIM card causes problems due to roaming. <em>This is also an organisational guideline.</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong> Only a limited number of mobile service providers is participating in roaming service consortium. It was made evident that when using a local SIM card, communication problems were minimised to zero.</td>
</tr>
<tr>
<td><strong>Rationale:</strong> Experience gained from GOOD ROUTE trials in all three sites.</td>
</tr>
</tbody>
</table>

### 8.3.2 Behavioural Guidelines

<table>
<thead>
<tr>
<th>All interfaces of all modules should be made available in the local languages, before any commercialisation of the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology:</strong></td>
</tr>
<tr>
<td><strong>Rationale:</strong></td>
</tr>
<tr>
<td>Aetiology:</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Rationale:</td>
</tr>
</tbody>
</table>

**GLD/ 21**

The navigation client designated for the drivers need to be further improved, before commercialisation, and resemble with commercial products in the area. Facilities and add-on features, like vocal interfaces, smart key features, etc. need to be added.

<table>
<thead>
<tr>
<th>Aetiology:</th>
<th>As commented in D7.2: “Pilot results consolidation” (Bekiaris, Gemou et al., 2009), in some cases, the fact that the interfaces were not available in native language created a series of problems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in all three sites (see D7.2).</td>
</tr>
</tbody>
</table>

**GLD/ 22**

The maps utilised by the system need to be as detailed as possible, in order to provide the most efficient possible route guidance to the user.

<table>
<thead>
<tr>
<th>Aetiology:</th>
<th>As reported in D7.2: “Pilot results consolidation” (Bekiaris, Gemou et al., 2009), some Italian drivers stated that the actual maps to be used in the commercial application should be more detailed than those used in the trial case in order to enable the most efficient possible route guidance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in Frejus tunnel in Italy (see D7.2).</td>
</tr>
</tbody>
</table>

**GLD/ 23**

The drivers, as well as all actors involved, need definitely to be informed of a system malfunction. A feature in the navigation client should indicate the operation of the system or not, while malfunction should be always indicated in a specific way. Delays should be also indicated (addition of a loading status bar like in all ICT system could be of help).

<table>
<thead>
<tr>
<th>Aetiology:</th>
<th>This is recommended in order to avoid confusion of the actors, in case of malfunctions or delays.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in all three sites (see D7.2).</td>
</tr>
<tr>
<td>GLD/ 24</td>
<td>Drivers and operators need to get training, specifically dedicated to the system, before proceeding with the actual use of the system.</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Aetiology:</td>
<td>This is an innovative system, which also it may fit in the existing routines of drivers and operators, incorporates additional ICT features, some of which require training and upgrade of know-how.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 25</th>
<th>All users of the system need to go through the user manuals developed for each module of the system, before the actual use of the system, in the context of specialised training.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>As shown through the Pilots, the navigation and the Control Centre interfaces have proved to be complex for some users, despite their educational background and experience. This implies that training before actual use of the system is mandatory.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>D8.2: “Training Schemes for DG drivers and Traffic Control Operators” (Bekiaris and Gemou, 2009); D7.2: “Pilot results consolidation” (Bekiaris, Gemou et al., 2009).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 26</th>
<th>It is absolutely mandatory that training provided prior to the use of the system by all types of users, should include both theoretical and on-the-job training.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>As shown through the Pilots the drivers and the operators were not always able to easily handle the interfaces on-route. In addition, training needs reported in D8.2 have proved that existing training schemes lack of road safety practical sessions. The training proposed includes generic road safety sessions incorporating system specific related sessions. The experimental plan followed for the Pilots would be of use for such a type of training.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>D8.2: “Training Schemes for DG drivers and Traffic Control Operators” (Bekiaris and Gemou, 2009); D7.2: “Pilot results consolidation” (Bekiaris, Gemou et al., 2009).</td>
</tr>
</tbody>
</table>

### 8.3.3 Legal/Organisational Guidelines

<table>
<thead>
<tr>
<th>GLD/ 27</th>
<th>Usage of a foreign SIM card causes problems due to roaming.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>Only a limited number of mobile service providers is participating in roaming service consortium. It was made evident that when using a local SIM card, communication problems were minimised to zero.</td>
</tr>
</tbody>
</table>
### Rationale:
Experience gained from GOOD ROUTE trials in all three sites.

<table>
<thead>
<tr>
<th>GLD/ 28</th>
<th>Security over the air and Internet need to be assured and carefully investigated, before any commercialisation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>Human Factors assessment proved that the majority of the actors were not convinced of the security aspects of the application.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Experience gained from GOOD ROUTE trials in all three sites (Bekiaris, Gemou et al., 2009).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 29</th>
<th>The whole scheme and especially specific parts of it, like the enforcement and the emergency need to comply with existing standards before being adopted. In case there are no standards yet on a European level (like for the enforcement), they should emerge soon. Further upgrade of the system and evaluation at pan-European transport network level needs to take place in order to solve compliance issues with emerging standards (i.e. C2C).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>This is essential requirement for the system penetration in the market.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>D8.3 (Negkas, Ayeridis et al., 2009).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLD/ 30</th>
<th>The platform needs to be upgraded in such a way, so as not to replace but rather be compatible with existing platforms used.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aetiology:</td>
<td>This requirement emerged from the Human Factors assessment in GOOD ROUTE.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>As reported in D7.2 (Bekiaris, Gemou et al., 2009).</td>
</tr>
</tbody>
</table>

### 8.4 Training Recommendations

Upon the feedback gathered by the Pilots and the identification of the training needs for drivers and infrastructure operators through the relevant benchmarking, two training curricula have been formulated, one for the Dangerous Goods drivers and one for the infrastructure operators. Results coming from INFORMED and IN-SAFETY projects (Vandenbergen and Gemou, 2004; Winkelbauer, Gaitanidou, et al., 2008; Winkelbauer, Nussbaumer, et al., 2008), as well as other modules/tools/applications/curricula tracked in the field have inspired the formulation of the training curricula.
In the same context, a series of training manuals have been developed in order to support the training proposed. All training manuals provide guidelines for use, installation and maintenance (whenever applicable) of the respective module they address. The training manuals have been used also in the project Pilots, prior to the trials execution for the various users’ acquaintance with the system.

The training curricula proposed are in compliance with relevant European regulation (i.e. “The European convention for international road transport of dangerous goods” – often mentioned as “The ADR convention” or just “ADR”, the European Councils Directive 94/55/EU about Transport of Dangerous Goods by Road, the European Councils Directive 95/50/EU about the introduction of Common Control Procedures in connection with transport of Dangerous Goods by Road, the UN Model Regulations of the Transport of Dangerous Goods) and national schemes, if existing, and, as such, are proposed as intermediate training sessions to existing training curricula. In this way, it is considered that their adoption on a common pan-European framework will be much more feasible. The training proposed for both drivers and operators includes both theoretical and on-the-job/practical sessions.

It should be noted that the proposed curricula and the intervention of the developed system in them should be seen as a pattern for the introduction of training on eSafety systems and ITS in general in current training schemes. In the same way, system specific dedicated sessions have been embedded, training sessions for other innovative ITS systems may and should be embedded, given their wide penetration in the respective market segments. In this way, all types of users involved in the transportation chain will be enabled to keep up with the evolution and will be more susceptible in it, as soon as a basic framework has been set (meaning that it will be much easier for users already trained how to use a safety system to learn about more, emerging systems, when needed).

The source document, describing in detail the training curricula is public (Bekiaris and Gemou, 2009), since it is intended to serve as a basis for future updates of the relevant EC Directives and other national schemes for training in the Dangerous Goods field (and far beyond) around Europe. The outline of the training curricula can be found at Appendix C of this issue.
9 CONCLUSIONS

The current publication, entitled “Dangerous Goods Transportation: A European cooperative system for routing, monitoring, re-routing, enforcement and driver support, for dangerous goods vehicles” discusses the major outcomes of the GOOD ROUTE European Commission STREP funded program, entitled “Dangerous Goods Transportation Routing, Monitoring and Enforcement” (Contract Number: IST-4-027873-STREP; Duration: 01/01/2006-31/01/2009; http://www.goodroute-eu.org). GOOD ROUTE has been a collective effort of a multidisciplinary Consortium of 14 Partners, coming from 6 European member countries (Finland, Germany, Greece, Italy, Spain, Switzerland), coordinated by CERTH (with the Informatics and Telematics Institute-ITI being the Coordinator and the Hellenic Institute of Transport-HIT being the Technical Manager of the project). The current publication focuses, mainly, on the work outcomes of CERTH.

Dangerous Goods represent about 5% of all goods transported on roads – more than half of this share being attributable to flammable liquids. Their transportation involves risks, which exist due to the nature, the hazardous properties or the state of these substances, and has the potential to harm not only the truck’s driver, but also the population being present at a certain distance along the pathway of the truck, such as the off-road residents living along the pathway and the on-road drivers and passengers of the other vehicles moving near the truck, which carries the dangerous goods.

Several thousands of vehicles carrying Dangerous Goods circulate on daily basis in European urban and rural roads, highways, tunnels and long bridges, in some of which are not allowed access. But, in such cases, the actual accident risk and impact when using secondary roads or other alternative ways is not calculated.

In addition, when due to unforeseen events (traffic jams, accidents, etc.) they need to change route, they do not have any particular guidance on the safest alternative nor are consequences of road choice to the business chain and societal risk calculated.

Thus, the management of risks involved in the transportation of dangerous goods has become a necessity. Most vehicle navigation systems are assisting with the mobility of individual vehicles, so that they reach their destinations with the
minimum cost or in the minimum amount of time. This happens without regard to the presence of other vehicles on the road network. Given that the impact of a fatal accident involving a Dangerous Goods Vehicle (DGV) can affect a great number of people and infrastructure elements, this approach is not sufficient.

Thus, the need arises for a system that will allow the necessary movement of Dangerous Goods in a manner that will not place unnecessary risks to society. Specifically, the actors involved (such as Dangerous Goods transporters, infrastructure operators, etc.) have so far implemented measures to mitigate such problems and deficiencies, but are lacking a global policy, an effective integrated technical infrastructure and the possibility of enforcement. As a result, the measures employed are limited in scope and can even be unfair to particular population groups. For example, a major highway or tunnel operator may wish to protect the other users of its infrastructure and the infrastructure itself by sending DGVs over high mountain roads, which however may pass through villages or other populated areas, inequitably exposing them to risks.

GOOD ROUTE's answer to this need has been the development of a prototype cooperative system for dangerous goods vehicle routing, monitoring, re-routing (in case of need), enforcement and driver support, based upon dynamic, real time data, aiming to minimise the Societal Risks related to their movements, while still generating the most cost efficient solution for all actors involved. It has achieved to do so via the use of real time infrastructure information, detailed and accurate knowledge of the materials being transported and the vehicles transporting them, on-board sensors, and V2I/V2V communications advanced routing algorithms which calculate and take into account transport risks as well as economic parameters, enabling in this way DGVs to reach their destinations efficiently and safely, without imparting unnecessary risks to the human populace in the vicinity of their trajectories. Risk distribution equity has been an explicit element of the system, as is the incorporation of enforcement capabilities.

The system being constitutes of the the mobile part (on board unit), the roadside part (local node) and the core part (DSS, data fusion, portal) and the connected external modules (logistics support). The mobile, roadside and external modules collect data in real time and feed the Decision Support System (DSS) for producing the optimal minimum risk route.

The core of the system is the real time decision support system (DSS) that optimises the routing of Dangerous Goods Vehicles within a transportation network by balancing the economic costs and societal risks associated with their
transport. Transport risks are calculated using the methodology of Probabilistic Risk Analysis applied to the material being transported and a time-dependent path optimisation algorithm is used for routing. Inputs to the system include the road network, population distribution data, real-time as well as statistical traffic data and historical accident data. Novel methods were developed for obtaining real time response from the system in spite of the complexity of the associated computations.

Via a thorough accident and user needs analysis, 9 major system case studies of the system have been defined and oriented the full development and evaluation process of the system together with the common ontological framework being developed.

Three pilot sites were chosen to test, validate and demonstrate the system. These were the Finnish Road Enterprise/FINRE located at Finland between Turku and Helsinki, the Gotthard Road Tunnel/GST located at Switzerland and the Frejus/SITAF tunnel located at Bardonnechia in Italy. A truck demonstrator was used for the final trials with users, in order to systemically validate the project concept and the target use cases in real life conditions. The trailer was emulated and the cargo emulated was liquid. 50 users participated in total, consisting of all types of users involved in the (envisaged) transportation chain, representing the Dangerous Goods drivers, infrastructure operators, consignees, local enforcement authorities and emergency bodies and the dispatchers.

Pilots aimed to evaluate the system performance and assess its robustness across all use cases defined, to evaluate the system usefulness and user acceptance on behalf of all above types of users and to provide a preliminary insight on the expected impacts of the system in terms of safety, transport operation efficiency and inherent costs and finally comfort and Quality of Life (QoL). The system was evaluated across these aspects following a common pattern (experimental plan) in all three sites established on the basis of the common evaluation framework and evaluation scenarios developed for this purpose.

Trials were executed with and without the Decision Support System, which served to distinguish the current (without the system) situation and the envisaged future (with the system) situation. In the “without the system” case, the DSS was replaced by a conventional (and commercial) navigation system.

System performance from the technical point of view was sound with only some poorest performance in case of insufficient service GPRS/UMTS service level.
Technical validation also proved that the emergency service (with notification of all the corresponding actors through the GOOD ROUTE portal) can be accomplished within 1.8 minutes (by average), which means that in hardly 2 minutes, all emergency actors are notified of any accident/incident happening; the safety impacts are self-evident.

In addition, according to the tests, the system does not create any additional delays in the transport pre-trip and on-trip phases. The operation time between the Control Centre and the DSS, which encompasses both the communication time and the processing time of the DSS and the Control Centre is negligible, while the DSS does not also seem to affect at all the overall time required for the accomplishment of the routing/re-routing scenarios (in comparison to the existing route guidance systems), although one should take into consideration the fact that the DSS is still a prototype, which by default does not incorporate all those, frequently “heavy” features, that a commercial product does.

As also shown from the Pilots, efficient enforcement is also enabled. While nowadays the overall check time per vehicle is 10-30 minutes with the expected rate of rules violation to be roughly 7-10%, technical validation showed that for the accomplishment of the enforcement task (where both the driver and the respective enforcement units are being notified) less than 1.5 minutes are required (mean value according to the test results) for all vehicles in the area. This reveals the great economic, traffic efficiency but also safety impact the enforcement system being developed could bring about. Time delays related to enforcement are minimised, automation inevitably prevents from unnoticed violations, which could result in great safety risks, whereas the enforcement personnel effort is minimised.

On the other hand, users’ acceptance in the trials was positive, with drivers wanting more accurate maps and even more automatic process in communication. Main advantages of the system according to them relate to safety, security and time aspects and its potential to enhance the daily routines of all involved actors (drivers, operators, emergency/enforcement bodies, consignees, dispatchers), and despite the fact that in some cases, some of them might found it complex and not intuitive enough (sometimes also time consuming), the overall usefulness and satisfaction of the system (user acceptance rates) have been always positive for all types of actors.

In addition to the above results, according to the off-line safety impact assessment conducted with the assistance of the DSS simulator, the minimum safety risk route emerging would result in 82.8% reduction in fatalities (if the
route was performed during the day), 92.3% reduction in 2nd degree injuries (if the route was performed during the day), 82.8% reduction in fatalities (if the route was performed during the day), 92.7% reduction in 1st degree injuries (if the route was performed during the day), 66.66% reduction in fatalities (if the route was performed during the night), 75% in 2nd degree injuries (if the route was performed during the night) and 70% in 1st degree injuries (if the route was performed during the night). It is evident from the above that the safety impact of the system can be enormous.

It has been made obvious that the deviation which the non-equipped DGV is forced to follow has a very negative impact to all the observed values. The distance increases by 28.58%, the travel time by 65.76%, the total economic cost by 40.64% and the total risk by 189.49%!

It has been concluded that the combined route, which minimises cost and risk in the best possible way in each case and which is the one the developed system has been based upon, is the optimal one, when we take into account the overall risk as well as the business needs and that the use of the system cannot only reduce the overall risk, but the total economic cost as well, when sensitive parts of the infrastructure are concerned, which makes it also easier to be adopted by the stakeholders.

Finally, according to the socioeconomic study performed, on one hand, the system itself takes a minimum investment of 2.66 Mio. € for one year operation in one site and within a time horizon of five years, the system costs reach a total of +27 Mio. € for one site. The main reason for this economic fact is the massive investment and operational cost related to the OBUs of the DG vehicle fleet, which can be hardly justified for a single infrastructure object (one site). Thus, although even one site can be theoretically operated with overall benefits under certain assumptions, nevertheless, it is recommended, for both economic and safety reasons, that the system is being introduced for all/most critical infrastructures in a region (at least two sites).

Comparing to the State of the Art, the developed system and service has been innovative in many aspects. The ontology is considered to be innovative, since there is no relevant ontology known, which addresses the special conditions existing in DG transportation and has classified a series of info about the driver, the cargo, the company, the environmental conditions, the vehicle and the logistic chain, so that the needs of all interested actors (i.e. infrastructure, drivers, customers, companies, etc.) are being addressed. Its main benefits lie in
the fact that the ontology is open, easily interfaced and also amenable to further enrichment and editing.

Furthermore, the Route Guidance System and its embedded DSS is the first and only (so far) system that optimises routing by taking into account the risk associated with the road transport of dangerous goods in addition to the usual economic factors, such as time, distance and/or fuel consumed. From the analysis of available offerings in both sectors, it has been made clear that existing Quantitative Risk Assessment tools do not include facilities for dynamic vehicle routing, whereas Route Guidance systems do not take into account transport risk related factors.

The DSS, on the other hand, is a system that combines methodologies from the area of Quantitative Risk Assessment and Vehicle Routing Optimization under real time conditions and local information. Even though existing systems overlap with particular areas covered by the developed system DSS and most of the relevant technologies and know-how deployed are available, the integrated functionality offered is truly unique and novel.

Finally, the enforcement module developed within the project is connected to DTCO and anticipates the capability to transmit through wireless communication links driver and vehicle information to control centres and infrastructure nodes.

The success of the system penetration is dependent on two market factors, namely overall growth of the relevant market segments (personal navigations systems and fleet management systems/services markets) and technological trends/evolution that may favour the uptake of the relevant services provided. In this issue, it has been proved that the market is mature enough to host the application developed (and those ones similar to it).

Furthermore, accident statistics (see Chapter 2), according to which, trucks are involved in a high percentage of accidents (55% of total accidents according to GES, 52% according to FARS, etc.), make evident that, from the users’ needs perspective, there is an emerging need for the prompt adoption in the market of services similar to the ones developed and presented herein.

As resulted from the socioeconomic studies, the major innovation and strength of the system is the fact that calculates the minimum risk route (route with the minimum cost, with the maximum safety, combined route with minimum cost and maximum safety) in opposition to existing conventional fleet management
systems, which are operating on the basis of the fastest or shortest route. In this way, it is the first time that a system, placed actually in the fleet management segment, does take into consideration the safety aspects of the drivers all road users, as well of the 3rd party populations.

All conditions (business reasons, traffic jam or accident, weather conditions, other) are automatically identified by the system and the minimum risk re-routing is directly estimated, according to the rules set behind (depending upon the deployment scenario, it could be the company, the infrastructure operator or other entities that set these rules) and acknowledged to all actors of the logistic chain.

This offers each user group a very high process automation and guidance level in terms of daily operations and decision making. Taking into account that the offered service constitutes a win-win business proposition to all involved stakeholders, everyone involved benefits in terms of safety, comfort and even operational costs.

There is also a noticeable potential for added value services as an extension of the current ones, e.g. (security, overall environmental safety). This creates the opportunity to further improve the system and to keep it as state of the art for the next years. Besides investment costs, the driver acceptance, in specific, has been identified as critical parameter for the system adoption. In a possible roll out scenario, driver training can minimise acceptance discrepancies.

The system exploitation/adoption in any level could follow two basic paths:

- Either to be incorporated in the dangerous goods legislation, as supplementary to or amending existing clauses describing compulsory procedures. This case is concerning the European legislation or potentially the general framework of the national legislations harmonized to the European one.
- To be applied by the relevant actors involved in the dangerous goods transportation in a way that without any violation of the legislation in action, to facilitate the application of the enforced procedures. In this case the involvement of local agents (infrastructure management, local traffic police, etc.) is excluded or reduced, and the necessary procedures should be implemented by some central nodes of the system, such as the expedition companies or national or regional system centres.

However, from the societal research conducted, it has been recognised that the mandatory use of the system seems to be the most desirable scenario; the
voluntary use of the system for internal purposes is not expected to bring about the same positive impacts. Cost Benefit Analysis proved that system implementation to less than 3 sites would imply high investment costs for a basic setup and lower benefits due to a reduced area of effectiveness.

The system has been aligning to key relevant standards during the whole phase of implementation and it has further proceeded with proposals for contribution to them. It has come up with a set of application guidelines being applicable for all relevant parties, while it has developed training frameworks and recommendations in order to further support its innovative developments.

Further improvement lies mainly in the instantiation/update of map data as well as of real time accident and population databases.

The most outstanding threats for the system adoption, however, is the global economic recession, which will most likely reduce the available social and private funds that could be used for setting up and maintaining similar services: still it will enhance the need for reducing the costs related to transport operation delays, fuel consumption, loss of human lives and infrastructure damage, thus it may also constitute an opportunity for them.

Another barrier could be also considered the shift of the research focus on European and international level from safety to the environmental protection, although the possibility of widening the scope, to take into account environmental aspects as contributing factors for the estimation of the (combined) minimum risk route, is a promising asset of the system.

Overall, the context of use may be easily extended in many aspects. The decision making may anticipate more dimensions than the ones already considered (i.e. security, environmental safety), the telematic system could include more functionalities (like driver monitoring systems and other Advanced Driver Assistance Systems), more actors, if applicable, could be involved and access the Control Centre, whereas the context of use could be enlarged, including other transportation segments, besides the Dangerous Goods transportation, as well as other transportation modes, besides road transport. The cooperative principles embedded in the system architecture would allow more advanced communication potentials, which have not been demonstrated in the context of GOOD ROUTE, like communication with other vehicles or other infrastructure items (VMS, beacons, V2V, etc.).
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DANGEROUS GOODS TRANSPORTATION
CERTH – HIT – PR – A – 2012 – 1


SMARTFREIGHT, [online], available: http://www.smartfreight.info/ [accessed 25 November 2008]


## 11 Appendix A: Parameterised Prioritisation of Dangerous Goods Accidents Per Source

*Table A.1: Dangerous Goods accidents parameterised prioritisation per sources.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GES database</th>
<th>FARS database</th>
<th>FACTS accident database</th>
<th>MHIDAS accident database</th>
<th>BP accident database</th>
<th>GUNDHI accident database</th>
<th>National accident data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visibility conditions</strong></td>
<td>1: High (83.9%)&lt;br&gt;2: Medium (14.9%)&lt;br&gt;3: -</td>
<td>1: High (69.8%)&lt;br&gt;2: Medium (26.7%)&lt;br&gt;3: -</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
</tr>
<tr>
<td><strong>Road surface conditions</strong></td>
<td>1: Dry (77%)&lt;br&gt;2: Wet (15.5%)&amp; icy, snowy or slushy conditions for tank trucks&gt;4500 kg (16.7%)&lt;br&gt;3: Icy, snowy or slushy conditions (6.3%)</td>
<td>1: Dry (66.2%)&lt;br&gt;2: Icy, snowy or slushy (20.4%) &amp; wet for tank trucks (21.4%)&lt;br&gt;3: Wet (13.3%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: Dry road surface (79%)-Greek data&lt;br&gt;2: Wet road surface (21%)-Greek data&lt;br&gt;3:-</td>
</tr>
<tr>
<td><strong>Light conditions</strong></td>
<td>1: Daylight (66.7%)&lt;br&gt;2: Dark but lighted (20.7%) &amp;</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: Lighted roads (57%)-Greek data&lt;br&gt;2: Darkness (lighted or not) (29%)-Greek data</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>GES database</th>
<th>FARS database</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Dark for articulated trucks (15.8%) and for articulated tank trucks (13.4%) 3: Dark (10.9%)</td>
<td>Dark for articulated trucks (15.8%) and for articulated tank trucks (13.4%) 3: Dark (10.9%)</td>
<td>1: Straight (47.1%) &amp; intersection for tank trucks (32%) 2: Curve (21.3%) 3: Intersection (20%) &amp; rail grade crossing for trucks (15.4%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>3: No lights (14%) - Greek data</td>
</tr>
<tr>
<td>Roadway alignment</td>
<td>1: Straight (36.8%) &amp; Driveway, Alley Access, etc. for tank trucks&gt;4500kg (25%) 2: Intersection (23%) &amp; Curve for tank trucks&gt;4500 kg (20.8%) 3: Curve (9.8%)</td>
<td>1: Straight (47.1%) &amp; intersection for tank trucks (32%) 2: Curve (21.3%) 3: Intersection (20%) &amp; rail grade crossing for trucks (15.4%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: Straight roads (66%) with no junctions (79)%- Greek data 2: Not straight roads (33%)- Greek data 3: No junctions (79.2%)- Greek data</td>
</tr>
<tr>
<td>Type of cargo</td>
<td>1: Liquid fuel (47.7%) &amp; gas for tank trucks&gt;4500 kg (20.8%) &amp; Non existing data</td>
<td>1: Liquid fuel (47.7%) &amp; gas for tank trucks&gt;4500 kg (20.8%) &amp; Non existing data</td>
<td>1: Hazardous liquid (72%)- mainly transport fuel (61%)</td>
<td>1: Liquid fuel for transportatio n use (45%) 2: Acid (20%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: Inflammable liquids (55.50%)- Class 3- Italian data 2: Inflammable gases (19.40%)- 3: Non existing data</td>
</tr>
</tbody>
</table>
### ACCIDENTS PARAMETERISED PRIORITISATION PER SOURCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GES database</th>
<th>FARS database</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Travel speed related to accidents</td>
<td>solid hazardous substances for trucks &gt; 4500 kg (25%) 2: Other hazardous liquid substances (17.8%) &amp; solid hazardous substances for articulated trucks &gt; 4500 kg (15.8%) 3: Gas (9.2%)</td>
<td>2: Liquid gas press. (12%) 3: Gas (6%)</td>
<td>3: Gas (6%) and Oil products (5%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Class 2F &amp; Corrosive materials (18.50%)-Class 8-Italian data 3: All other types of cargo-Italian data</td>
</tr>
<tr>
<td>Vehicle</td>
<td>1: “Going”</td>
<td>1: “Going”</td>
<td>Non existing</td>
<td>1: Negotiating</td>
<td>1: “Noise-to-”</td>
<td>Non</td>
<td>Non existing data</td>
</tr>
<tr>
<td>Parameter</td>
<td>GES database</td>
<td>FARS database</td>
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</tr>
<tr>
<td>manoeuvre</td>
<td>straight” (57.5%) &amp; “Decelerating in traffic lane” for trucks&gt; 4500 kg (25%)</td>
<td>straight” (75.6%)</td>
<td>data</td>
<td>a bend and turn manoeuvre (3%)</td>
<td>tail collision” (35%)</td>
<td>existing data</td>
<td></td>
</tr>
<tr>
<td>Type of road/type of location</td>
<td>Non existing data</td>
<td>1: Highway (63.6%) &amp; rural for tank trucks (53.6%)</td>
<td>1: Highways, especially for road tankers (26%)</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: Highways (50%) and non-residential area (67%) &amp; rural local roads especially for tank trucks (33.3%), Greek data; main roads (36%); Finnish data</td>
</tr>
<tr>
<td></td>
<td>Non existing data</td>
<td>2: Rural (28.9%) &amp; urban for trucks (23%) and for tank trucks (14.3%)</td>
<td>2: Intersections (4%) &amp; 3: All other roads including toll ways, roundabouts, country roads, bridges crossing rivers (26%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non existing data</td>
<td>3: Urban (7.6%) with regard to location:</td>
<td></td>
<td></td>
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<table>
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<th>Parameter</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1: Nearby rivers, creeks, etc. (28%)</td>
<td>2: Residential quarters (24%)</td>
<td>3: Industrial area/estate/park (6%)</td>
<td>1: Clear and Sunny (12%)</td>
<td>2: Clouded (8%)</td>
<td>3: Rain (4%) &amp; Frost (4%) &amp; Snow (4%)</td>
<td>3: Rural arterials (21%) · Greek data:</td>
</tr>
<tr>
<td>Weather conditions</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
</tr>
<tr>
<td>Time of day</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>1: 13:00-18:00 (26%)</td>
<td>2: 00:00-06:00 (24%) &amp; 06:00-12:00 (24%)</td>
<td>3:18:00-24:00 (14%)</td>
<td>Non existing data</td>
<td>1: 10:00-11:00 (20%)</td>
</tr>
<tr>
<td></td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
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<tr>
<td>Time of week</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
<td>Non existing data</td>
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<td></td>
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<td></td>
<td>2: Monday (12.5%) · Greek data</td>
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</table>
| **Time of year**   | Non existing data | Non existing data | Non existing data | 1: May (12%) & August (12%)  
2: March (10%) & October (10%) & December (9%) & January (9%), April (8%)  
3: All other months  
1: January (12%) & February (11%) & July (11%)  
2: November (9%) & June (9%) & October; September, August; May (8%)  
3: December & April (6%)  
1: June  
1: July (20.8%)-&
December (16.7%) - Greek data  
2: August (12.5%) & September (12.5%) & February (12.5%)-
Greek data |
| **Vehicle type**   | 1: Articulated tank trucks (55.7% of total accidents)  
2: Tank truck> 4500 kg (13.8% of total accidents)  
3: Articulated truck (10.9% of total accidents)  
1: Road tankers (74%)  
2: Truck (22%)  
3: Pick-up (4%)  
1: Road tanker (81%)  
2: Portable transport containers (15%)  
3: Tank containers (4%)  
1: Heavy goods vehicle (65%)  
2: Light (26%)  
3: Plant (6%)  
1: Lorries which transporte d cargo of >10000lt (were 4.5 times more often involved in fire or explosion accidents than)  
1: Tank trucks (62.5%)-Greek data;  
2: Articulated tank truck (33.3%)-Greek data |
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<tr>
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<td></td>
<td>GUNDHIN accident database</td>
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<tr>
<td></td>
<td>National accident data</td>
</tr>
<tr>
<td>Vehicle, driver, cargo and other info related to accidents/incident s</td>
<td>lorries with less cargo.</td>
</tr>
<tr>
<td>s leading to the identification of the attributes that need to be</td>
<td></td>
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<tr>
<td>monitored for the routing, re-routing and emergency functionalities</td>
<td></td>
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<tr>
<td>Need for monitoring of:</td>
<td></td>
</tr>
<tr>
<td>o Adverse weather conditions:</td>
<td></td>
</tr>
<tr>
<td>Accidents when road surface is wet is 15.5% of total accidents</td>
<td></td>
</tr>
<tr>
<td>o Type of cargo transferred: Liquid fuel transits (47.7%) of total</td>
<td></td>
</tr>
<tr>
<td>Need for monitoring of:</td>
<td></td>
</tr>
<tr>
<td>o Type of cargo transported:</td>
<td></td>
</tr>
<tr>
<td>o Transit of gasoline, related most of all types of cargo to fatal</td>
<td></td>
</tr>
<tr>
<td>accidents, when released since leads to explosion and fire and transit</td>
<td></td>
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<tr>
<td>of transport liquid fuel in general</td>
<td></td>
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<tr>
<td>Need for monitoring of:</td>
<td></td>
</tr>
<tr>
<td>o Crossovers (31%)</td>
<td></td>
</tr>
<tr>
<td>o Spillages (31%)</td>
<td></td>
</tr>
<tr>
<td>o Fire explosion (10%)</td>
<td></td>
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<tr>
<td>Need for monitoring of:</td>
<td></td>
</tr>
<tr>
<td>o Spillages (24.6%).</td>
<td></td>
</tr>
<tr>
<td>o Fire explosion (12.1%).</td>
<td></td>
</tr>
<tr>
<td>o Fire or explosion accident s on roads were twice as less</td>
<td></td>
</tr>
<tr>
<td>Need for monitoring of:</td>
<td></td>
</tr>
</tbody>
</table>
| o Adverse weather conditions. Vast majority of accidents have occurred in wet, icy slippery, frosty, etc. conditions. Heavy traffic involvement in these cases is significant, especially in fatal accidents. Finnish data: Accidents in Greece with drizzle rain and
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<tr>
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<tbody>
<tr>
<td></td>
<td>GES database</td>
</tr>
<tr>
<td>accidents</td>
<td>accidents</td>
</tr>
<tr>
<td>Vehicle failure (4% of total accidents)</td>
<td>(4%)</td>
</tr>
<tr>
<td>Vehicle, driver, cargo and other info related to</td>
<td>Need for monitoring of:</td>
</tr>
</tbody>
</table>

Hellenic Institute of Transport / Centre for Research & Technology Hellas
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</tr>
</thead>
<tbody>
<tr>
<td>release (20%)</td>
<td>Fire occurrence (16% of the incidents occurred)</td>
<td>explosion (80% of the incidents occurred)</td>
<td>release related to most accidents (91%)</td>
<td>drivers with Category E license are more often involved in accidents (66.7%)-Greek data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel speed exceeding 80 km/h (13.8%) or inappropriate upon conditions (12%)</td>
<td>Human failure (56%)</td>
<td>Cargo explosion (10%)</td>
<td>Spillages (31%)</td>
<td>Number of years of driver’s license acquaintance (in 62.5% of accidents, driver license was more than 4 years old)-Greek data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver distraction (25%)</td>
<td>Overturining of vehicle (73%) and cargo release (82%), especially in case of transport fuel transported</td>
<td>Overturning (roll-over) of vehicle (76%)</td>
<td>Theft (8%)</td>
<td>Driver fatigue (20%)-fatigue related accident data (section 3.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol in driver (7.5%)</td>
<td>Loss of control on behalf of the driver (4%)</td>
<td>Loss of awareness (44%)</td>
<td>Fire (8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic violation (27%)</td>
<td>Driver impairment (2%)</td>
<td>Behaviour (the percentage related to traffic violation) (25%)</td>
<td></td>
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</tbody>
</table>

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# Appendix B: Potential Contribution to European Enactments

**Table B.1: Potential contribution to European enactments.**

<table>
<thead>
<tr>
<th>No</th>
<th>Enactment</th>
<th>Legal Requirement</th>
<th>Potential GOOD ROUTE system contribution</th>
</tr>
</thead>
</table>
| 1. | ADR Annex A Chapter 1.4 Paragraph 1.4.2.2.4. | If, during the journey, an infringement which could jeopardize the safety of the operation is observed, the consignment shall be halted as soon as possible bearing in mind the requirements of traffic safety, of the safe immobilisation of the consignment, and of public safety. The transport operation may only be continued once the consignment complies with applicable regulations. The competent authority(ies) concerned by the rest of the journey may grant an authorization to pursue the transport operation. | The consignment halting suspending the transit timetable and thereof expires the transit licenses through border stations, regions and infrastructures (since such licenses have been issued by infrastructure management). In the same way, when the consignment permitted to be continued, all the competent authorities should be informed and new transit licenses should be issued or the previous ones should be activated. Use Cases application:  
- UC1: “Passport”  
- US5: “Enforcement”  
- UC6: “Logistics”  
- UC8: “C2C communication”  
- UC9: “Critical info” |
| 2. | ADR Annex A | The competent authorities of the Contracting Parties may, on their national territory, at any time, conduct spot checks to verify whether the | The GOOD ROUTE system will facilitate the sample checks implementation, since all data of the expedition will be available on real time to the |
### Table of Legal Requirements and Potential GOOD ROUTE System Contribution

<table>
<thead>
<tr>
<th>No</th>
<th>Enactment</th>
<th>Legal Requirement</th>
<th>Potential GOOD ROUTE system contribution</th>
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</table>
|    | Chapter 1.8 Paragraph 1.8.1.1 and 1.8.1.2. | Requirements concerning the carriage of dangerous goods have been met including, in accordance with 1.10.1.5, those concerning security measures. These checks shall, however, be made without endangering persons, property or the environment and without major disruption of road services. Participants in the carriage of dangerous goods (Chapter 1.4) shall, without delay, in the context of their respective obligations, provide the competent authorities and their agents with the necessary information for carrying out the checks. | Competent authorities. Moreover, through the GOOD ROUTE system the checks could be not sample ones, since any time, any vehicle and any expedition of dangerous goods could be checked in the territory of the competent authority. Use Cases application:  
- US5: “Enforcement”  
- UC6: “Logistics” |
<p>|    | ADR Annex A Chapter 1.8 Paragraph 1.8.1.4 | If the competent authorities observe that the requirements of ADR have not been met, they may prohibit a consignment or interrupt a transport operation until the defects observed are rectified, or they may prescribe other appropriate measures. Immobilization may take place on the spot or at another place selected by the authorities for safety reasons. These measures shall not cause a major disruption in road services. | Same comments as in no 1. |
|    | ADR Annex A Chapter 1.8 Paragraph 1.8.3.3. | The adviser's duties also include monitoring the following practices and procedures relating to the relevant activities of the undertaking: | The safety adviser apart from the emergency plans implementation could inform all the involved and interested in the expedition parts (road police, fire brigade, sender, receiver and other vehicles) for undertaking immediate actions, expedition timetable modification and other vehicles re- |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>5. ADR</td>
<td>Additional provisions falling within the scope of 1.9.2 are as follows:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annex A</td>
<td>(a) Additional safety requirements or restrictions concerning vehicles using certain structures such as bridges, vehicles using combined transport modes such as ferries or trains, or vehicles entering or leaving ports or other transport terminals:</td>
<td></td>
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<tr>
<td></td>
<td>Chapter 1.9</td>
<td>(b) Requirements for vehicles to follow prescribed routes to avoid commercial or residential areas, environmentally sensitive areas, industrial zones containing hazardous installations or roads presenting severe physical hazards:</td>
<td></td>
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<tr>
<td></td>
<td>Paragraph 1.9.3.</td>
<td>The driver is being informed in:</td>
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<tr>
<td></td>
<td></td>
<td>• additional constraints on transportation and transit</td>
<td></td>
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<td></td>
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<td>• potential alternative permissible re-routing</td>
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<td>The national or regional competent authorities are being informed in the data of any vehicle and its freight moving in the territory of their responsibility.</td>
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<tr>
<td></td>
<td></td>
<td>The sender and the receiver are being informed in any modification in the expedition timetable.</td>
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<td></td>
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<td>Use Cases application:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• UC1: “Passport”</td>
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<tr>
<td>No</td>
<td>Enactment</td>
<td>Legal Requirement</td>
<td>Potential GOOD ROUTE system contribution</td>
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</table>
|    | (c) Emergency requirements regarding routeing or parking of vehicles carrying dangerous goods resulting from extreme weather conditions, earthquake, accident, industrial action, civil disorder or military hostilities: (d) Restrictions on movement of dangerous goods traffic on certain days of the week or year. | - UC2: “Route guidance”  
- UC3: “Environmental-related re-routing”  
- UC4: “Business-related re-routing”  
- US5: “Enforcement”  
- UC6: “Logistics”  
- UC9: “Critical info” | |
| 6. | ADR Annex A Chapter 5.1 Paragraph 5.1.5.2. | Approval of shipments and notification And specifically the part: 5.1.5.2.4. (d) The consignment notification shall include: (i) sufficient information to enable the identification of the package or packages including all applicable certificate numbers and identification marks: (ii) information on the date of shipment, the expected date of arrival and proposed routeing: (iii); (iv); (v). | This procedure could be completed without any time delay using the GOOD ROUTE system. Additionally, the alternative re-routing could be defined and approved in time and without any dead time in the expedition. Use Cases application:  
- UC1: “Passport”  
- UC2: “Route guidance”  
- US5: “Enforcement”  
- UC6: “Logistics” |
<p>| 7. | Directive 2004/54/EC Transit procedure processing. | Use Cases application: | |</p>
<table>
<thead>
<tr>
<th>No</th>
<th>Enactment</th>
<th>Legal Requirement</th>
<th>Potential GOOD ROUTE system contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Directive 2004/54/EC</td>
<td>Road tunnel closed due to maintenance procedure or due to unexpected event, without direct involvement of the vehicle.</td>
<td>Use Cases application:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• UC1: “Passport”</td>
</tr>
<tr>
<td>9.</td>
<td>Directive 2004/54/EC</td>
<td>The vehicle is directly being involved in an unexpected event in a road tunnel.</td>
<td>Use Cases application:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• US5: “Enforcement”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• UC6: “Logistics”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• UC7: “Emergency”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• UC8: “C2C communication”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• UC9: “Critical info”</td>
</tr>
<tr>
<td>10.</td>
<td>Directive 95/50/EC</td>
<td>Carrying out of checks.</td>
<td>Same comments as in no 2</td>
</tr>
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</table>
### 13 Appendix C: Training Curricula

*Table C.1: Training Curriculum for Drivers*

<table>
<thead>
<tr>
<th>GOOD ROUTE Training Curriculum for Drivers</th>
<th>Totally: Max. 26 training hours&lt;sup&gt;16&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of the physical and the mental condition of the drivers</td>
<td></td>
</tr>
<tr>
<td>Each Training Day Foreground (15-30 minutes)</td>
<td></td>
</tr>
<tr>
<td>♦ Introduction</td>
<td></td>
</tr>
<tr>
<td>♦ Schedule of the training day</td>
<td></td>
</tr>
<tr>
<td>♦ Informal conversation</td>
<td></td>
</tr>
<tr>
<td>♦ Observation of social behaviour</td>
<td></td>
</tr>
<tr>
<td>♦ Review of the last training session taught the previous day, if applicable</td>
<td></td>
</tr>
<tr>
<td>1. BASIC COURSE (12 ½ teaching hours)</td>
<td></td>
</tr>
<tr>
<td>BASIC COURSE – Theoretical Part (about 9 teaching hours)</td>
<td></td>
</tr>
<tr>
<td>Training courses realised on national level including:</td>
<td></td>
</tr>
<tr>
<td>1. General requirements governing the carriage of dangerous goods (1 teaching hour)</td>
<td></td>
</tr>
<tr>
<td>“GOOD ROUTE training sessions”</td>
<td></td>
</tr>
<tr>
<td><strong>Scenarios:</strong> Introduction to safety systems (ADAS, IVIS, etc.); GOOD ROUTE functionalities (20 minutes)</td>
<td></td>
</tr>
<tr>
<td>Training courses realised on national level including:</td>
<td></td>
</tr>
<tr>
<td>2. Traffic Laws</td>
<td></td>
</tr>
<tr>
<td>3. General information concerning civil liability and other legal issues including the necessary documents and safety equipment, which must accompany transport of dangerous goods and the compliance of such documents and equipment with the regulations: (1 teaching hour totally)</td>
<td></td>
</tr>
<tr>
<td>“GOOD ROUTE training sessions”</td>
<td></td>
</tr>
<tr>
<td><strong>Scenarios:</strong> National Schemes related to ADR transportation in key infrastructures (tunnels, bridges, etc.) (45 minutes)</td>
<td></td>
</tr>
<tr>
<td>Training courses realised on national level including:</td>
<td></td>
</tr>
<tr>
<td>4. Main types of hazard;</td>
<td></td>
</tr>
<tr>
<td>5. Preventive and safety measures appropriate to the various types of hazard;</td>
<td></td>
</tr>
<tr>
<td>6. Marking, labeling, placarding and orange-coloured plate marking requirements and performance ways;</td>
<td></td>
</tr>
<tr>
<td>7. Information on multimodal transport operations; Handling and stowage of packages;</td>
<td></td>
</tr>
<tr>
<td><em>(1 ¼ teaching hour totally)</em></td>
<td></td>
</tr>
<tr>
<td>“GOOD ROUTE training sessions”</td>
<td></td>
</tr>
<tr>
<td><strong>Scenarios:</strong> GOOD ROUTE ontologies (30 minutes)</td>
<td></td>
</tr>
</tbody>
</table>

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<sup>16</sup> One training hour corresponds to 45 minutes.
**GOOD ROUTE** Training Curriculum for Drivers

**Totally: Max. 26 training hours**

Training courses realised on national level including:

8. What a driver should and should not do during the carriage of dangerous goods.
9. Information on environmental protection in the control of the transfer of wastes.
10. What to do after an incident/accident that may affect safety during the transport, loading or unloading of dangerous goods (first aid, road safety, basic knowledge about the use of protective equipment, etc.): **(60 minutes totally)**

“**GOOD ROUTE training sessions**”

Scenarios: Emergency functionalities **(45 minutes)**

Training courses realised on national level including:

11. Purpose and the method of operation of technical equipment on vehicles;
12. Acquaintance with technical parts of the vehicle and basic principles of function, maintenance and recovery;
13. Prohibitions on mixed in the same vehicle or container;
14. Precautions to be taken during loading and unloading of dangerous goods:

(1 teaching hour totally)

“**GOOD ROUTE training sessions**”

Scenarios: Navigation, Routing, Re-routing and OBU **(45 minutes)**

Training courses realised on national level including:

15. Ethical Issues;
16. Management, Market issues and Customers’ Responsiveness issues:
   Health and Fitness (including alcohol and medicine effects and potential impacts): **(45 minutes totally)**

“**GOOD ROUTE training sessions**”

Scenarios: Enforcement functionalities **(15 minutes)**

Training courses realised on national level including:

17. Preparing Accident Reports on serious accidents, incidents or serious infringements recorded during the transport, loading or unloading of dangerous goods.

(15 minutes)

**BASIC COURSE – Practical Part** Case Studies (3 ½ teaching hours)

Training courses realised on national level including:

18. Provision of first aid to themselves and other people;
19. Fire-fighting;
20. What to do in case of an incident or accident (Introduction for “ROAD SAFETY COURSE”)
21. Loading and unloading of dangerous goods, with use of real or mock-up on-the-job equipment;
22. Handling and stowage of packages, with use of real or mock-up on-the-job equipment;
23. Acquaintance with technical parts of the vehicle and basic principles of
**GOOD ROUTE** Training Curriculum for Drivers  
Totally: Max. 26 training hours

Function, maintenance and recovery.

24. **Check and Operation of technical equipment on vehicles**, with use of real or mock-up on-the-job equipment:

**Outside Vehicle Check (circle check)**
- General Vehicle Characteristics
- Tyres
- Tightening of wheel-nuts
- Lights
- Oil
- Water
- Fire extinguisher(s)
- ADR-equipment
- Outside cleanliness

**Inside Vehicle Check (circle check)**
- Visibility check (including dead-angle camera/mirror and any obstructions of the line of sight)
- ADR-equipment
- Equipment specially needed for specific type of work
- Personal protective equipment (if applicable)
- Documents
- Fuel
- Dashboard check
- Safety belt
- Inside cleanliness
- Air-conditioning
- Music (there must be no possibility of changing CDs whilst driving)
- Adjusting of the seat/steering wheel to correct and make comfortable posture

**ROAD SAFETY COURSE** (around 12 teaching hours)

**ROAD SAFETY COURSE- Theoretical Part** (4 teaching hours)

Training courses realised on national level (if applicable) including:

25. **Defensive Driving**;
26. **Antiskid**;
27. **Anti-rollover**;
28. **Fatigue Management**;
29. **Eco-Driving**.

(up to 3 teaching hours totally)

“**GOOD ROUTE training sessions**”

**Scenarios**: Safest routing (1 hour)

**ROAD SAFETY COURSE- Practical Part** (2 ½ hours and 4 hours totally)

Training courses realised on national level (if applicable) including:

30. **Defensive Driving**;
**GOOD ROUTE** Training Curriculum for Drivers

Totally: Max. 26 training hours

| 31. Antiskid: |
| 32. Anti-rollover: |
| 33. Fatigue Management: |
| 34. Eco-Driving: |

“GOOD ROUTE on the road training scheme”  
(maximum 4 hours including breaks)

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**EACH TRAINING DAY DEBRIEFING (15-30 minutes)**

- Overall evaluation of the course/day
- Verification of checklist and observations (explanation of both positive and negative remarks)
- Identification of areas for improvement and suggested action(s)
- Remarks by the trainee (critique of the course) and signature by the trainee of the evaluation report
- Issue of final report by trainer (sent to the line manager of each trainee)
### Table C.2: GOOD ROUTE training curriculum for Infrastructure Operators

<table>
<thead>
<tr>
<th>TMC Task Integral Function</th>
<th>Time Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1. Provide Travel Information</strong></td>
<td>2 teaching hours&lt;sup&gt;17&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>GOOD ROUTE:</strong> Ontologies and interfaces to other modes of transport</td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F2. Records Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>GOOD ROUTE:</strong> Traffic safety data collection and management</td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F3. Congestion Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F4. Failure Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F5. Incident Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F6. Special Event Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>GOOD ROUTE:</strong> Passport, routing and re-routing</td>
<td>2 teaching hours</td>
</tr>
<tr>
<td><strong>F7. Traffic Flow Monitoring</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F8. Emergency Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>GOOD ROUTE:</strong> Emergency functionalities</td>
<td>2 teaching hours</td>
</tr>
<tr>
<td><strong>F9. Provide/Coordinate Service Patrols</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F10. Reversible &amp; HOV Lane</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F11. Traffic Signal System Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F12. Transit Vehicle Monitoring</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>GOOD ROUTE:</strong> TMC and allied services monitoring and access levels</td>
<td>2 teaching hours</td>
</tr>
<tr>
<td><strong>F13. APTS System Management</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F14. Environmental &amp; RWIS Monitoring</strong></td>
<td>1 teaching hour</td>
</tr>
<tr>
<td><strong>F15. Overheight Vehicle</strong></td>
<td>1 teaching hour</td>
</tr>
</tbody>
</table>

<sup>17</sup> One training hour corresponds to 45 minutes.
### GOOD ROUTE Training Curriculum for Infrastructure Operators

<table>
<thead>
<tr>
<th>Management</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GOOD ROUTE: Enforcement functionalities</td>
<td>1 teaching hour</td>
</tr>
<tr>
<td>F16. Rail Crossing Management</td>
<td>1 teaching hour</td>
</tr>
<tr>
<td>GOOD ROUTE: Control Centre operation and maintenance</td>
<td>3 teaching hours</td>
</tr>
<tr>
<td>GOOD ROUTE: On the job training</td>
<td>1 week to 6 months</td>
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**Document Summary Information**

**Authors**

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<th>Initials</th>
<th>Full Name</th>
<th>Organisation</th>
<th>Role*</th>
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<tr>
<td>MG</td>
<td>Maria Gemou</td>
<td>HIT</td>
<td>MA</td>
</tr>
<tr>
<td>EB</td>
<td>Evangelos Bekiaris</td>
<td>HIT</td>
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(*) SA = Supervisor Author  
MA = Main Author  
CA = Co-author

**Quality Control**

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<td>Revision of content and comments.</td>
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<tr>
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<td>Prof. George Giannopoulos (HIT)</td>
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**Revision History**

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<td>G. Giannopoulos, M. Boile</td>
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<td>M. Gemou, E. Bekiaris</td>
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<td>21/05/12</td>
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