GOOD ROUTE: The aim, the approach and the outcomes

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General info

- **GOOD ROUTE**: Dangerous **Goods** Transportation **Routing**, Monitoring and **Enforcement**

- **Project start/end date**: 01/01/2006-31/12/2008

- **Aim**: GOOD ROUTE aims to develop 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.

- **Web site**: www.goodroute-eu.org
Main objectives

Analysis of DG accidents and needs of all involved actors

Use Cases & specifications

Ontological classification framework on the driver, the vehicle, the cargo, the environmental conditions, logistics chain nodes, etc.

Collaborative platform, able to gather and process in real time vehicle, cargo and environmental data.

Minimum risk guidance system for routing and re-routing of DG vehicles, taking into account individual and societal risks & conflict resolution and equity schemes.

Control Centre algorithms dealing with movements of all participating DG vehicles, which will provide traffic and environmental data to drivers and inform in real time the logistic chain for any unscheduled re-routing required.

On-board automatic data retrieval and storage system, to monitor key dangerous goods vehicle parameters and supply them to local nodes for enforcement purposes.

Optimal user interfaces for the DG vehicles drivers and the control centre operators, without adversely affecting their workload or causing unnecessary behavioural adaptations.

Integration in a prototype vehicle and evaluation in three Pilot sites across Europe, to evaluate their reliability, usability, successfulness, cost efficiency and thus estimate their potential safety impact and viability.

Involvement of all key actors in the DG transportation chain.

Viable business strategy for wide and quick diffusion of the system.
The Consortium

14 Partners from 6 countries

Developers: CERTH (ITI + HIT), USTUTT, ICCS, UPM/LST, COAT.

OEM’s: CRF, IVECO.

Suppliers: PTV, SIEMENS, TID.

Road operators: SITAF, FINRE, GST, ELPA.
GOOD ROUTE Use Cases & Ontological Framework

- Nine priority GOOD ROUTE use cases have been identified:
  - 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”

- Ontology fields address the driver, the vehicle, the cargo and the environmental conditions.
- In the context of these fields, the itineraries, the company data and all significant logistics items have been considered.
- The GOOD ROUTE ontology has been developed in XML schemas and is open to other systems, in order to be interfaced and interface other existing ontological frameworks related to DG vehicles transportation.
GOOD ROUTE Ontological Framework

<table>
<thead>
<tr>
<th>Ontological “profile”</th>
<th>GOOD ROUTE 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>

**GOOD ROUTE Use Case Ontological “profile”**

<table>
<thead>
<tr>
<th>Information need</th>
<th>Information channel</th>
<th>Condition/Attribute</th>
<th>Value matches</th>
<th>Value threshold</th>
<th>From whom</th>
<th>To whom</th>
<th>Profile</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.19.1.1 Travel booking</td>
<td>WGS 84 Geocodesal</td>
<td>NA</td>
<td>FG-vehicle</td>
<td>Infrastructure</td>
<td>“Passport”</td>
<td>24 hours before the time of arrival</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.19.1.2 Travel destination labels position</td>
<td>WGS 84 Geocodesal</td>
<td>NA</td>
<td>FG-vehicle</td>
<td>Business Chain</td>
<td>“Logistics”</td>
<td>Upon request</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.19.3 Type of destination</td>
<td>Text (supply, freight, cargo, etc.)</td>
<td>NA</td>
<td>FG-vehicle</td>
<td>Infrastructure</td>
<td>“Passport”</td>
<td>24 hours before the time of arrival</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.19.4 Type of emergency</td>
<td>Text (injection, trip, feeding emergency, rescue, emergency, etc.)</td>
<td>NA</td>
<td>FG-vehicle</td>
<td>Business Chain</td>
<td>“Logistics”</td>
<td>Upon request</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.19.5 Time of registration</td>
<td>GPS</td>
<td>NA</td>
<td>FG-vehicle</td>
<td>Infrastructure</td>
<td>“Passport”</td>
<td>24 hours before the time of arrival</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GOOD ROUTE System Architecture
**Architecture subsystems:**
On Board System;
GOOD ROUTE Core System;
Logistics Support System;
GOOD ROUTE Portal;
Data Fusion Platform (DFP);
Local Node

**Architecture users:**
DGV Driver;
Control Centre Operator;
Enterprise Room Operator;
Final Client;
Allied services
GOOD ROUTE Decision Support System

- Processes **static and dynamic data** from in-vehicle and infrastructure sources.
  - Takes into account:
    - safety critical aspects;
    - infrastructure capacity risk analysis algorithms;
    - different social and business group demands;
    - conflict resolution between enterprises.
- For every segment of the Transportation Network and for every single transport request, calculates:
  - the economic cost;
  - the Individual Risk (IR);
  - the Societal Risk (SR);
  - a combined cost, combining the corresponding economic and risk costs.
- Uses a **Time-Dependent Optimum Path algorithm** to evaluate the Minimum Combined Cost Route.
- Feeds the calculated route to the Conflict Resolution Unit.
Decision Support System (DSS) & Conflict Resolution Unit (CRU)

Risk Estimation Module
- Event Tree
- Risk Models
  - Release Models
  - Dispersion Models
  - Exposure Models

Route Calculation Module
- Estimated Fatalities
- Estimated Risk per Link

Conflict Resolution Unit
- Optimum Route

DSS

External Provider
- Weather Data (real time)

OBU
- Cargo Data (real time)

GIS
- Statistical Data
- Population Data
- Road Network Data
- Accidents Database

Substance Properties Database

Resource
- Good Route

Every logical downward path on the left corresponds to one branch of an event tree...

All models have been implemented
Liquid Leakage
After an accident or a malfunction a flammable gas leaks (associated probabilities for large and small leaks).
An example of events

**Liquid pool formation**
A liquid pool forms – pool formation model.
An example of events

Pool fire

There is a probability (e.g. 30%) of ignition.
Pool fire
As the pool fire develops the other compartments are heated and the enclosed liquid may reach its boiling point after a while (associated probabilities and models).
Explosion (BLEVE)
Pressure builds up while the container walls weaken because of the intense heat. This may result (depending on the amount of leakage and prevailing conditions) in a “boiling liquid expanding vapor explosion” (BLEVE)-(Associated probability and consequence modeling)
Individual Risk (IR)

- The **Individual Risk** for a point-location around the dangerous goods transportation activity is defined as the probability that an average unprotected person permanently present at that point location, would get killed due to an accident during the dangerous goods transportation activity.
- It is used to estimate the risk of a hypothetical “average” individual as a function of distance from the hazard.
• The **Societal Risk** is defined as the probability of \( N \) or more fatalities due to an accident.

• Societal Risk is usually expressed in the form of cumulative F-N curves, which are plots of the cumulative frequency \( F(n) \), of \( N \) or more fatalities during a specific time period (e.g. 1 year).

• From an F-N curve a single value \( C_r \) can be extracted representing the risk-related cost of a particular road segment, at a certain time interval, for certain weather conditions and for a particular cargo.

\[
C_r \propto \sum_n f_n n^a
\]
Societal Risk Transformation

A single value representing the risk of a particular road segment, at a certain time interval, for certain weather conditions and for a particular cargo.

\[ \sum_{n} f_{n} r^{\alpha} \]

Risk Cost
Economic Cost Evaluation

The following parameters are taken into account for the evaluation of the economic cost:

- Average fuel price
- Average fuel consumption
- Work hour price
- Tolls price (per vehicle category)
- Vehicle category
- Vehicle average speed
Optimum Route Calculation (1/2)

\[ C = W \cdot R + (1-W) \cdot C \]

- \( R \): Risk Cost \([l,t]\)
- \( E \): Economic Cost \([l,t]\)
- \( C \): Combined Cost \([l,t]\)
- \( W \): Weighting factor

Time-Dependent Lowest-Cost-Path Algorithm

i) Fixed-departure time
ii) Fixed-arrival time

- i: road segment
- t: time interval
The **Route Calculation Algorithm**:  
- can handle time-dependent data  
  The day is divided into a number of time intervals, each of them having different values assigned to them. The costs (economic, risk, combined) which are assigned to each road segment form n-size arrays, where “n” is the number of time intervals.

- has two versions  
  - fixed-departure time  
  - fixed-arrival time

- supports rest (stop) points

- is effective and fast (the speed depends on the number of the time intervals)

- makes use of parallelization, so as to increase the speed of calculations in multi-core processors, or multi-processor systems
The Minimum Risk Route Guidance System

The minimum economic cost route between two locations.

The minimum safety risk route between the same two locations.

The combined minimum safety risk and cost route between the same two locations.
## The Control Centre

Different users have different rights and views

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Driver: A, B, etc.</td>
<td>Logistics Company: A, B, etc.</td>
<td>Infrastructure: A, B, etc.</td>
<td>Administrator</td>
</tr>
<tr>
<td>2</td>
<td>Create account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Delete account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Login</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Change account</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Plan a route</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Trigger re-routing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Change route</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Delete Routes from portfolio</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>Monitor company trucks</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>Monitor all trucks</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>Monitor company routes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>Monitor all routes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>14</td>
<td>Enter (alert) messages in portal (to be sent to mobile device)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>15</td>
<td>See logistic data per vehicle in portal</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>16</td>
<td>Change logistic data in portal</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>17</td>
<td>Login from Mobile to portal</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>Access portfolio</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
On-board telematic system

- Local nodes Infrastructure or Vehicles
- Mobile Navigation
- GoodRoute control center
- Tractor OBU
- Trailer OBU
- Tyres Monitoring Receiver
- Tyres monitoring transmitter
- Note: the "CAN LINK" cable is a specific dedicated line for the communication between the tractor and the trailer

Truck tractor

Truck trailer emulator
Tractor OBU Integration

OBU front panel display

Driver OBU HMI architecture

Tractor OBU integrated in truck cabin

- E-call
- UP
- DOWN
- Exit
- GoodRoute Menu

- Speakers
- Microphone
- Radio
- OBU + front panel display

Vehicle Available Parameters

Tractor

- **FMS CAN parameters**
  - Vehicle Id
  - Engine coolant temperature
  - Fuel temperature
  - Engine oil temperature
  - Turbo oil temperature
  - Fuel level and consumption
  - Vehicle speed
  - Engine speed
  - Actual engine percent torque
  - Clutch, Brake, EBS switch
  - ABS Lamp state,
  - ABS/EBS warning state
  - Driver’s demand engine % torque

- **Autonomous sensors:** Tractor Tyres Pressure

- **GPS:** Vehicle position coordinates
  - Cargo weight (from RFID)
  - CARGO - vehicle dimensions (from RFID)
  - Cargo Id (from RFID)
  - Cargo Temperature (from WSN)
  - Cargo Pressure (from WSN)

- **Monitoring main functionalities**
  - On line route check
  - Truck failures estimation
  - Estimation of driving behaviour
  - Driving violations evaluation
  - Cargo emergency detection
  - Enforcement logic and decision support

Trailer

Design and development of the local node to vehicle and vehicle to local node communication module.

1. Transmission of vehicle parameters from OBU to Local Node
2. Analysis of parameters vs. permitted limits in the local node
3. Transmission of decisions from the local node to the OBU
4. Transmission of decision and data to Control Centre... and eventually to public authorities.

When Cargo temperature passes a presented limit threshold, an alarm is sent to Local Node through DSRC connection.
Main functions of the on board HMI

1. React to events (traffic, vehicle status, ...)
2. Select a route for navigation
3. Trigger re-routing
4. Report emergency / breakdown
5. Plan & change dangerous goods transportation routes
6. Organise all planned routes relevant to the driver
Nomadic client

- Navigation system consisting of a **mobile PC**, a **Bluetooth GPS-receiver** and a **mobile phone** (to connect via GPRS)

Windows Pocket PC
- Operating system: Win XP
- Processor: Intel A110 800 MHz
- RAM: 1 GB
- Display: 7" TFT, 1024 x 600 (WSVGA)
- Connection: GPRS, WIFI
- Storage: 60 GB - 4200 rpm
Main functions of logistics chain HMI

1. Plan & change dangerous goods transportation routes.
2. Organise and monitor all planned routes.
4. Administrative functions:
   a. Create / delete dispatcher accounts
   b. Create / delete driver accounts
   c. Register / deregister vehicles and customers
   d. Delete or change the own account
Main functions of infrastructure operators HMI

1. Monitor single transports and retrieve necessary / critical information.

2. Monitor all relevant transports at a time.

3. Manually grant or deny access to applying transports.

4. Set rules & restrictions for automatic access granting / denial.

5. Administrative functions:
   a. Create TMC account
   b. Delete or change the own account
Main functions of the fire brigades HMI

1. Get alerts as quickly as possible in case of an emergency
2. Keep an overview on all alerts
3. Respond to the system if action is taken
4. Get all necessary information for mitigation:
   a. Vehicle
   b. Driver
   c. Goods
   d. Stowage
5. Administrative functions
### GOOD ROUTE Pilots

- Pilots in all three sites with and without the system.
- Objective (via log files and nodes records) and subjective data (via interviews) recorded.

<table>
<thead>
<tr>
<th>Pilot Site</th>
<th>Road type</th>
<th>Venue</th>
<th>Site map</th>
</tr>
</thead>
<tbody>
<tr>
<td>North: E18 motorway area (Finland-FINRE)</td>
<td>Highway, Urban, tunnels, bridges</td>
<td>E18 Motorway area in Finland, between Turku and Helsinki.</td>
<td></td>
</tr>
<tr>
<td>Central: Gotthard Road Tunnel (Switzerland-GST)</td>
<td>Highway long tunnel</td>
<td>Part of the Swiss A2, passing through the Alps and connecting the Italian border (Chiasso) with Germany and France (Basel).</td>
<td></td>
</tr>
<tr>
<td>South: Outskirt area of Torino (Italy-SITAF)</td>
<td>Highway, Urban bypass, Tunnels</td>
<td>Outskirt area of Torino where the “tangenziale” motorway ring is located and where the A32 highway starts. Connecting Italy to France.</td>
<td></td>
</tr>
</tbody>
</table>
GOOD ROUTE status

- GOOD ROUTE underwent its second EC annual review with success on 18-19 March, 2008 in Turin and Bartonecchia (Italian site), where the GOOD ROUTE system was demonstrated upon its Use Cases.
- Integration is finished.
- Pilots in Italy and Switzerland are completed.
- Finnish Pilots are underway.

What you should wait for until the end of the project:
- Consolidation of Pilots results
- Socio-economic analysis
- Training curricula for drivers and operators
- Application guidelines and recommendations for standards
Thank you for your attention!

If you wish to join our User Forum and receive our eNewsletters, please visit our web site and be a member of our User Forum.

http://www.goodroute-eu.org