SIXTH FRAMEWORK PROGRAMME

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COORDINATION ACTION

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D9.1
Report on the findings of Tasks 9.1 and 9.2

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PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Executive summary

This Deliverable reports on the work carried out and the results achieved in WP 9 of the IMPRINT-NET Coordination Action, “External cost calculation: harmonisation of approaches and validation of the GRACE software”.

The objectives of WP 9 are the following:

A. To conduct a systematic review of the external cost values recommended in the DG TREN Handbook (with emphasis on road urban and interurban transport)
B. To assess the consistency of the Handbook values with the external cost values generated by the GRACE software
C. To assess the consistency of the cost functions used in the GRACE software with those adopted by the IMPACT study in producing the Handbook
D. To implement specific adjustments that might be needed to ensure better compatibility between the Handbook and the GRACE software-generated values
E. To present and disseminate the GRACE software

Chapter 1, *Differences in methods*, reviews the consistency of the methodological approaches adopted in the GRACE tool and in the IMPACT Handbook. The review shows a significant consistency in the methods adopted, in particular for air pollution, and global warming (via the impact pathway approach) and congestion (through the use of speed-flow relationships).

Chapter 2, *Differences in input values and data sets*, reports about the consistency in terms of data sets used in the two approaches. The comparison shows that for air pollution and global warming the data sets are similar. For noise and accidents the most important difference lies in the fact that the IMPACT Handbook relies on case studies evidences (e.g. the VOSL from UNITE in the accident external costs evaluation), while GRACE takes account of the HEATCO data.

Chapter 3 finally reports about the comparison of the external cost estimations. Congestion, global warming and noise show a high degree of harmonization, to the

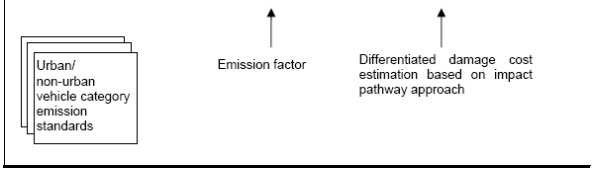
extent that the GRACE estimations systematically fall within the IMPACT Handbook ranges, i.e. the minimum/maximum values around the central recommended value.
Concerning air pollution, the GRACE evaluations are broadly consistent with the recommended central values in the IMPACT Handbook. Accident costs are extremely dependent on the local conditions. For example, an exceptionally high accident rate may determine higher accident external costs compared to the recommended average estimations provided by the IMPACT Handbook.

Following the identification, assessment and interpretation of divergences between the IMPACT handbook and the GRACE webtool (Objectives A, b and C above), a series of adjustments were carried out to ensure maximum harmonisation (Objective D). The results presented and discussed in this report refer to the revised version of the GRACE webtool, i.e. after implementation and testing of the adjustments. A detailed account of the harmonisation process and of the adjustments ultimately implemented is provided in ANNEX I. The ANNEX II provides the updated GRACE webtool user manual.

1 Differences in methods

1.1 Air pollution

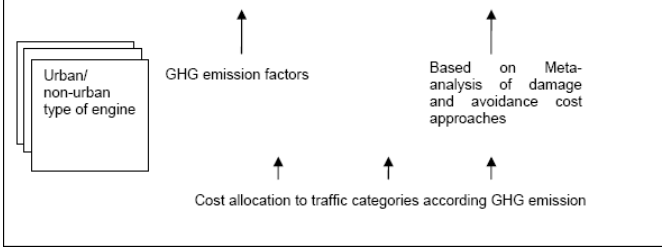
The methodological basis for the assessment of external costs of air pollution in the GRACE tool and in the IMPACT Handbook is the same. Both are in fact based on the impact pathway approach, as shown in the figure below.

IMPACT	GRACE
External Air Pollution Costs = specific emission * Cost factor per pollutant  	$C_{AP} = \sum_{P}[(EF_{dir}(m, v, l, p) * DF_{dir}(c, m, l, p) + FC(m, v, l, f) * DF_{FP}(c, m, f))]$ C_{AP} = Costs due to air pollution [€/vkm] EF_{dir} = emission factor – direct emissions [g/vkm] DF_{dir} = damage factor – direct emissions [€/g] FC = fuel or electricity consumption factor [g/vkm or kWh/train-km] DF_{FP} = damage factor –fuel production [€/g or €/kWh] m = mode v = vehicle technology (including vehicle/vessel/aircraft type, fuel type, emission standard) l = location (urban, non-urban) p = pollutant ($PM_{2.5}$, NO_x, SO_2, NMVOC) c = country f = fuel type (electricity, petrol, diesel, …)

The air pollution external costs are the results of a set of differentiated damage factors (Euro per tonne of pollutant) depending on the location (urban and non urban context), vehicle technology (car, HGV), emissions standards and fuel consumption. The differentiated set of damage factors, including the country in the GRACE tool, are multiplied by the emission factors (in grams of pollutant emitted per vehicle-kilometre), in order to obtain the cost per vehicle kilometre.

1.2 Global warming

As for air pollution, the methodological approach for the assessment of global warming external costs is the same in the IMPACT Handbook and in the GRACE tool..

IMPACT	GRACE
External Climate Change Costs = Specific GHG-emissions* External cost factor of CO_2 equivalent  	$C_{GW} = \Sigma (EF_{dir}(m, v, g, l) * DF_{dir}(m, g) + FC(m, v, f, l) * DF_{FP}(m, f))$ C_{GW} = Costs due to global warming from greenhouse gas emissions [€/vkm] EF_{dir} = emission factor – direct emissions [g / vkm] DF_{dir} = damage factor – direct emissions [€ / g] FC = fuel or electricity consumption factor [g / vkm] DF_{FP} = damage factor –fuel production [€ / g] m = mode v = vehicle technology (including vehicle/vessel/aircraft type, fuel type, emission standard) g = greenhouse gas (CO_2) l = location (urban, non urban.) f = fuel type (electricity, petrol, diesel, …)

Ideally, the costs caused by greenhouse gas emissions would be calculated as damage cost using the principles of the impact pathway approach, i.e. modelling the pressure (e.g. CO2 emissions), resulting burden (e.g. episodes of extreme hot summer days due to climate change), response of receptors (e.g. increased mortality due to heat stress) and monetary valuation.

Given the high uncertainties attached to the values of the damage costs, the unit cost of greenhouse gas emissions is in fact derived from the available estimates of abatement (or avoidance) costs. The costs resulting from the vehicle emission of greenhouse gases (usually expressed as CO2 equivalent) is then obtained by multiplying the amount of CO2 equivalent emitted by a cost factor (the unit cost). Due to the global scale of the damage caused, there is no difference how and where in Europe the emissions of greenhouse gases take place.

1.3 Congestion

The theoretical basis (methodology and Value of Time values) for estimating congestion costs is fully consistent in the two approaches. The congestion cost levels that result from applying the GRACE tool depend on the traffic volumes at the road segment under consideration that need to be put into the tool by the user. The IMPACT hand-book does not include a set that is differentiated according to traffic volumes. The output values mentioned in the handbook reflect typical values for the congestion cost when traffic demand is about 100% of the road capacity. The IMPACT handbook

recommends the application of a (preferably local) speed-flow function. The GRACE software tool includes such an approach by using a reference speed flow function (in interurban context). Therefore the GRACE software tool can be regarded as an example of a more sophisticated approach using Speed-flow Relationships which is explicitly recommended in the IMPACT Handbook.

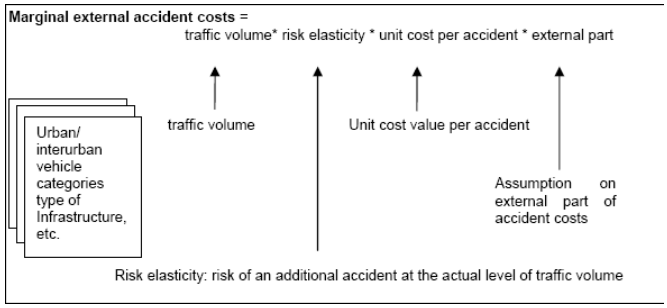
IMPACT	GRACE
$MEC_{Cong}(Q) = \frac{VOT \cdot Q}{v(Q)^2} \cdot \frac{\partial v(Q)}{\partial Q}$ With: VOT: Value of Time (€ / veh.-hour) Q: Current traffic level (veh./hour) v(Q): Speed-flow function (km/hour) MEC_{Cong}: Marginal external congestion costs	$MECC = -\frac{Q}{S^2}\frac{\partial S}{\partial Q}v$ Reference speed flow curve based on the UK speed-flow relationships for different road types where S = speed; Q = flow; v=value of time

An important difference between the two approaches is that the congestion costs in the IMPACT Handbook should be considered as optimal congestion costs (charge), i.e. setting traffic flows at their optimal level, while the GRACE tool calculates the congestion costs at the current traffic level. This means that the congestion costs estimates from the GRACE tool can not directly be applied to set optimal charge levels. However, this is a difference in the way data are presented rather than that it reflects a fundamentally different approach.

1.4 Accidents

The methodological issues arising from the comparison of the IMPACT Handbook and the GRACE tool concerning the marginal external cost of accidents derive from the different data input: the basic methodology used in GRACE and IMPACT is the same, however, the input data and way of generalising estimates are different.

The IMPACT recommended values are derived from case studies; i.e. the UNITE and GRACE case studies following a bottom-up approach, while the GRACE methodological approach relies on the identification of a cost function by using the key drivers derived from literature review.

IMPACT	GRACE
	$AC_i = (\Sigma_j A_{ij} / Q_i)*(VSL_J+NLP_j+MEDC_j)$ $AC_{external} = AC_i (1\text{-theta}))$ $MC_{external} = AC_{external} * E$

Another important methodological aspect that needs to be considered is the risk elasticity due to traffic increase. Given the lack of robust evidence available from research, the GRACE tool uses one single coefficient, which is therefore not differentiated by type of road (urban and motorways).

1.5 Noise

The two methodological approaches are similar: the bottom up approach used in the IMPACT Handbook is based on the INFRAS case studies, that have been used as reference case for deriving the IMPACT values. The approach is consistent with the GRACE noise cost function approach, i.e. identifying the key drivers (exposed population, location, time of the day, etc), in order to estimate the noise marginal cost.

IMPACT	GRACE
The bottom-up approach is developed in the ExternE-project and is generally called the 'Impact Pathway Approach'. The starting point of this approach is the micro level, i.e. the traffic flow on a particular route. Two scenarios are calculated: a reference scenario reflecting the present scenario with traffic volume, speed distribution, vehicle technologies, etc., and a marginal scenario which is based on the reference scenario, but includes one additional vehicle. The difference in damage costs of both scenarios represents the marginal external noise costs of that vehicle.	In the Grace tool we use the following formula: $C_N = NLI(l, t, b, s) * VA(v, l) * Pop (l) * DF(b, c)$ In which: C_N = Costs due to noise [€/vkm] NLI = noise level increment due to one additional reference vehicle [dB(A)] VA = road vehicle specific noise level adjustment Pop = exposed population [persons / km] DF = damage factor [€ / (dB(A) / person] l = location (urban, non-urban) t = time of day (day, night) b = background noise level (high, low) s = situation (peak, off-peak) v = vehicle type (passenger car, HGV, intercity train, high speed train, goods train,) c = country

2 Differences in input values and basic data

2.1 Air pollution

The following table summarises the input values and data sets used for the evaluation of air pollution external costs in the GRACE tool and in the IMPACT Handbook.

	GRACE tool	IMPACT handbook
Basis of data	› Valuation of PM2.5 and PM10: HEATCO; Valuation of NOx, NMVOC, SO2: CAFÉ CBA › Emission factors: German handbook	› Valuation of PM2.5 and PM10: HEATCO; Valuation of NOx, NMVOC, SO2: CAFÉ CBA › Emission factors: German handbook
Pollutants included	› NOx, CO2, PM 2.5 exhaust, NMVOC, SO2 › PM non-exhaust not included	› NOx, CO2, PM 2.5 exhaust, PM10 non-exhaust, NMVOC, SO2
Unit of measure	€ 2000/g of emissions	€ 2000/t of pollutant
Differentiation	› Specific data for EU 27, other countries: EU average › For PM2.5 into urban metropolitan, urban and outside built-up areas	› EU 27 › For PM2.5 and non-exhaust PM10 into urban metropolitan, urban and outside built-up areas, for exhaust PM10 into Urban metropolitan and Outside built-up areas

The table shows that the main difference is that the GRACE tool does not explicitly include non-exhaust PM emissions.

2.2 Global warming

The following table summarises the input values and data sets used for the evaluation of global warming external costs in the GRACE tool and in the IMPACT Handbook.

	GRACE tool	IMPACT handbook
Basis of data	IMPACT handbook 2010 value	Based on comprehensive literature review and on experience with EU ETS
Pollutants included	CO2	CO2
Differentiation	› No differentiation for short and long-term	› Differentiation for different years of application

The GRACE tool uses an estimate of CO2 emissions of 25 Euro per tonne CO2, which is the value recommended in the IMPACT handbook for 2010. For the long term, the handbook recommends higher valuation up to 85 Euro per tonne of CO2 in 2050.

2.3 Congestion

The following table summarises the input values and data sets used for the evaluation of congestion costs in the GRACE tool and in the IMPACT Handbook.

	GRACE tool	IMPACT handbook
Basis of data	› Based on speed-flow relationships using SATURN outputs › Marginal congestion costs in 8 UK towns › Cost at current traffic level	› Based on different European case studies (UNITE, GRACE, TRENEN-II-STRAN, MC-ICAM, etc.) › Results represent 'Proposed ranges of marginal social cost prices' of congestion by road class and type of area (values represent maximum MSCP) › Cost at optimal traffic level (with optimal congestion charge)
VOT	› HEATCO, Differentiated: value for business and leisure	› HEATCO, differentiated by Business, Commuting, Other purposes
PCU	› Based on IMPACT (urban) › PCU HGV on the basis of the UK speed-flow relationship (interurban)	› PCU HGV depending on road type
Unit of measure	€2002/passenger, hour	€2000/vkm
Differentiation	› Differentiated per country › For countries without diff. values European average values used.	› Single value for EU 25, values have been adjusted acc. to VOT of different countries within the impact analysis

The table shows that no major differences can be observed in the data sets underlying the two approaches.

2.4 Accidents

The following table summarises the input values and data sets used for the evaluation of accident costs in the GRACE tool and in the IMPACT Handbook.

	GRACE tool	IMPACT handbook
Basis of data		
VOSL	› Based on HEATCO	› Based on UNITE (value of safety per se, direct and indirect economic costs)
Unit of measure	€/fatality and injury	€ct/vkm
Differentiation	› Level of injury: fatality, severe injury, slight injury › Type of road: motorway, urban road, non-urban road	› Level of injury: fatality, severe injury, slight injury › Type of road: motorway, urban road, other roads

The only difference concerns the VOSL, taken from the UNITE case studies in the IMPACT Handbook and from HEATCO in the GRACE tool.

2.5 Noise

The following table summarises the input values and data sets used for the evaluation of noise costs in the GRACE tool and in the IMPACT Handbook.

As for the accident case, the main difference concerns the data sets with monetary evaluations, taken from the INFRAS/IWW case studies in the IMPACT Handbook and from HEATCO in the GRACE tool.

	GRACE tool	IMPACT handbook
Basis of data	› Damage factors from HEATCO › Road vehicle specific noise level adjustment: Bickel	INFRAS/IWW 2004
Unit of measure	€ct/vkm	€ct/vkm
Differentiation	› Urban/non-urban › Day/night › Low background level/high background level › Peak/off-peak › Urban, suburban, rural › Values for EU 27	› Urban/non-urban › Day/night › Low background level/high background level › Peak/off-peak › Urban, suburban, rural › EU average value, which can be translated to other countries a defined value transfer procedure

3 Comparative review of the Handbook values and those generated by the GRACE tool

The comparison between the IMPACT recommended values and the GRACE tool estimates of external costs must consider the following important differences in the two approaches.

The GRACE tool has been basically designed for providing estimates at corridor (or node) level, taking into account the specific characteristics of a given link or node in terms of population density, noise background level, number of accidents, etc. On the other hand, the IMPACT recommended values represent the "central" average values between a minimum and a maximum, taking from literature review and involving several case studies and evaluations.

This implies that the criteria for comparing the two sets of results, i.e. a case study (as resulting from the GRACE tool) and an average value, as resulting from the Handbook is that the value of the case study must be included in the range of the recommended values, and, if not, taking in consideration the hypothesis that some value of the case study is influenced by site specific characteristics highly different from the average conditions.

For example, the follwiong table compares the GRACE estimations of external costs for a HGV > 18 ton with the recommended IMPACT values in day/peak and night traffic conditions. The estimations are expressed in €/vkm for travelling along the overall corridor, whose length is about 1,800 km and that can be divided in 8 segments, corresponding to four suburban areas (A14-A1 Bari-Bologna , A14 Bologna area, Milano-A9-Chiasso , A3 Bonn area) and four non urban segments (A14-A1 Bari-Bologna , A1 Bologna-Milano , A2 Chiasso-Basel , A3 Basel-Koln). The rationale in distinguishing between suburban and non urban segments lies in the different damage factors in the two contexts.

HGV Euro2	>18 t	Grace		Handbook's reccomended values					
Brindisi - Koln				Day/ Peak			Night		
		Day/ Peak	Night*	Central	Min	Max	Central	Min	Max
Congestion:	Motorway/ Suburban	**0,722**	**0,018**	0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural	**0,673**	**0,017**	0,350	0,000	0,700	0,000	0,000	0,000
Noise:	Suburban/ Rural	**0,006**	**0,029**	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution	Motorway	**0,121**	**0,121**	0,120	0,120	0,120	0,120	0,120	0,120
Global warming	Motorway	**0,022**	**0,022**	0,022	0,006	0,040	0,022	0,006	0,040
Accident	Motorway	**0,208**	**0,208**	0,027	0,000	0,035	0,027	0,000	0,035

** Congestion cost night = off peak*

The table shows that:

- concerning congestion costs and noise, the GRACE values are included within the ranges of the recommended IMPCT values

- concerning air pollution and global warming , the GRACE values are included to the recommended IMPACT values

- concerning accidents costs, the GRACE values are substantially higher than the recommended IMPACT values, i.e. 0,208 €/vkm against 0,027 €/vkm

This difference is in fact due to the sensitivity of the GRACE calculation to the specific values of accident risks at the segment level: the GRACE total corridor value of accident costs is thus influenced by the higher accidents costs along the Milano-Chiasso segment, for which, as showed in the table below, the accident value in equal to 1,035 €/vkm. The

HGV Euro2 >18 t		Grace		Handbook's reccomended values					
Milano - Chiasso suburban area				Day/ Peak			Night		
		Day/ Peak	Night*	Central	Min	Max	Central	Min	Max
Congestion:	Motorway/ Suburban								
	Motorway/ Rural	**0,724**	**0,010**	0,880	0,350	1,400	0,000	0,000	0,000
Noise:	Suburban/ Rural	**0,023**	**0,097**	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution	Motorway								
		0,090	**0,090**	0,120	0,120	0,120	0,120	0,120	0,120
Global warming	Motorway	**0,028**	**0,028**	0,022	0,006	0,040	0,022	0,006	0,040
Accident	Motorway	**1,035**	**1,035**	0,027	0,000	0,035	0,027	0,000	0,035

** Congestion cost night = off peak*

On the other hand, if we consider along the same corridor the segment corresponding to the Bonn urban area, the accident value does fall within the range of the IMPACT values, as shown in the table below, thus confirming the overall consistency of the two sets of figures.

HGV Euro2 >18 t		Grace		Handbook's reccomended values					
Bonn suburban area				Day/ Peak			Night		
		Day/ Peak	Night*	Central	Min	Max	Central	Min	Max
Congestion:	Motorway/ Suburban	**0,719**	**0,011**	0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural								
Noise:	Suburban/ Rural	**0,027**	**0,113**	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution	Motorway								
		0,133	**0,133**	0,120	0,120	0,120	0,120	0,120	0,120
Global warming	Motorway	**0,028**	**0,028**	0,022	0,006	0,040	0,022	0,006	0,040
Accident	Motorway	**0,033**	**0,033**	0,027	0,000	0,035	0,027	0,000	0,035

** Congestion cost night = off peak*

It can also be noted that the air pollution and global warming values at segment level, e.g. in the Bonn suburban area and Milano-Chiasso, differ from the average at total corridor level, to the extent that the segment values are influenced by the different damage values at country level (air pollution) and the different emissions level in the suburban areas.

4 Conclusions

The following table summarises the findings about methods, input data and evaluations of the IMPACT Handbook and the GRACE tool.

The conclusions by cost categories have been summarized in terms of an evaluation of the degree of harmonization between the IMPACT recommended values and the GRACE tool estimates of the transport external costs.

External cost categories	Degree of harmonization	Comparison of evaluations
Congestion	High	GRACE estimates included in the IMPACT ranges
Air pollution	High	GRACE estimates included in the IMPACT ranges
Climate change	High	GRACE estimates included in the IMPACT ranges
Noise	High	• GRACE estimates included in the IMPACT ranges, with the possibility to report variability due to particular conditions, e.g. high population density
Accident	Medium	• GRACE estimates may fall within or outside the IMPACT ranges, reflecting the sensitivity of the calculation to the specific values of accident rates on individual links.

ANNEX I: Detailed account of the harmonisation process

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Reviewing data requirements for running the GRACE tool, identification of the relevant corridors and urban areas to be analysed in the Workshop (March 2008)

The following tables specify for the urban and non urban (corridor) contexts, rail and road transport modes, the list of data required for running the GRACE tool. The tables were prepared and circulated among the Workshop experts in order to collect and discuss the relevant data for running the GRACE tool.

Urban area

Data required	Description	Unit of Measure	Period
1) Noise background level	It is the level of background noise present in the urban area as a whole	The following qualitative assessment is required: High ☐ Low ☐	The most recent evaluation
2) Exposed population	It is the resident population per km	Persons/km	The most recent evaluation
3) Average speed in Peak and Off peak hour	It is the average speed for a typical trip in Peak and Off peak hour	Km/h Peak Km/h Off Peak	The most recent evaluation
4) Accidents	It is the number of Fatality Severe injuries Slight injuries By: car HDV (including LDV)	Absolute number	The most recent evaluation (annual basis)
5) Flows	It is the number of cars and HDV (including LDV) * km travelling in the urban area	Cars*km/year HGV/LDV* km/year	The most recent evaluation (annual basis)
6) Km roads	It is the lengths of the urban roads	Km	The most recent evaluation (annual basis)

Corridor (road)

Data required	Description	Unit of Measure	Period
1) Noise background level	It is the level of background noise along the corridor	The following qualitative assessment is required: High ☐ Low ☐	The most recent evaluation
2) Road type	Indicate the type of road: Motorway urban Motorway non urban Main road urban Main road non urban		The most recent evaluation
3) Accidents	It is the number of Fatality Severe injuries Slight injuries By car HDV (including LDV)	Absolute number	The most recent evaluation (annual basis)
4) Flows	Indicate the number of cars and HGV/LDV * km travelling along the corridor/segment	Cars*km/year HGV/LDV* km/year	The most recent evaluation (annual basis)
5) Exposed population	It is the resident population per km along the corridor/segment	Persons/km	The most recent evaluation
6) Vehicles/h Peak, Off peak and Night	It is the number of vehicles travelling along the corridor (both direction) in peak, off peak and night time	PCU vehicles (passenger car unit) per hour	The most recent evaluation (annual basis)

Corridor (rail)

Data required	Description	Unit of Measure	Period
1) Noise background level	It is the level of background noise along the corridor	The following qualitative assessment is required: High Low	The most recent evaluation
2) Exposed population	It is the resident population per km along the corridor	Persons/km	The most recent evaluation
3) Km roads	It is the lengths of the rail corridor for Intercity/Freight and High Speed rail track	Km	The most recent evaluation (annual basis)

As follow up of the discussion, it was decided:

- to feed the GRACE tool with the case studies experts insights and, at a more general level, with the following sources:

  Noise and exposed population:
  http://www.eea.europa.eu/

  Accidents:
  http://ec.europa.eu/transport/roadsafety/road_safety_observatory/care_en.htm

  Flows:
  http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136228,0_45572945&_dad=portal

- to identify a number of relevant rail and road corridors at EU level and a number of urban areas.
  The corridors and the urban areas are the following:

1. Genova-Preston (road and rail)
2. Milan-Koln (road and rail)
3. Athens-Gothenburg (road and rail)
4. Barcelona-Warsaw (road and rail)
5. Rotterdam-Brussels (road and rail)
6. Paris-Wien (road and rail)
7. Paris-Brussels (road and rail)
8. Rotterdam-Constanza (rail)
9. Baltic Road corridor (rail)
10. Transalpine road corridor
11. Budapest and Gyor (road and rail)

12. Harwich to Swinford road corridor (UK)
13. Sevilla-Brussels (road)
14. Paris-Warsaw (road)
15. Brisndisi-Koln (road)
16. Hamburg-Gothenburg (road)

The urban areas are the following (road):

1. Trondheim
2. Milan
3. Rome
4. Brussels
5. London

- to invite the following experts to discuss the results during the Workshop:

    - Nathan Bowden (TNO) for the Rotterdam-Constanza rail corridor
    - Chrstophe Liebe (ECOPLAN) for the Transalpine road corridor
    - Karsten Sten Pedersen (COWI) for the Baltic rail corridor
    - Adam Torok (BUTE) for the Budapest /Gyor corridor
    - Peter Sellen, Department for Transport (UK) for the Harwich to Swinford road corridor
    - Angleo Martino(TRT, Italy) for the Milan urban area
    - Terje trevtik (SINTEF) for the Throndhem urban areas

Preliminary assessment of the external costs values obtained running the GRACE software compared with the IMPACT Handbook recommended values (March 2008)

In order to start the analysis, a preliminary assessment of the external costs estimated in the two case studies presented in the GRACE D7, i.e. the road corridor Milan-Rotterdam and the Central London area, was carried out. The preliminary assessment focused on the comparison of the GRACE estimations with the IMPACT Handbook recommended values.

The following tables show the results with reference to Car (diesel and petrol) and HGV:

a) The Milan-Rotterdam case study

Car petrol

The following tables compare the overall external costs in €vkm along the **total corridor** for a medium car fuel type petrol 1.4-2L Euro 2 standard (interurban trip).

For a meaningful interpretation of the comparison, it should be noted that:

- the external cost categories considered are homogenous, i.e. wear and tear costs (estimated in the GRACE tool) and nature & landscape and soil & water consumption (estimated in IMPACT) are not included. Up and downstream processes (estimated separately in IMPACT) are included in the air pollution costs in GRACE (through fuel and electricity production costs).
- the external costs categories in IMPACT are classified by peak (day) and night, given that the only external cost category showing different values in off peak traffic conditions is congestion (which is then equal to 0).
- Congestion costs in GRACE have been estimated based on an average traffic composition of 50%-50% between business and leisure along the corridor
- Figures in IMPACT are generally at € 2000, while in GRACE the general time reference is € 2002 (with some minor departure).

Interurban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.006	0.01	0.029
Congestion	0.141	0.002	0.001
Accident	0.008	0.008	0.008
Air pollution	0.003	0.003	0.003
Climate change	0.005	0.005	0.005
	0.163	**0.028**	**0.046**

Interurban petrol IMPACT car 1.4-2L.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.001	0.000	0.001	0.002	0.001	0.002
Congestion	0.100	0.000	0.200	0.000	0.000	0.000
Accident (average cond.)	0.016	0.000	0.026	0.016	0.000	0.026
Air pollution * (average cond.) and Up and Down	0.007	0.007	0.013	0.007	0.007	0.013
Climate change (average cond.)	0.004	0.001	0.008	0.004	0.001	0.008
	0.129	0.009	0.247	**0.036**	0.016	0.060

The tables show a general consistency of the estimates, as shown by the fact that the GRACE values (total external costs) are included in the range of IMPACT values. Not surprisingly, noise and congestion costs (two among the most controversial external costs categories) show the higher gaps. The GRACE congestion costs in peak traffic condition are however included in the IMPACT range.

It is interesting to show the sensitivity of the specific GRACE **national segments** of the Milan-Rotterdam corridor with respect to the IMPACT recommended values (car fuelled by petrol, 1.4-2L.)

Milano-Chiasso
Interurban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.007	0.011	0.035
Congestion	0.147	0.002	0.001
Accident	0.015	0.015	0.015
Air pollution	0.003	0.003	0.003
Climate change	0.005	0.005	0.005
	0.177	**0.036**	**0.059**

Chiasso-Basilea
Interurban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.004	0.007	0.021
Congestion	0.194	0.003	0.001
Accident	0.008	0.008	0.008
Air pollution	0.003	0.003	0.003
Climate change	0.005	0.005	0.005
	0.214	**0.026**	**0.038**

Basel-Duisburg
Interurban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.005	0.009	0.027
Congestion	0.123	0.002	0.001
Accident	0.008	0.008	0.008
Air pollution	0.003	0.003	0.003
Climate change	0.005	0.005	0.005
	0.144	**0.027**	**0.044**

Duisburg-Rotterdam
Interurban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.009	0.014	0.043
Congestion	0.122	0.002	0.001
Accident	0.006	0.006	0.006
Air pollution	0.003	0.003	0.003
Climate change	0.005	0.005	0.005
	0.145	**0.030**	**0.058**

Interurban petrol IMPACT car 1.4-2L.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.001	0.000	0.001	0.002	0.001	0.002
Congestion	0.100	0.000	0.200	0.000	0.000	0.000
Accident (average cond.)	0.016	0.000	0.026	0.016	0.000	0.026
Air pollution * (average cond.) and Up and Down	0.007	0.007	0.013	0.007	0.007	0.013
Climate change (average cond.)	0.004	0.001	0.008	0.004	0.001	0.008
	0.129	0.009	0.247	**0.036**	0.016	0.060

The Milano-Chiasso and Chiasso-Basel segments suffer of the higher congestion and accident costs, due to the presence of the highly urbanized areas nearby Milan (along the Milano-Chiasso route). In such cases the total external costs approximate the higher range of the IMPACT values (on the Chiasso-Basel segment)

Car diesel

The same considerations hold in the case of a medium car fuelled by diesel, as shown in the table below (total corridor estimates).

Interurban petrol GRACE car diesel

	Peak	Off-Peak	Night
Noise	0.006	0.01	0.029
Congestion	0.141	0.002	0.001
Accident	0.008	0.008	0.008
Air pollution	0.007	0.007	0.007
Climate change	0.004	0.004	0.004
	0.166	**0.031**	**0.049**

Interurban petrol IMPACT car diesel 1.4- 2L.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.001	0.000	0.001	0.002	0.001	0.002
Congestion	0.100	0.000	0.200	0.000	0.000	0.000
Accident (average cond.)	0.016	0.000	0.026	0.016	0.000	0.026
Air pollution * (average cond.) and Up and Down	0.013	0.013	0.027	0.013	0.013	0.027
Climate change (average cond.)	0.004	0.001	0.007	0.004	0.001	0.007
	0.134	0.015	0.261	**0.040**	0.020	0.071

HGV

The HGV considered in GRACE is a typical HGV > 18 tons Euro 2, 4 or 5. In order to compare the results with the IMPACT HGV (> 32 tons, Euro 3), the GRACE air pollution and global warming external costs have been averaged between the Euro 2 and 3 results.

Interurban petrol GRACE HGV>18

	Peak	Off-Peak	Night
Noise	0.038	0.063	0.190
Congestion	0.746	0.010	0.005
Accident	0.056	0.056	0.056
Air pollution	0.022	0.022	0.022
Climate change	0.019	0.019	0.019
	0.881	**0.170**	**0.292**

Interurban petrol IMPACT HGV Euro 3.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.011	0.004	0.011	0.020	0.007	0.020
Congestion	0.350	0.000	0.700	0.000	0.000	0.000
Accident (average cond.)	0.027	0.000	0.035	0.027	0.000	0.035
Air pollution * (average cond.) and Up and Down	0.112	0.112	0.281	0.112	0.112	0.281
Climate change (average cond.)	0.022	0.006	0.040	0.022	0.006	0.040
	0.522	0.122	1.067	**0.208**	0.152	0.443

As for the passenger cars, the GRACE total external costs are included in the range of the IMPACT values. With reference to the recommended values, the higher GRACE external costs reflect the higher estimations for congestion, noise and accident external costs, while the reverse happens with air pollution external costs.

Milano-Chiasso
Interurban petrol GRACE HGV>18

	Peak	Off-Peak	Night
Noise	0.046	0.076	0.230
Congestion	0.724	0.011	0.004
Accident	0.115	0.115	0.115
Air pollution	0.022	0.022	0.022
Climate change	0.019	0.019	0.019
	0.926	**0.243**	**0.390**

Chiasso-Basel
Interurban petrol GRACE HGV>18

	Peak	Off-Peak	Night
Noise	0.028	0.046	0.138
Congestion	1.001	0.012	0.005
Accident	0.078	0.078	0.078
Air pollution	0.027	0.027	0.027
Climate change	0.019	0.019	0.019
	1.152	**0.181**	**0.266**

Basel-Duisburg
Interurban petrol GRACE HGV>18

	Peak	Off-Peak	Night
Noise	0.036	0.059	0.178
Congestion	0.657	0.009	0.004
Accident	0.050	0.050	0.050
Air pollution	0.022	0.022	0.022
Climate change	0.019	0.019	0.019
	0.784	**0.159**	**0.273**

Duisburg-Rotterdam
Interurban petrol GRACE HGV>18

	Peak	Off-Peak	Night
Noise	0.058	0.095	0.287
Congestion	0.660	0.009	0.004
Accident	0.028	0.028	0.028
Air pollution	0.023	0.023	0.023
Climate change	0.019	0.019	0.019
	0.788	**0.174**	**0.361**

Interurban petrol IMPACT HGV Euro 3.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.011	0.004	0.011	0.020	0.007	0.020
Congestion	0.350	0.000	0.700	0.000	0.000	0.000
Accident (average cond.)	0.027	0.000	0.035	0.027	0.000	0.035
Air pollution * (average cond.) and Up and Down	0.112	0.112	0.281	0.112	0.112	0.281
Climate change (average cond.)	0.022	0.006	0.040	0.022	0.006	0.040
	0.522	0.122	1.067	**0.208**	0.152	0.443

The situation in the specific segments of the corridor may in part explain the gaps: in the segment Milano-Chiasso and Chiasso-Basel, the high congestion and accident external costs make the total external costs higher than the upper range of the IMPACT bandwidth.

b) The London case study

Car petrol

This case study concerns the central London area as defined by the congestion charging scheme.

Urban petrol GRACE car petrol

	Peak	Off-Peak	Night
Noise	0.007	0.009	0.024
Congestion	2.756	0	0
Accident	0.178	0.178	0.178
Air pollution	0.003	0.003	0.003
Climate change	0.004	0.004	0.004
	2.948	**0.194**	**0.209**

Urban petrol IMPACT car 1.4- 2L.

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.008	0.008	0.019	0.014	0.014	0.034
Congestion	2.000	1.500	3.000	0.000	0.000	0.000
Accident (average cond.)	0.041	0.000	0.065	0.041	0.000	0.065
Air pollution * (average cond.) and Up	0.011	0.011	0.016	0.011	0.011	0.016

and Down						
Climate change (average cond.)	0.007	0.002	0.012	0.007	0.002	0.012
	2.067	1.521	3.111	**0.083**	0.037	0.139

The comparison considers the IMPACT central reference values for congestion in urban areas (local street centre) with the resident population higher that 2 millions of inhabitants (as in the case of London).

A general consistency in the total external costs (peak traffic conditions) and noise can be observed. The IMPACT air pollution and global warming external costs show higher values.

Car diesel

The comparison for a typical diesel car shows a trend similar to the petrol cars. Diversely from the petrol cars, however, the external costs of air pollution do not diverge significantly.

Interurban petrol GRACE car diesel

	Peak	Off-Peak	Night
Noise	0.007	0.009	0.024
Congestion	2.756	0	0
Accident	0.178	0.178	0.178
Air pollution	0.018	0.018	0.018
Climate change	0.003	0.003	0.003
	2.962	**0.208**	**0.223**

Urban petrol IMPACTcar diesel

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.008	0.008	0.019	0.014	0.014	0.034
Congestion	2.000	1.500	3.000	0.000	0.000	0.000
Accident (average cond.)	0.041	0.000	0.065	0.041	0.000	0.065
Air pollution * (average cond.) and Up and Down	0.021	0.021	0.037	0.021	0.021	0.037
Climate change (average cond.)	0.005	0.001	0.009	0.005	0.001	0.009
	2.075	1.530	3.130	**0.088**	0.043	0.155

HGV

The comparison for HGV confirms the consistency of the evaluation (being the GRACE evaluations included in the IMPACT range), together with the lower air pollution estimates in GRACE (similar to the trend observed for cars) and the higher accident costs.

Interurban petrol GRACE HGV diesel

	Peak	Off-Peak	Night
Noise	0.062	0.082	0.214
Congestion	5.511	0.000	0.000
Accident	0.081	0.081	0.081
Air pollution	0.044	0.044	0.044
Climate change	0.016	0.016	0.016
	5.714	**0.223**	**0.355**

Urban diesel IMPACT HGV Euro 3

	Peak/Day	Min	Max	Night	Min	Max
Noise	0.070	0.070	0.170	0.128	0.128	0.310
Congestion	3.000	4.000	6.000	0.000	0.000	0.000
Accident (average cond.)	0.105	0.000	0.139	0.105	0.000	0.139
Air pollution * (average cond.) and Up and Down	0.112	0.112	0.281	0.112	0.112	0.281
Climate change (average cond.)	0.022	0.006	0.040	0.022	0.006	0.040
	3.309	4.188	6.630	**0.394**	0.273	0.837

The following preliminary conclusion were then reached, setting the stage for the harmonization

- The preliminary analysis shows a general consistency between the GRACE tool evaluations and the IMPACT Handbook values. The GRACE estimations in fact systematically fall within the range proposed by the IMPACT review, with the exception of the Chiasso-Basel corridor (HGV), higher than the upper value of IMPACT bandwidth (1.152 vs 1.067).

- For some cost categories, e.g. total external costs for passenger cars (petrol), the GRACE estimations slightly exceed (+20%) the IMPACT recommended value

- The gap between the GRACE and IMPACT estimations rises for HGV, for which congestion, accident and noise external costs represent the most important divergent values. In such a case, the sensitivity of the external costs evaluations to the site-specific conditions are deemed as the most important factors explaining the gaps

Developing the supporting activities to the harmonization of the IMPACT Handbook values with the GRACE calculation tool (April 2008)

A Call for Tender for a service study on the harmonization between IMPACT and GRACE was launched on February 2008 in order to support ISIS in the harmonization exercise. The contractor should have provided the following tasks:

a) assisting ISIS in data collection for running the case studies through the GRACE tool
b) reporting on results
c) helping to solve inconsistencies
d) participation to a dedicated Workshop in Brussels

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CE DELFT and INFRAS provided the best offer for the service study. The contents of the service included the following tasks:

- Task 1 Reaction to the report drafted by ISIS.
- Task 2 Discussion session with ISIS + participation to the workshop with 'technical people'.
- Task 3 Reaction to the report drafted by ISIS.
- Task 4 Contribution/participation to final conference.

On April 22 the technical meeting with the contractor took place at ISIS premises in Rome. Topics of the meeting were:

- Reviewing differences in methods
- Reviewing differences in input values and external costs evaluations
- Differences in the level of differentiation of results

Differences in methods

Congestion (road)

The following table summarises the two approaches adopted in the IMPACT Handbook and in the GRACE tool.

IMPACT	GRACE
$MEC_{Cong}(Q) = \frac{VOT \cdot Q}{v(Q)^2} \cdot \frac{\partial v(Q)}{\partial Q}$ With: VOT: Value of Time (€ / veh.-hour) Q: Current traffic level (veh./hour) v(Q): Speed-flow function (km/hour) MEC_{Cong}: Marginal external congestion costs	$MECC = -\frac{Q}{S^2}\frac{\delta S}{\partial Q}v$ Reference speed flow curve based on the UK speed-flow relationships for different road types where S = speed; Q = flow; v=value of time

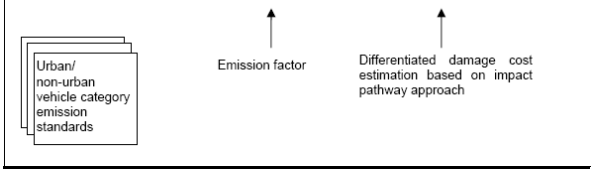
The formal equation is the same in the two approaches. However, the speed-flow functions are different: based on the German EWS speed-flow in the IMPACT Handbook and on the UK speed-flow in GRACE (interurban case).

Furthermore, the assessment of urban congestion costs in GRACE is based the SATURN outputs (eight UK cities).

Another difference is in the potential use of the congestion costs evaluations in terms of charging policies: the IMPACT recommended congestion costs result in fact from an equilibrium iterative process with traffic flows and can be used consequently for charging the congestion costs at the optimum. On the other hand, the GRACE congestion costs do not consider the traffic reactions arising from price elasticity of demand.

Air pollution

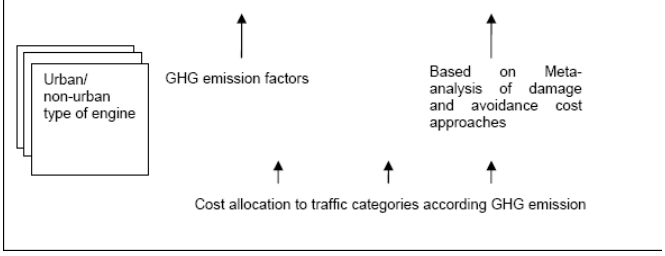
The methodological approach for the assessment of air pollution external costs is the same as in the IMPACT Handbook and in the GRACE tool.

IMPACT	GRACE
External Air Pollution Costs = specific emission * Cost factor per pollutant  	$C_{AP} = \sum_P [(EF_{dir}(m, v, l, p) * DF_{dir}(c, m, l, p) + FC(m, v, l, f) * DF_{FP}(c, m, f))]$ C_{AP} = Costs due to air pollution [€/vkm] EF_{dir} = emission factor – direct emissions [g/vkm] DF_{dir} = damage factor – direct emissions [€/g] FC = fuel or electricity consumption factor [g/vkm or kWh/train-km] DF_{FP} = damage factor –fuel production [€/g or €/kWh] m = mode v = vehicle technology (including vehicle/vessel/aircraft type, fuel type, emission standard) l = location (urban, non-urban) p = pollutant ($PM_{2.5}$, NO_x, SO_2, NMVOC) c = country f = fuel type (electricity, petrol, diesel, …)

The only difference, affecting data rather than evaluation methods, is that the GRACE air pollution evaluations also include the indirect costs, i.e. air pollution costs arising from the fuel production. In order to ensure comparability, the GRACE tool evaluation should separate the air pollution marginal costs assessment into indirect costs (Up and down steam costs) and direct air pollution costs.

Global warming

As for the air pollution, the methodological approach for the assessment of global warming external costs is the same in the IMPACT Handbook and in the GRACE tool..

IMPACT	GRACE
External Climate Change Costs = Specific GHG-emissions* External cost factor of CO_2 equivalent  	$C_{GW} = \Sigma (EF_{dir}(m, v, g, l) * DF_{dir}(m, g) + FC(m, v, f, l) * DF_{FP}(m, f))$ C_{GW} = Costs due to global warming from greenhouse gas emissions [€/vkm] EF_{dir} = emission factor – direct emissions [g / vkm] DF_{dir} = damage factor – direct emissions [€ / g] FC = fuel or electricity consumption factor [g / vkm] DF_{FP} = damage factor –fuel production [€ / g] m = mode v = vehicle technology (including vehicle/vessel/aircraft type, fuel type, emission standard) g = greenhouse gas (CO_2) l = location (urban, non urban.) f = fuel type (electricity, petrol, diesel, …)

Noise

The two approaches are similar: the bottom up approach developed in the INFRAS case studies has been used as reference case for deriving the IMPACT values. The approach is consistent with the GRACE noise cost function approach, i.e. identifying the key drivers (exposed population, location, time of the day, etc), in order to estimate the noise marginal cost.

IMPACT	GRACE
The bottom-up approach is developed in the ExternE-project and is generally called the 'Impact Pathway Approach'. The starting point of this approach is the micro level, i.e. the traffic flow on a particular route. Two scenarios are calculated: a reference scenario reflecting the present scenario with traffic volume, speed distribution, vehicle technologies, etc., and a marginal scenario which is based on the reference scenario, but includes one additional vehicle. The difference in damage costs of both scenarios represents the marginal external noise costs of that vehicle.	In the Grace tool we use the following formula: $C_N = NLI(l, t, b, s) * VA(v, l) * Pop (l) * DF(b, c)$ In which: C_N = Costs due to noise [€/vkm] NLI = noise level increment due to one additional reference vehicle [dB(A)] VA = road vehicle specific noise level adjustment Pop = exposed population [persons / km] DF = damage factor [€ / (dB(A) / person] l = location (urban, non-urban) t = time of day (day, night) b = background noise level (high, low) s = situation (peak, off-peak) v = vehicle type (passenger car, HGV, intercity train, high speed train, goods train,) c = country

However, the following methodological aspects in the GRACE approach need to be clarified:

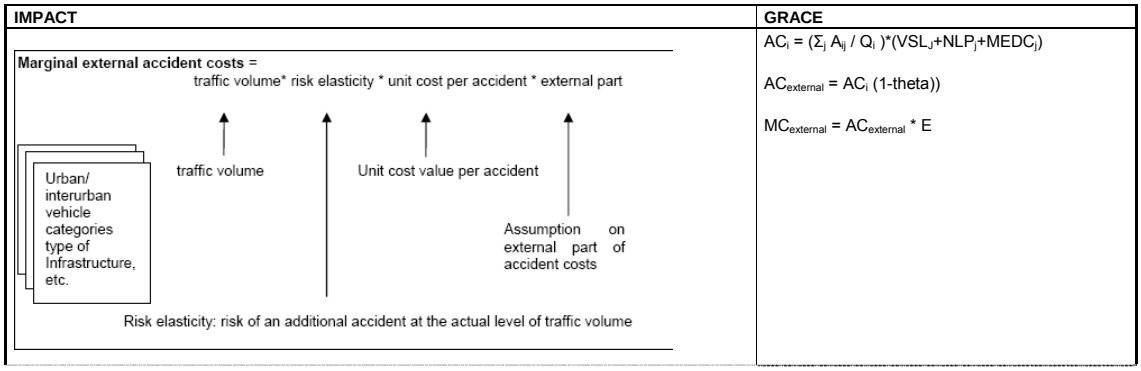
- the GRACE exposed population (in person per linear kilometre) need to be specified, i.e. what is the distance from the noise emitting source considered ? Is it the same in the urban and non urban context ?

- the GRACE NLI parameter, deriving the noise level increment due to one additional reference vehicle [dB(A)] per noise background level, time of the day, traffic intensity and type of road, needs to be specified with reference to the

background methodological sources, i.e. how the NLU have been assessed ? On the basis of what assumptions ?

Accidents

The methodological issues arising from the comparison of the IMPACT Handbook and the GRACE tool concerning the marginal external cost of accidents are similar to the noise case. In both cases the IMPACT recommended values are derived from case studies; i.e. the UNITE and GRACE case studies following a bottom-up approach for the accident, while the GRACE methodological approach tries to derive a cost function using the key drivers drawn from literature review.



The methodological aspect that needs to be further investigated is the risk elasticity due to traffic increase. The GRACE approach in fact uses just one coefficient by type of vehicle without differentiation for the type of road. Further research is needed for deriving such coefficient at least for urban (road type) and non urban areas (motorways).

Differences in input values and external costs evaluation

Congestion (road)

	GRACE tool	IMPACT Handbook
Basis of data	• Based on speed-flow relationships using SATURN outputs (urban) • Marginal congestion costs in 8 UK towns (urban)	• Based on different European case studies (UNITE, GRACE, TRENEN-II-STRAN, MC-ICAM, etc.)
VOT	HEATCO value for business and leisure	HEATCO, differentiated by Business, Commuting, Other purposes
PCU	Input by the user by road type (interurban)	PCU for HGV depending on road type
Unit of measure	€2002/passenger, hour	€2000/vkm

The overall results of the GRACE tool[1] are consistent with the range of recommended values of the IMPACT Handbook. Both approaches use the VOT from HEATCO.

Air pollution

	GRACE tool	IMPACT Handbook
Basis of data	• HEATCO	• For PM2.5 and PM10: HEATCO • NOx, NMVOC, SO2: CAFÉ CBA
Emission factors	Road: Data are based on German conditions and include cold start (source: HBEFA (Handbuch Emissionsfaktoren des Straßenverkehrs, Handbook emission factors for road transport, UBA 2004) Vehicle technology: EUROII, EUROIV, EUROV. Rail: source: UCTE Air: EMEP/CORINAIR Emission Inventory Guidebook – 2006 IWW: TREMOVE Base case Maritime: ENTEC (2005)	TREMOVE version 2.4.1 Vehicle technology: Euro standards EURO 0-V (all modes)
Pollutant	• NOx, CO2, PM 2.5 exhaust, NMVOC, SO2 • PM non-exhaust not included	All PM emissions included (for non exhaust emissions PM10 figures of HEATCO
Unit of measure	€ 2002/g of emissions	€ 2000/t of pollutant

The comparison shows the different reference values in the emission factors and damage factors used in the IMPACT Handbook and in the GRACE tool. In particular:

- PM2.5 urban: GRACE values for urban areas lie slightly above IMPACT values for "urban metropolitan" and about a factor 3 above "urban" values (depends on the definition of urban: HEATCO urban values represent rather 'urban metropolitan' values than 'urban values'
- Germany: GRACE: 0.434 €2002/g (urban), IMPACT: 0.384 €2000/g (=0.389 €2002)
- Sweden: GRACE: 0.438 €2002/g (urban), IMPACT: 0.352 €2000/g (=0.361 €2002/g)

[1] Tested on the road corridor Milan-Rotterdam

- PM2.5 non-urban: GRACE values lie slightly above IMPACT values:
- Germany: GRACE: 0.08 €2002/g (non-urban), IMPACT: 0.075 €2000/g (=0.076 €2002/g)
- Sweden: 0.04 €2002/g (non-urban), IMPACT: 0.034 €2000/g (= 0.035 €2002/g
- NOx: IMPACT value are about a factor 2 higher than GRACE values (for some countries even more), Reason: valuation of secondary particles different, IMPACT based on CAFÉ CBA, GRACE based on HEATCO/ExternE. ExternE considers secondary particles as less toxic than CAFÉ CBA)
- NMVOC: Values differ between countries, for some countries GRACE values are abo ve IMPACT values, for others below, Reason: IMPACT applies CAFÉ values.
- Germany: GRACE: 1126 €2002/t, IMPACT: 1700 €2000/t (=1720 €2002/t)
- Italy: GRACE: 1570 €2002/t, IMPACT: 1100 €2000/t (=1119.8 €2002/t)
- Sweden: GRACE: 256 €2002/t, IMPACT: 300 €2000/t (=302 €2002/t)
- SO2: IMPACT values are about a factor 2 higher than GRACE values (for some countries even more),:
- Germany: GRACE: 4450 €2002/t, IMPACT: 11'000 €2000/t (=11'132 €2002/t)
- Sweden: GRACE: 1020 €2002/t, IMPACT: 4'300 €2000/t (=4333.8 €2002/t).

Furthemore, the GRACE PM external costs do not include the damage evaluation from the non-exhaust emissions and have not been provided in the metropolitan areas (a sort of intermediate level between urban and non urban areas).

All these factors may explain the systematic lower values of air pollution costs in GRACE, compared to the IMPACT Handbook.

Summing up, the actions suggested for ensuring better harmonization are,
a) the inclusion of non-exhaust air pollution external costs,
b) the use of the IMPACT damage costs evaluation;
c) the differentiation of air pollution costs in urban, non urban and metropolitan areas (under the "Non Urban Area" in the GRACE main menu).

Another difference already mentioned above is that the GRACE tool does not separately show Up and Down stream air pollution costs (which are however included).

Global warming

	GRACE tool	**IMPACT Handbook**
Basis of data	• HEATCO, central estimation	• Based on comprehensive literature review and on experience with EU ETS
Pollutant	CO2	CO2

The only difference in reference data is that GRACE uses the shadow price – central estimate of 22 €2002/tonne of CO2 equivalent emitted (factor price) along the years of emission 2000-2009, while the recommended values in IMPACT are projected at 2010-2020-2030-3040-2050 (€/tonnne of CO2).

Concerning the external climate change cost evaluation, the overall results of the GRACE tool[2] are consistent with the range of recommended values of the IMPACT Handbook.

Noise

	GRACE tool	IMPACT Handbook
Basis of data	• Damage factors from HEATCO • Road vehicle specific noise level adjustment: GRACE partner	• Damage factors from INFRAS/IWW case studies (INFRAS/IWW 2004)
Unit of measure	• €/vkm	• €ct/vkm

The following table compares the IMPACT Handbook and the GRACE tool marginal noise costs in various situations.

	Time of day	Urban	Suburban
Car IMPACT values	Day	**0.76** (0.76 – 1.85)	**0.12** (0.04 – 0.12)
	Night	**1.39** (1.39 – 3.37)	**0.22** (0.08 – 0.22)
Car GRACE values	Day	High background level: 1.5 – 2.1 Low background level: 2.1 -3.1	High background level: 0.31 – 0.36 Low background level: 0.26 – 0.42
	Night	High background level: 4.56 Low background level: 5.41	High background level: 1.2 Low background level: 1.3
HGV IMPACT values	Day	**7.01** (7.01 – 17.00)	**1.10** 0.39 – 1.10
	Night	**12.78** (12.78-30.98)	**2.00** 0.72 – 2.00
HGV GRACE values	Day	High background level: 10.4-13.7 Low background level: 13.5-20.3	High background level: 1.5 – 1.8 Low background level: 1.3 – 2.1
	Night	High background level: 30.2 Low background level: 35.8	High background level: 6.3 Low background level: 6.4

- For cars, the day values of GRACE for urban areas lie close to the upper bandwidth of the IMPACT values or slightly above. For suburban areas, the GRACE values lie three times above the IMPACT values. The night values of GRACE lie above IMPACT values in both urban and suburban areas.
- For HGV, the day values for urban areas lie in about the same range than IMPACT values. Day values for cars in suburban areas are slightly higher. The night values for HGV lie above IMPACT values in both situations.

In general, it can be said that the GRACE tool values are higher than the IMPACT ones, in particular for cars. However, it is worthwhile to stress that the values are highly sensitive to the assumptions on exposed population.

Further research about the methodological assumptions behind the exposure population in GRACE is needed.

[2] Tested on the road corridor Milan-Rotterdam

Accidents

	GRACE tool	IMPACT Handbook
Basis of data	• CARE database, accident rates	• UNITE and GRACE case studies
VOSL	• Based on HEATCO UNITE cost value in €2002 (values expressed in PPP factor prices). It includes: VSL + other direct and indirect costs (medical costs, net production losses, administrative costs), (VSL based on UNITE assumptions) • Moreover, a factor has been applied in order to include material cost, respectively: Fatality: 0.8 Severe injuries: 0.25 Slight injuries 0.55	• Based on UNITE (value of safety per se, direct and indirect economic costs) €2000. It considers: • Fatality: VSL average value: €1.5 million • Severe injuries: 13% of VSL • Slight injuries: 1% of VSL
Unit of measure	• €/fatality and injury/vkm	• €ct/vkm

The comparison in terms of order of magnitude of the VOSL shows that the IMPACT Handbook and the GRACE tool have the same order of magnitude. For some countries, the IMPACT values lie slightly below the GRACE values, for other countries above. Furthermore,

- Severe injury: Values of GRACE lie above IMPACT values, for some countries up to15% higher.
- Slight injury: Values of GRACE lie considerably above IMPACT values, for some countries up to 50%

The comparison of the external cost evaluation shows that the GRACE values lie below the IMPACT values (car) and above the IMPACT values (HGV and urban car). Given that no significant difference have been found for the VOSL, the other important variable explaining the difference is the accident risk (however highly site-dependent). Further analysis is then required in order to differentiate the accident risk by type of road.

Differences in the level of differentiation of results

Congestion (road)

	GRACE tool	IMPACT Handbook
Differentiation	• Differentiated per country (VOT). For countries non EU 27 an average European values has been used • Location: Interurban, urban • Time period: Peak – off-peak • Network type: different road types • Time period: Peak, off-peak, night • Vehicle type: car, HGV	• Single value for EU 25, values have been adjusted acc. to VOT of different countries within the impact analysis • Road: • Location: Interurban, urban, metropolitan • Network type: different road types • Time period: Peak, off-peak • Vehicle type: car, HGV

No particular difference has been identified.

Air pollution

	GRACE tool	IMPACT Handbook
Differentiation	• Specific data for EU 27, other countries: EU average. For PM2.5: differentiation into urban, non-urban • <u>Road:</u> • Location: urban, interurban, motorway • Vehicle technology: EUROII, EURO IV, EURO V. • Vehicle type: car (medium size), HGV (<18t, >18t), LGV (urban) • Fuel type: petrol, diesel • Type of pollutants: NOx, NMVOC, SO2, PM 2.5 • <u>Rail:</u> • Location: interurban • Vehicle type: passenger, freight • Fuel type: electric • Technology type: Intercity ,	• EU 27 • For PM2.5 and non-exhaust PM10 into urban metropolitan, urban and outside built-up areas, for exhaust PM10 into Urban metropolitan and Outside built-up areas • <u>Road:</u> • Location: metropolitan, urban, interurban, motorway • Vehicle technology: Euro standard (0-V) • Vehicle type: car (>1.4l, 1.4-2l, >2l), HGV (<7.5t, 7.5-16t, 16-32t, >32t) • Fuel type: petrol, diesel • Type of pollutants: NOx, NMVOC, SO2, PM 2.5 • <u>Rail:</u> • Location: metropolitan, other urban, non urban

	GRACE tool	IMPACT Handbook
	HS train, goods train • Inland Waterways: • Different ship type • Type of pollutants: NOx, NMVOC, SO2, PM 2.5 • Air: • Different airplane types • Type of pollutants: NOx, NMVOC, SO2, PM 2.5 • Emissions calculated at airport (basing on Frankfurt case study) • Short Sea Shipping • Different vessel type • Type of pollutants: NOx, NMVOC, SO2, PM 2.5	• Vehicle type: passenger, freight • Fuel type: electric, diesel • Vehicle type: locomotive, railcar, HS train • Inland Waterways: • Different ship type • Air: • Emissions calculated for different flight distance

The most significant differences in terms of differentiation of results are the following:

- differentiation by urban, non urban and metropolitan areas in the IMPACT Handbook (only urban and non urban in the GRACE tool)
- classification of HGV vehicle type in four categories (<7.5t, 7.5-16t, 16-32t, >32t) in the IMPACT Handbook (only two categories in the GRACE tool; > and< 18t)

Rail air pollution costs in IMPACT differentiate diesel and electricity, while in GRACE only electricity trains are considered (due to the non significant share of diesel train in Europe).

Global warming

	GRACE tool	IMPACT Handbook
Differentiation	• No differentiation for short and long term	• Differentiation for different years of application

The differentiation by long term impacts in IMPACT does not represent a significant drawback, due to the possibility to change the reference values through the GRACE tool in sensitivity analysis.

Noise

	GRACE tool	IMPACT Handbook
Differentiation	• Road: • Network type: urban, motorways, non urban • Time period: day, night	• Road: • Location: urban, suburban, rural • Time period: day, night

	• Traffic condition: peak, off-peak, night • Vehicle type: car, LGV, HGV • Rail: • Location: interurban • Time period: day, night • Vehicle type: passenger, freight • Technology type: Intercity , HS train, goods train • Air: • Different airplane type • Time period: day, night • Activity: landing, take-off	• Vehicle type: car, MC, bus, LGV, HGV • Rail: • Location: urban, suburban, rural • Time period: day, night • Vehicle type: passenger, freight • Air: • Different airplane type • Time period: day, evening, night • Activity: landing, take-off

The differentiation proposed in the IMPACT Handbook and in the GRACE tool is similar. The GRACE tool differentiates the results by urban and non urban (motorways) areas, while the IMPACT Handbook provides differentiation by urban, suburban and rural areas. However, the approximation to the IMPACT Handbook suburban and rural areas can be obtained through the sensitivity option of the GRACE tool, by changing the population exposure value according to the IMPACT thresholds for suburban and rural areas.

Accidents

	GRACE tool	**IMPACT Handbook**
Differentiation	• Road: • Vehicle type: car, HGV • Network type: urban, motorways, non urban • Country	• Road: • Vehicle type: car, motorcycle, HGV • Network type: urban, motorways, other road • Country • Rail: • European average value

No particular difference has been identified. The GRACE tool do not include rail, air and waterborne marginal external costs of accidents (considered negligible).

Preliminary conclusions

The following table summarises the findings about methods, input data and level of differentiation as identified after a first comparison between the IMPACT Handbook and the GRACE tool.

The preliminary conclusions by cost categories have been summarized in terms of an evaluation of the current degree of harmonization between the IMPACT recommended

values and the GRACE tool estimates of the transport external costs (the second column of the table). The third column of the table shows the corresponding actions affecting the GRACE tool, to be carried out in order to improve the degree of harmonization. The actions will be undertaken before the technical Workshop on May 22.

External cost categories	Degree of harmonization	Actions affecting the GRACE tool
Congestion	High	No actions required
Air pollution	Medium	• To separate air pollution costs in direct and indirect (up & downs stream) costs • To include the air pollution costs in metropolitan areas • To include the non exhaust emission factors • To harmonize the emission factors with the IMPACT values • To harmonize the damage factors (monetary evaluation) with the IMPACT values
Climate change	High	No actions required
Noise	Medium	• To specify the methodological assumptions behind the population exposure index and the NLI (noise level increment due to one passenger car)
Accident	Medium	• To differentiate the accident elasticity risk by type of road

Concerning the other external costs categories, it is worthwhile to stress that the GRACE tool will try to address the issue of the order of magnitude of the external costs (road) in sensitive areas, using the findings of the GRACE case study.

4 Outcome of the Workshop (May 2008)

In preparation of the May 22nd workshop with the EC in Brussels, four road corridors were set up:

1. Paris –Warsaw, crossing five countries (including three suburban areas) for a total of 2163 km
2. Sevilla-Brussels, crossing three countries (including two suburban areas) for a total of 2124 km
3. Brindisi-Colonia, crossing three countries (including three suburban areas) for a total of 1836 km
4. Hamburg-Gothenburg, crossing three countries (including two suburban areas) for a total of 612 km

It is assumed that none of the corridors imply that vehicles enter into the city centres, while all of them pass in the vicinity of cities (suburban). Therefore, although the GRACE tool does allow to differentiate between rural, suburban and urban, only the rural and suburban classes have been used.

The calculations address congestion, noise and air pollution external costs by corridor segments (type of road: motorway). The results have been differentiated by non urban areas and suburban areas (when the motorway crosses an area surrounding the urban area). These areas have been identified by visual inspection through the Google Map tool. Traffic flows in PCU/h, that are required to calculate congestion costs, have been estimated through the information drawn from the TEN-STAC project.
Population exposure for noise assessment is based on the default values provided by the UIC/INFRAS study: 50 persons/km in rural areas and 250 persons/km for suburban areas.
Concerning freight transport the calculation of congestion, noise and air pollution external costs have been related to HGV: < 18 tonne and > 18 tonne
Sensitivity analysis has been carried out for road transport (car/HGV), showing the results of the sensitivity analysis carried out according the following assumptions:

- Congestion: an increase of traffic flows by 10%, 20% and 30%
- Noise: an increase of the exposed population by 20% and 80%

Furthermore, the sensitivity analysis has shown the results according the following assumptions:
Ratio between Night/Day noise costs of 1.5
Ratio between HGV/Car noise costs of 4
Finally, we have compared the corridor results with the recommended IMPACT values. In general, it can be said that for noise and congestion the GRACE estimations fall under the IMPACT recommended ranges; while for air pollution the GRACE estimations are on average lower. However, it should be considered that the adjustments to the GRACE tool in order to ensure full harmonization with the IMPACT recommended values have still to be completed (specifically for air pollution).

The following tables show the results as far as the comparison with the Handbook is concerned.

Brindisi-Koln

Comparison

CAR Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,250	0,100	0,400	0,000	0,000	0,000
	Motorway/ Rural		0,144	0,004	0,100	0,000	0,200	0,000	0,000	0,000
Noise:	Suburban/ Rural		0,001	0,004	0,001	0,000	0,001	0,002	0,001	0,002
Air Pollution& Up and Downstream:	Motorway	Petrol	0,003	0,003	0,007	0,007	0,013	0,007	0,007	0,013
		Diesel	0,007	0,007	0,013	0,013	0,029	0,013	0,013	0,029

** Congestion cost night = off peak*

HGV Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural		0,688	0,017	0,350	0,000	0,700	0,000	0,000	0,000
		HGV<18t	0,005	0,022						
Noise:	Suburban/ Rural	HGV>18t	0,006	0,029	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution& Up and Downstream:	Motorway	HGV<18t	0,029	0,029	0,086	0,086	0,086	0,086	0,086	0,086
		HGV>18t	0,038	0,038	0,120	0,120	0,120	0,120	0,120	0,120

** Congestion cost night = off peak*

Hamburg-Gothenburg

Comparison

CAR Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,250	0,100	0,400	0,000	0,000	0,000
	Motorway/ Rural		0,147	0,004	0,100	0,000	0,200	0,000	0,000	0,000
Noise:	Suburban/ Rural		0,001	0,005	0,001	0,000	0,001	0,002	0,001	0,002
Air Pollution& Up and Downstream:	Motorway	Petrol	0,002	0,002	0,007	0,007	0,013	0,007	0,007	0,013
		Diesel	0,005	0,005	0,013	0,013	0,029	0,013	0,013	0,029

** Congestion cost night = off peak*

HGV Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural		0,716	0,018	0,350	0,000	0,700	0,000	0,000	0,000
		HGV<18t	0,005	0,024						
Noise:	Suburban/ Rural	HGV>18t	0,007	0,032	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution& Up and Downstream:	Motorway	HGV<18t	0,016	0,016	0,086	0,086	0,086	0,086	0,086	0,086
		HGV>18t	0,019	0,019	0,120	0,120	0,120	0,120	0,120	0,120

** Congestion cost night = off peak*

Paris-Warsaw

Comparison

CAR Euro2					Handbook's reccomended values					
			Grace Corridor (Basecase)		Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,250	0,100	0,400	0,000	0,000	0,000
	Motorway/ Rural		0,121	0,003	0,100	0,000	0,200	0,000	0,000	0,000
Noise:	Suburban/ Rural		0,001	0,003	0,001	0,000	0,001	0,002	0,001	0,002
Air Pollution& Up and Downstream:	Motorway	Petrol	0,003	0,003	0,007	0,007	0,013	0,007	0,007	0,013
		Diesel	0,007	0,007	0,013	0,013	0,029	0,013	0,013	0,029

** Congestion cost night = off peak*

HGV Euro2					Handbook's reccomended values					
			Grace Corridor (Basecase)		Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural		0,571	0,014	0,350	0,000	0,700	0,000	0,000	0,000
		HGV<18t	0,003	0,014						
Noise:	Suburban/ Rural	HGV>18t	0,004	0,019	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution& Up and Downstream:	Motorway	HGV<18t	0,031	0,031	0,086	0,086	0,086	0,086	0,086	0,086
		HGV>18t	0,034	0,034	0,120	0,120	0,120	0,120	0,120	0,120

** Congestion cost night = off peak*

Sevilla-Brussels

Comparison

CAR Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,250	0,100	0,400	0,000	0,000	0,000
	Motorway/ Rural		0,136	0,003	0,100	0,000	0,200	0,000	0,000	0,000
Noise:	Suburban/ Rural		0,001	0,003	0,001	0,000	0,001	0,002	0,001	0,002
Air Pollution& Up and Downstream:	Motorway	Petrol	0,003	0,003	0,007	0,007	0,013	0,007	0,007	0,013
		Diesel	0,007	0,007	0,013	0,013	0,029	0,013	0,013	0,029

** Congestion cost night = off peak*

HGV Euro2			Grace Corridor (Basecase)		Handbook's reccomended values					
					Day/ Peak			Night		
			Day/ Peak	Night*	Reccommended	Min	Max	Reccommended	Min	Max
Congestion:	Motorway/ Suburban				0,880	0,350	1,400	0,000	0,000	0,000
	Motorway/ Rural		0,622	0,016	0,350	0,000	0,700	0,000	0,000	0,000
		HGV<18t	0,003	0,016						
Noise:	Suburban/ Rural	HGV>18t	0,004	0,021	0,011	0,004	0,011	0,020	0,007	0,020
Air Pollution& Up and Downstream:	Motorway	HGV<18t	0,030	0,03	0,086	0,086	0,086	0,086	0,086	0,086
		HGV>18t	0,034	0,034	0,120	0,120	0,120	0,120	0,120	0,120

** Congestion cost night = off peak*

Conclusions after the May 22 Workshop and further adjustments (June 2008)

The following conclusions by external costs categories were drawn:

- **Air pollution**: The valuation of emissions in the tool is fully consistent with the handbook since they use the same sources. However, the GRACE tool uses a different set of emission factors as the one used for calculating the output values in the IMPACT handbook. The GRACE tool does not include non-exhaust PM emissions. The GRACE tool presents upstream and direct emissions together in one figure, while the IMPACT handbook presents them separately, except for electricity production, which are included in the rail air pollution figures. Within the GRACE tool it also possible to view the contribution of the two separately.
- **Global warming**: The valuation of climate change emissions in the tool and the handbook is basically the same. The GRACE tool uses an estimate of CO2 emissions of 25 Euro per tonne CO2, which is the value recommended in the IMPACT handbook for 2010. The GRACE tool uses 22 Euro per tonne
- **Congestion**: The theoretical basis (methodology and Value of Time values) for estimating congestion cost is fully consistent. It should be considered that the Handbook values refer to optimal congestion cost, including the impact of a charge at optimal level, while the GRACE tool calculates the congestion cost at the current traffic level.
- **Accident**: The valuation factors is different, since the GRACE tool calculates the marginal accident costs on a respective corridor bottom-up based on the available data on accident casualties (fatalities and injuries, while the Handbook provides data per member state for a limited set of different vehicle types and road types.
- **Noise**: The IMPACT Handbook proposes a set of values for defined regional differentiations (rural, suburban, urban), GRACE calculates them bottom up with vehicle specific noise increments and considering background noise. Order of magnitude depends heavily on the population exposure input data (included as an external value in the tool).

As a consequence of the conclusions arising from the Workshop of May 22nd, the following adjustments to the GRACE tool data sets were implemented to ensure maximum harmonisation with those of the IMPACT Handbook. They are shown below through the comparison between before (the Before column) and after (the After column) the adjustments.

1) Damage factors of air pollution PM 2.5 exhaust

Germany €/t of pollutant	**Before**	**After**
Urban	434,000	384,500
Suburban		124,000
Rural	80,000	75,000

Before the adjustment the GRACE tool did not include the differentiation in suburban areas. After the adjustment, the damage factors of the GRACE tool have been desaggregated in urban (big city), suburban (small city) and rural areas, according to the Handbook classification.

2) The Damage factors of air pollution of NOx, NMVOC, SO2 in the GRACE tool have been updated with the CAFÉ CBA values, considered in the Handbook

Germany €/t of pollutant	**Before**	**After**
Nox	3,100	9,600
NMVOC	1,100	1,700
SO2	4,500	11,000

3) Harmonization of the electricity consumption factors (rail sector)

kWh/train.km	Before	After
Freight train	20.92	23.09
Intercity	16.6	8.00
High Speed	21.92	15.00

4) Harmonization of the damage factors electricity consumption factors (rail sector) by country

€/kWh	Before	After
Austria	0.0032	0.0026
France	0.0032	0.0016
Germany	0.0032	0.0061
…….	0.0032	…..

5) Global warming. Harmonization of the damage factor per ton of CO2 emitted

€/tonne of CO2	Before	After
	22	25

6) Noise. Harmonization of the exposed population (standard values) by geographical context

Persons/km	Before	After
Urban	600	2000
Suburban		250
Rural	160	50

ANNEX II: The GRACE webtool user manual

GRACE

Generalisation of Research on Accounts and Cost Estimation

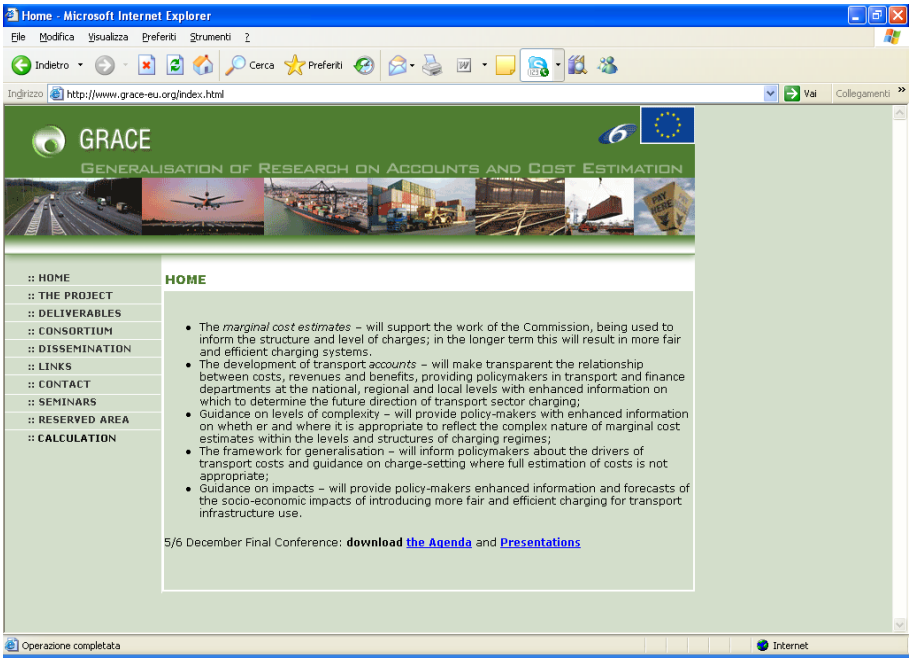
User Manual

Beta version (October 2008)

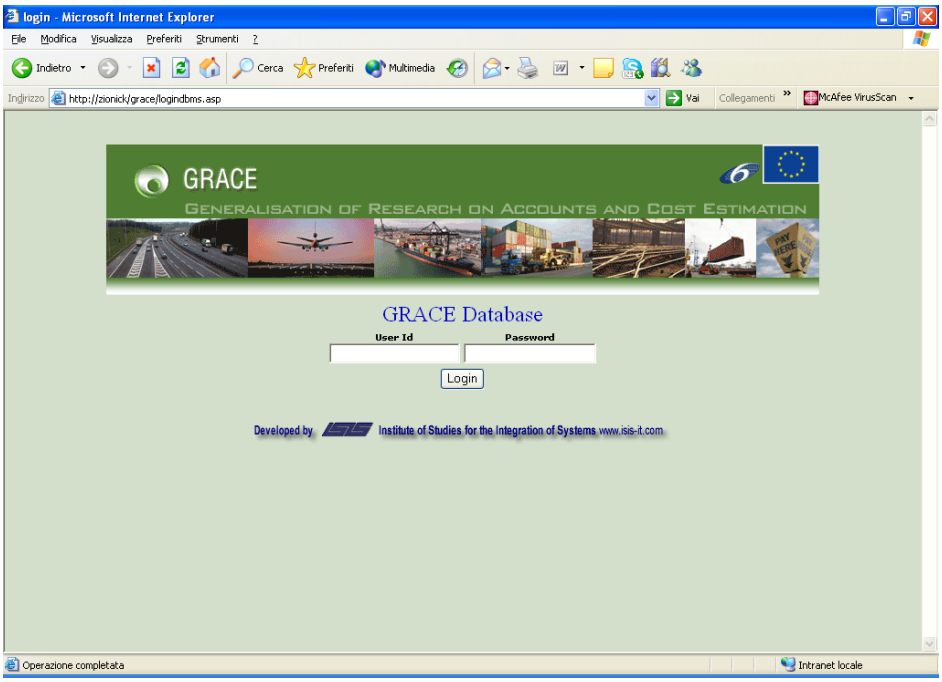
Table of Contents

Introduction

The GRACE tool is on the web. The address is www.isis-it.net/grace:



Click on the function *CALCULATION* to start a working session:



Insert your User-id and Password then push the button *LOGIN*
There are two levels of password, one allows the user to set up the network, the second one only allows access to the calculation function.

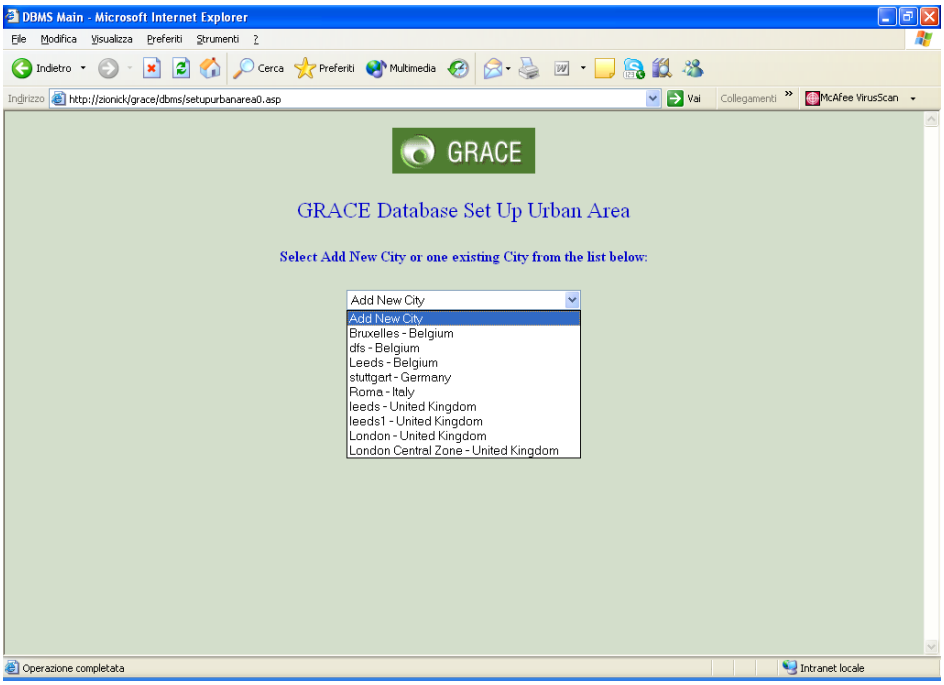
The tool allows the user to set up the following types of networks:

Urban Area
Non Urban Area
Corridor Road
Corridor Rail
Corridor Inland Water Ways
Sea Port
Airport

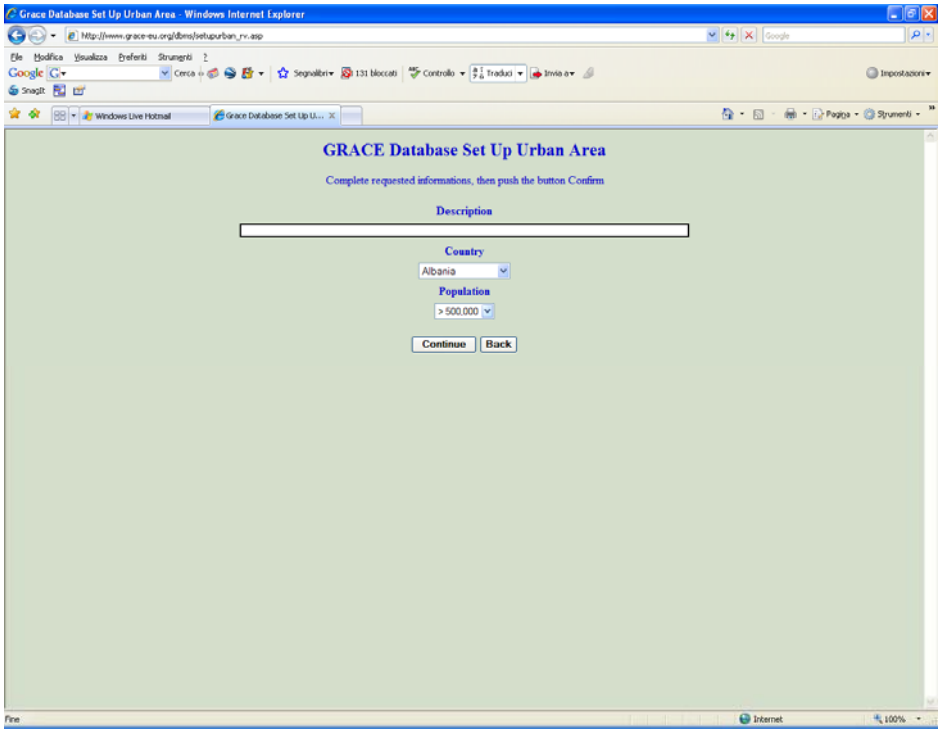
The GRACE database is organised in three parts, two parts are global and national data and the user cannot modify these information (although she can test possible alternative values within the "sensitivity analysis" function – see the relevant section of this manual) , the third part corresponds to network specific data and these must be provided interactively by the user..

To set up a network just click on the related link:

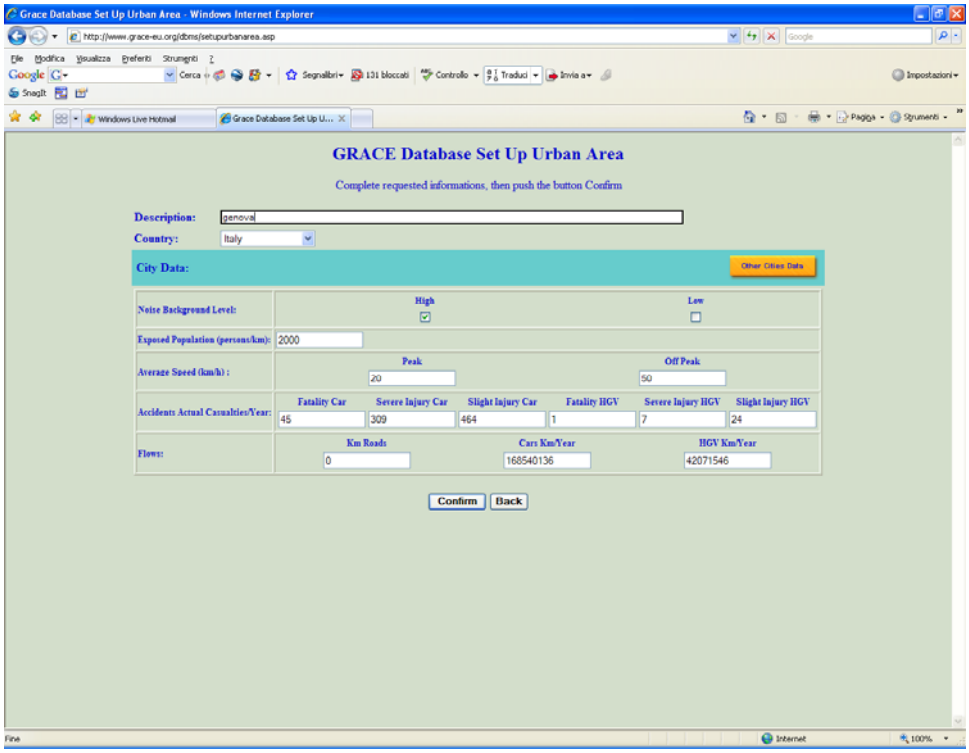
Set Up Urban Area



From the list in the middle of the screen select *Add New City* to add a new urban area to the database or an existing city to modify the data:



Type the name of the city, select the country from the pop up list, select the city size and press Continue.

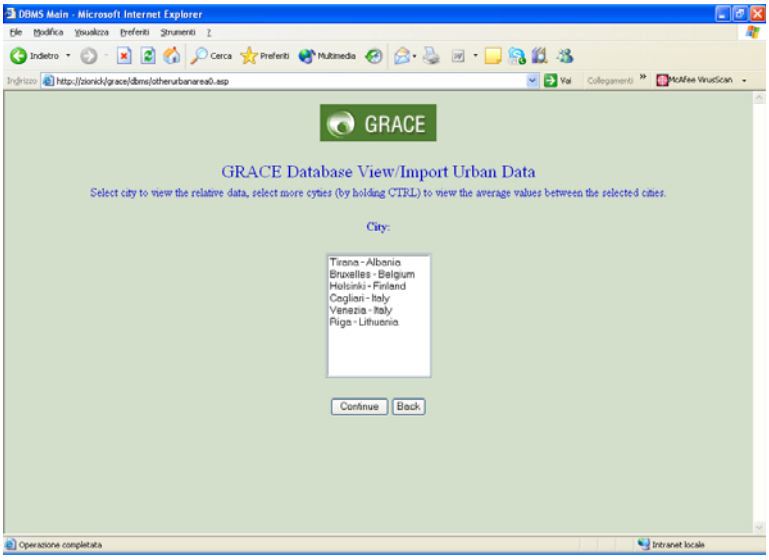


By default the average national data are proposed, the user can confirm or modify these data:

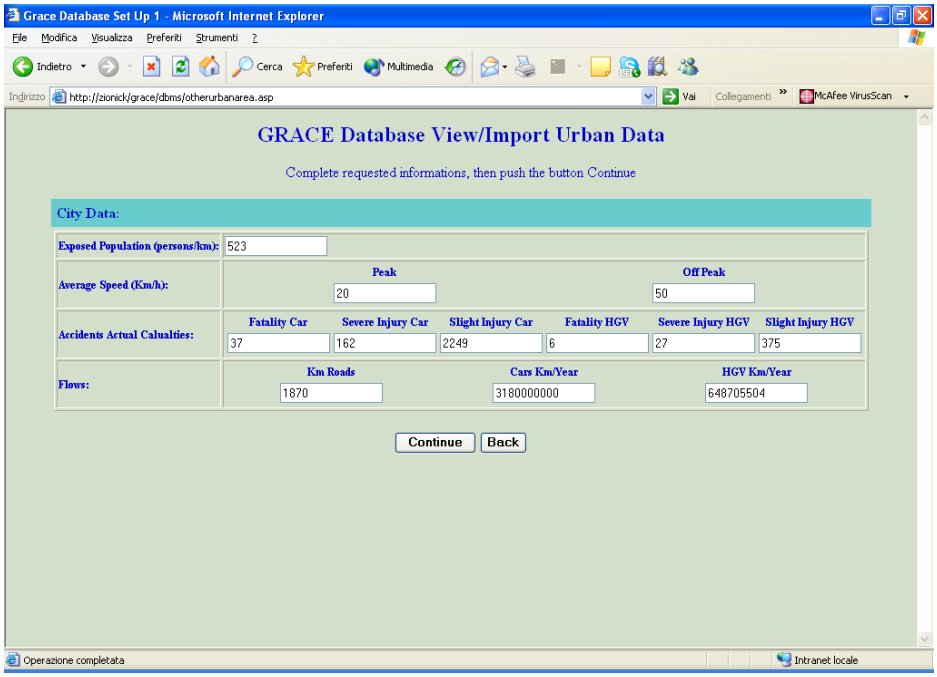
- Description of the urban area
- Country
- Noise background level (High/Low)
- Exposed population (persons/km)
- Average speed at peak and off peak period
- Number of accidents by mode (fatality, severe injury, slight injury)
- Kilometres of roads (non mandatory)
- Traffic flows by period and mode (vehicles.km/year)

Push the button *CONFIRM* to update the database.

Through the button *OTHER CITIES DATA* it is possible to import data from another city, or the average values between more cities:



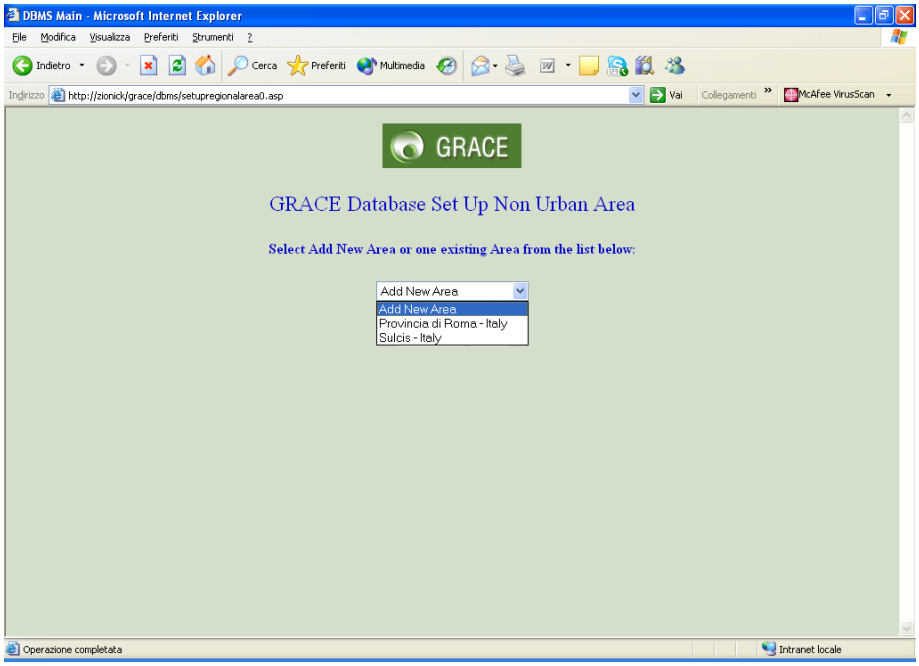
Select a city then push the button *CONTINUE* (to select more cities hold down CTRL)

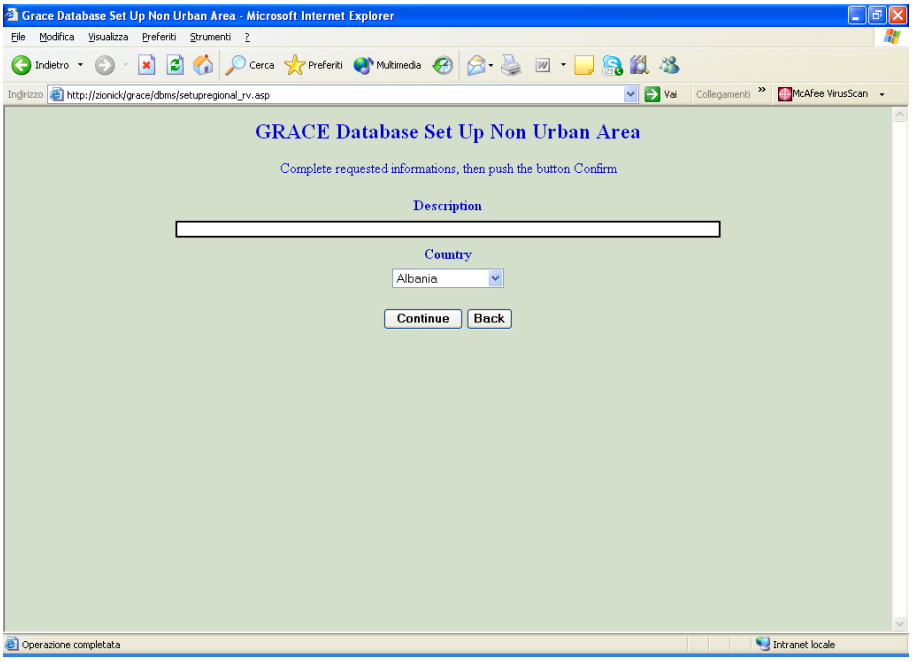


Push the button *CONTINUE* to import these data:

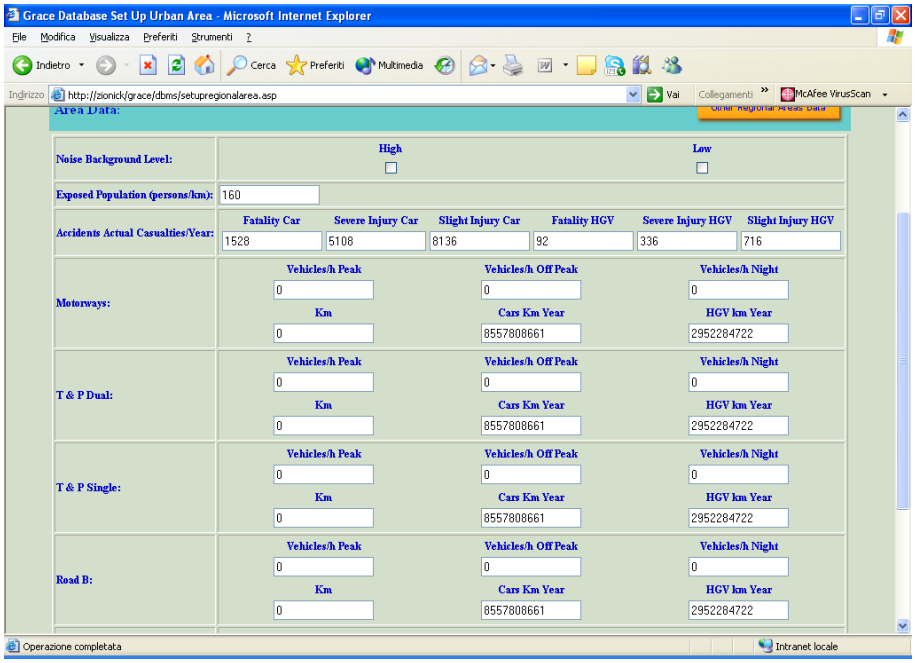
Set Up Non Urban Area

As in the previous section you can add a new area or modify an existing one





Type the description of the area, select the country from the pop up list and press Continue.



By default the average national data are proposed, the user can confirm or modify these data:

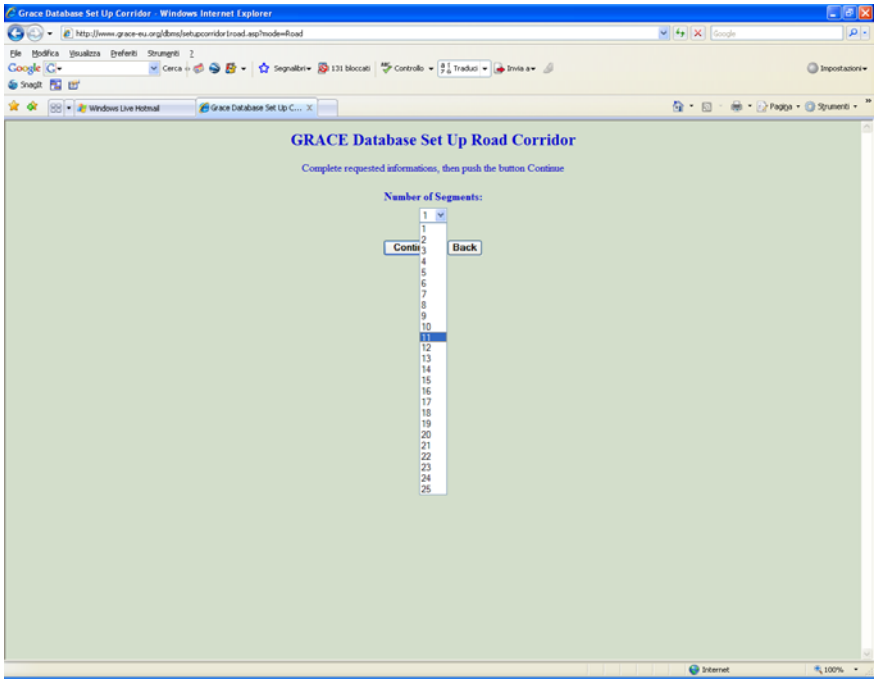
- Noise background level (High/Low)
- Exposed population (persons/km)
- Number of accidents by mode (fatality, severe injury, slight injury)
- Kilometres by type of road
- Per car unit by type of road, period (vehicles/h)
- Traffic flows by type of road, mode (vehicles.km/year, tonnes.km/year)
- Kilometres by type of railway

Push the button *CONFIRM* to update the database.

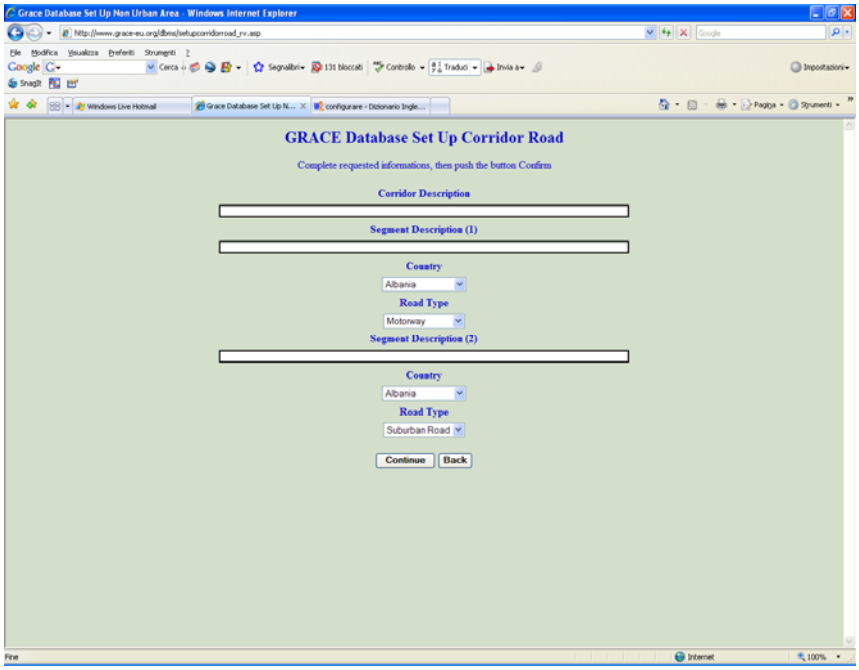
Through the button *OTHER REGIONAL AREA DATA* is possible to import data from another area, or the average values between more areas.

Set Up Corridor Road

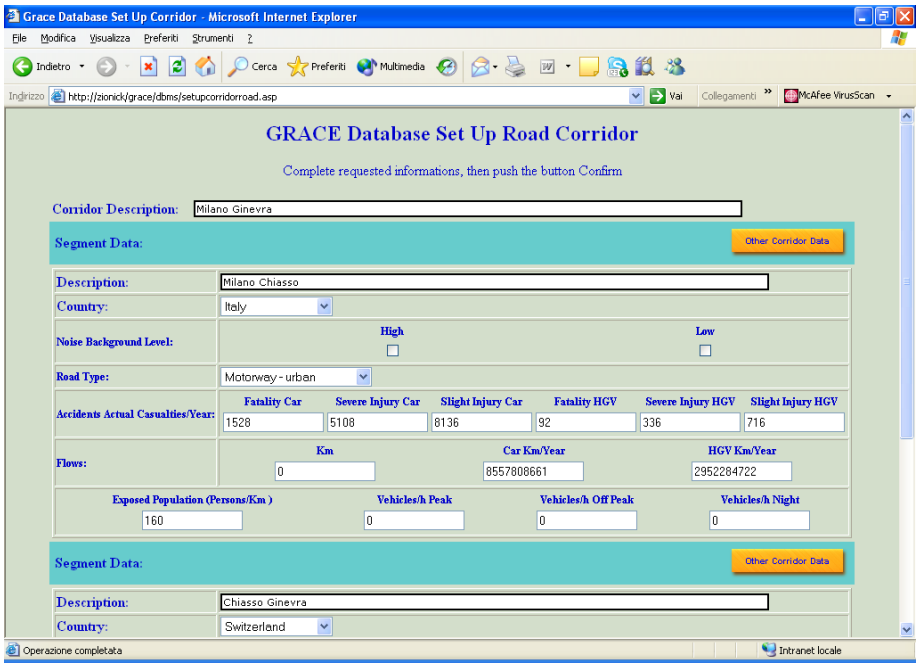
As in the previous section you can add a new corridor or modify an existing one
After selecting a corridor the first thing to do is to indicate the number of segments in which the corridor is divided.
The criteria of segmentation should be at least the change of type of road and the change of country, but is otherwise left to the user.
The type of road involves both the specification of network type and region. The distinction concerns roads pass in rural areas (i.e. motorways, T&P dual, T&P single, B roads and C roads) and roads pass in the vicinity of cities (i.e. suburban area).



Select the number of segments (max 25) and push the button *CONTINUE*



Type the description of the corridor and for each segment type the description and select the country and the type of road.



By default the average national data are proposed, the user can confirm or modify these data:

- Description of the segment
- Country
- Noise background level (High/Low)

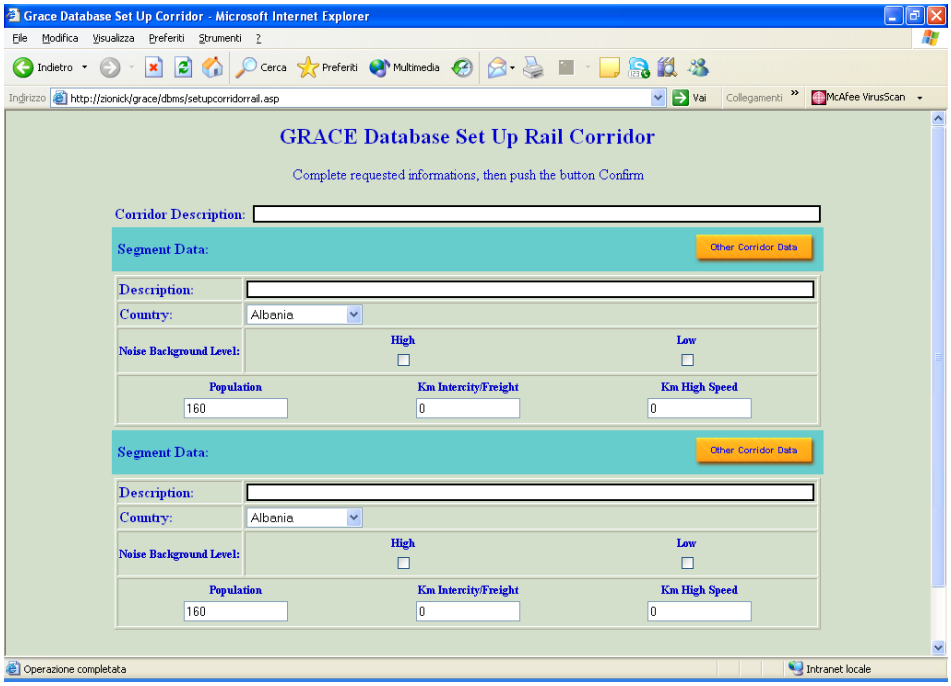
- Exposed population (persons/km)
- Type of road
- Number of accidents by mode (fatality, severe injury, slight injury)
- Kilometres by type of road
- Per car unit by type of road, period (vehicles/h)
- Traffic flows by type of road, mode (vehicles.km/year, tonnes.km/year)

Push the button *CONFIRM* to update the database.

Through the button *OTHER CORRIDOR DATA* is possible to view (not to import directly) data of another corridor.

Set Up Corridor Rail

Select New corridor or an existing one, select the number of segments:



For each segment the following data are requested:

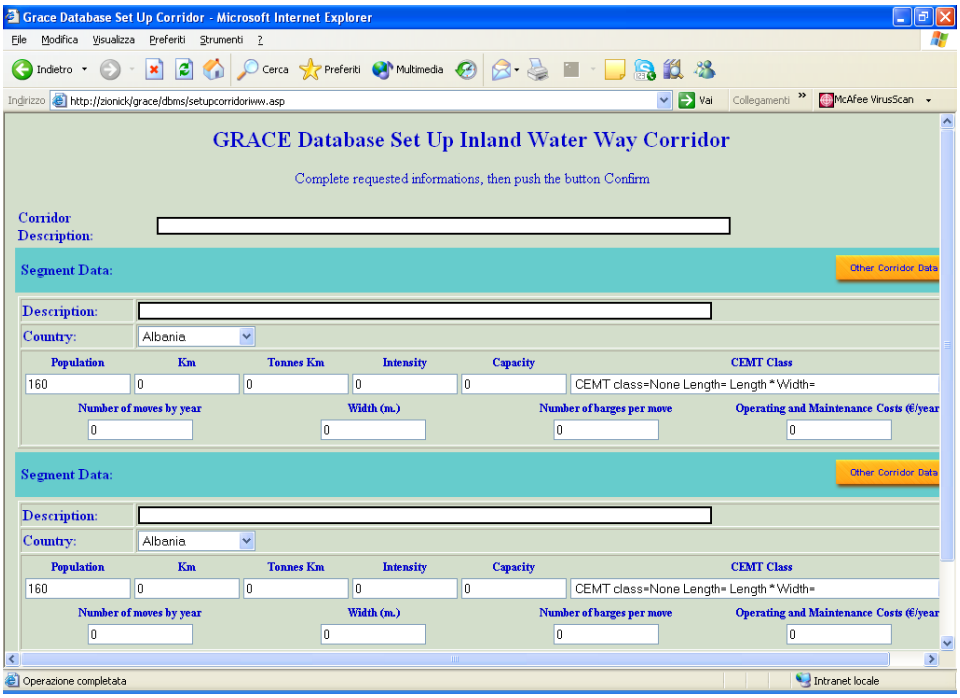
- Description of the segment
- Country
- Noise background level (High/Low)
- Exposed population (the proposed default value is 160 persons km)
- Kilometres

Push the button *CONFIRM* to update the database.

Through the button *OTHER CORRIDOR DATA* is possible to view (not to import directly) data of another corridor.

Set Up Corridor Inland Waterways

Select New corridor or an existing one, select the number of segments. In this case the first criterion to define segments is the existence of a lock, and in each segment only one lock is allowed:



For each segment the following data are requested:

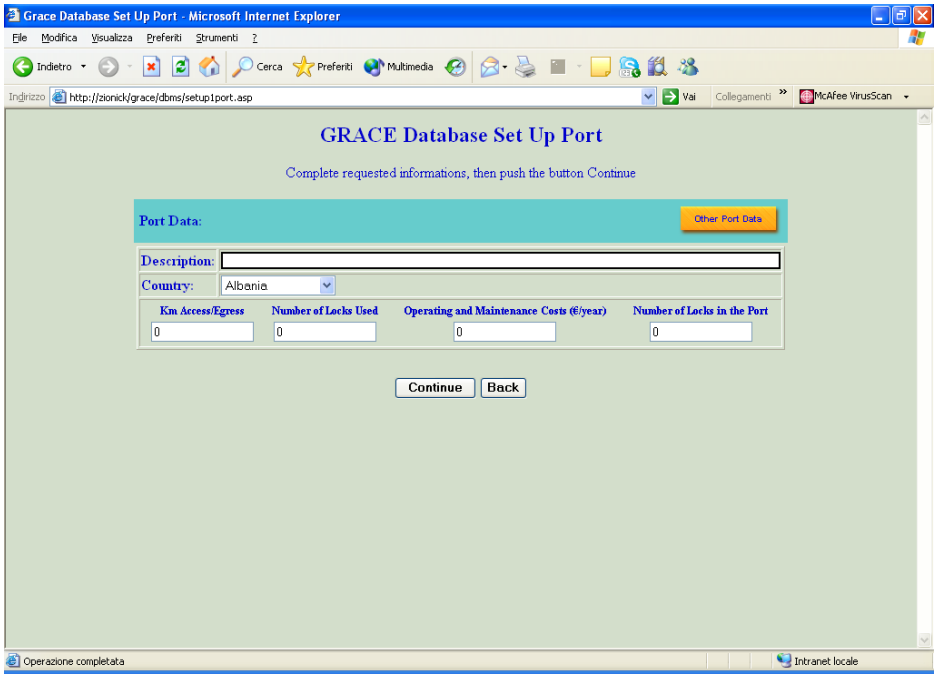
- Description of the segment
- Country
- Exposed population (the proposed default value is 160 persons km)
- Kilometres
- Traffic flows (tonnes.km)
- Traffic Intensity
- Capacity
- Class of lock
- Number of moves of the lock by year
- Width of the lock
- Number of barges per lock move
- Operating and maintenance costs

Push the button *CONFIRM* to update the database.

Through the button *OTHER CORRIDOR DATA* it is possible to view (not to import directly) data of another corridor.

Set Up Port

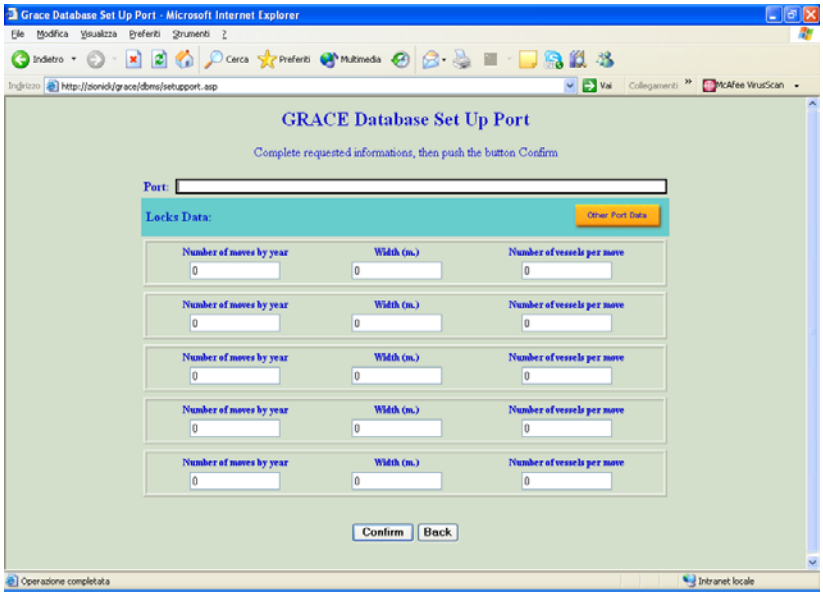
Select New port or an existing one.



Insert the following data:

- Description of the port
- Select the country
- Km access/egress
- Type the number of locks used
- Total number of locks
- Operating and maintenance costs

Push the button *CONTINUE*



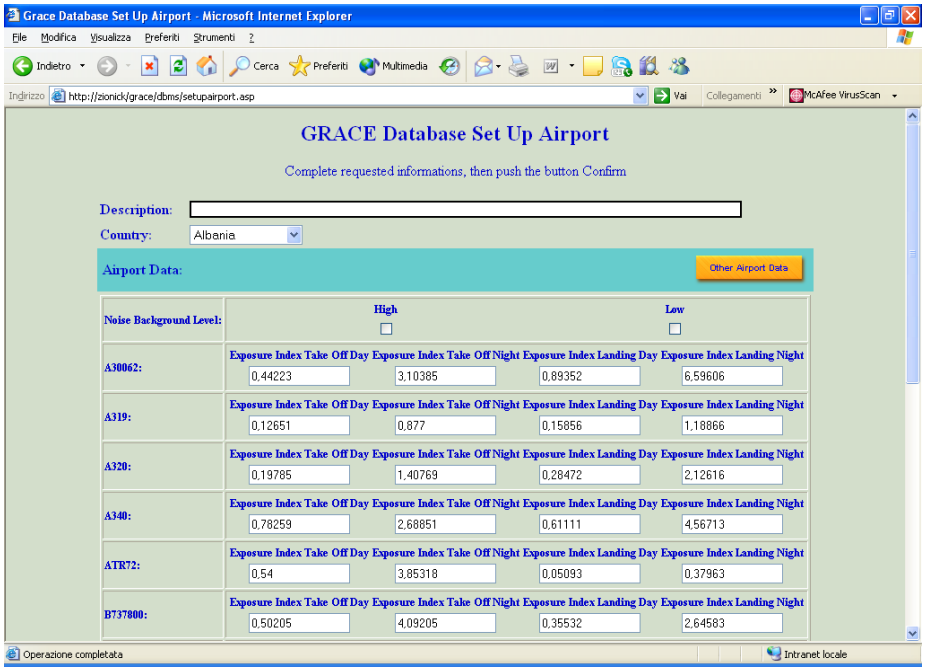
For each lock insert the following data:

- Number of moves of the lock per year
- Width of the lock
- Number of vessels per lock move

Through the button *OTHER PORT DATA* it is possible to view (not to import directly) data of another port.

Set Up Airport

Select New Airport or an existing one.



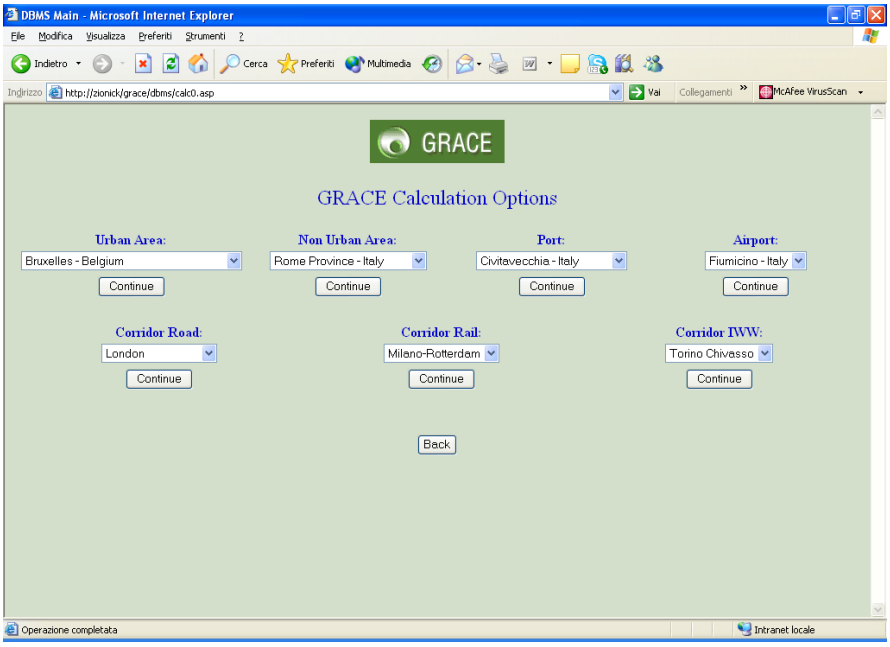
A default set of data for 12 type of aircrafts is porposed, you can confirm or modify these data.

- Description of the airport
- Country
- Noise background level (high/low)
- Exposure index by take off/landing and day/night (for each aircraft type)
- Capacity
- Infrastructure reference costs

Complete the requested information and push *CONFIRM* to update the database.

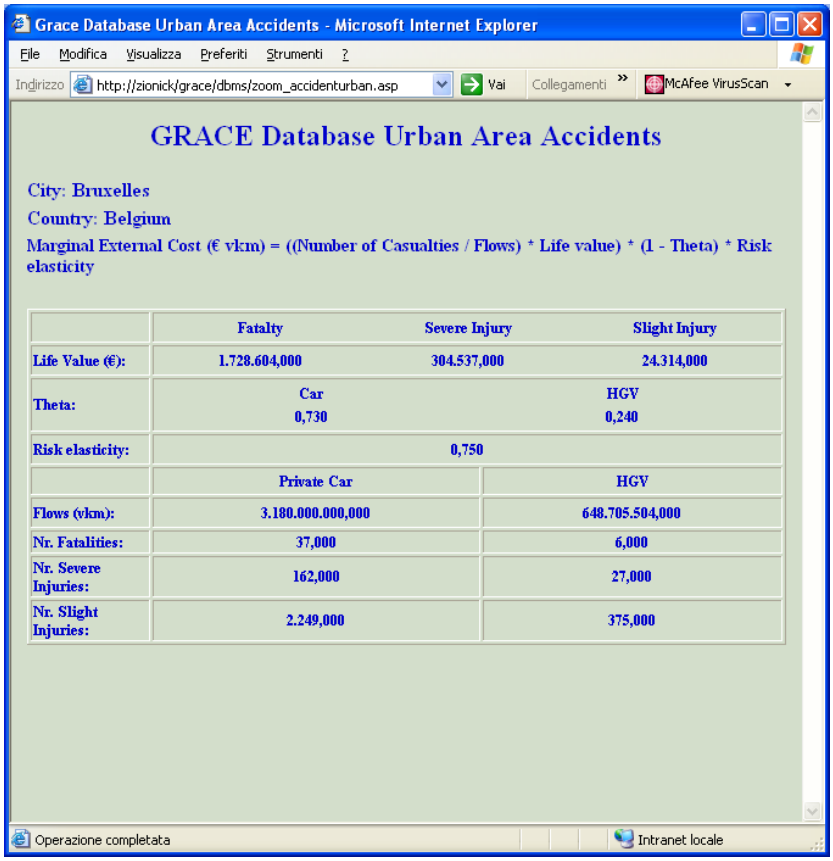
Through the button *OTHER AIRPORT DATA* it is possible to view (not to import directly) data of another airport.

Calculation

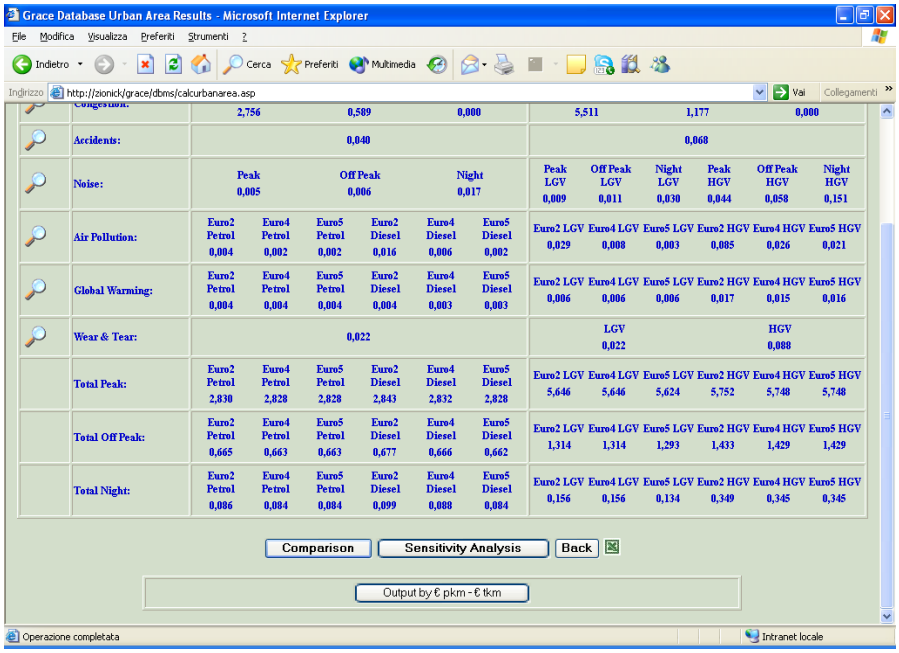


From the lists in the central part of the screen select a network section [urban area, or non urban area, or corridor (road, rail, iww), or port, or airport] then push the button *CONTINUE* below the chosen network to start the calculation section.

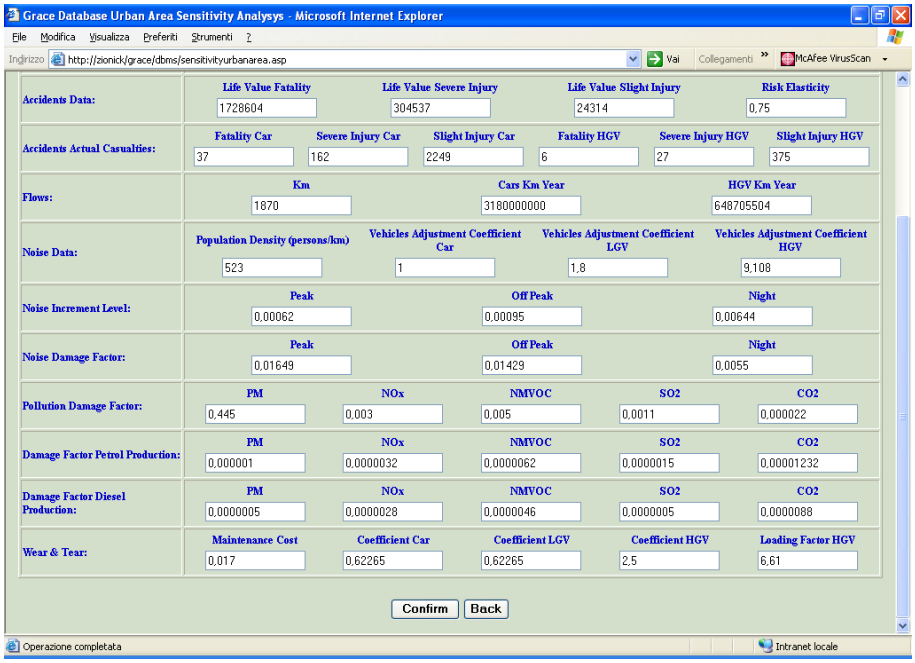
By clicking on the zoom icons in the left of the table it is possible to view the detail of the calculation for each type of externality:



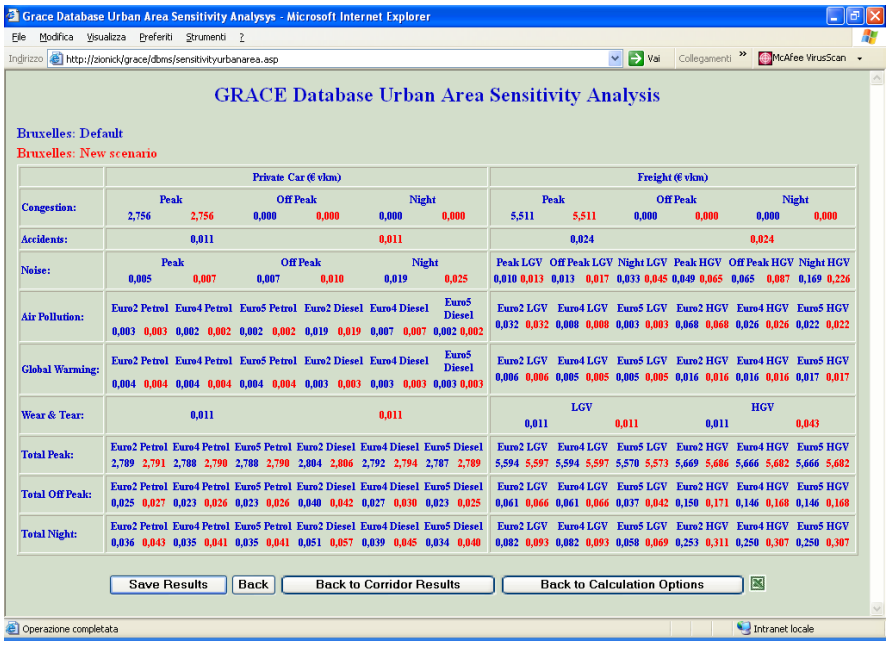
By default, results are shown in € cent/vkm, but it is possible to change the unit in € cent/pkm and € cent/tkm by pressing the button *Output by € pkm -€ tkm* at the bottom of the screen.



SENSITIVITY ANALYSIS can be initiated by pushing the corresponding button

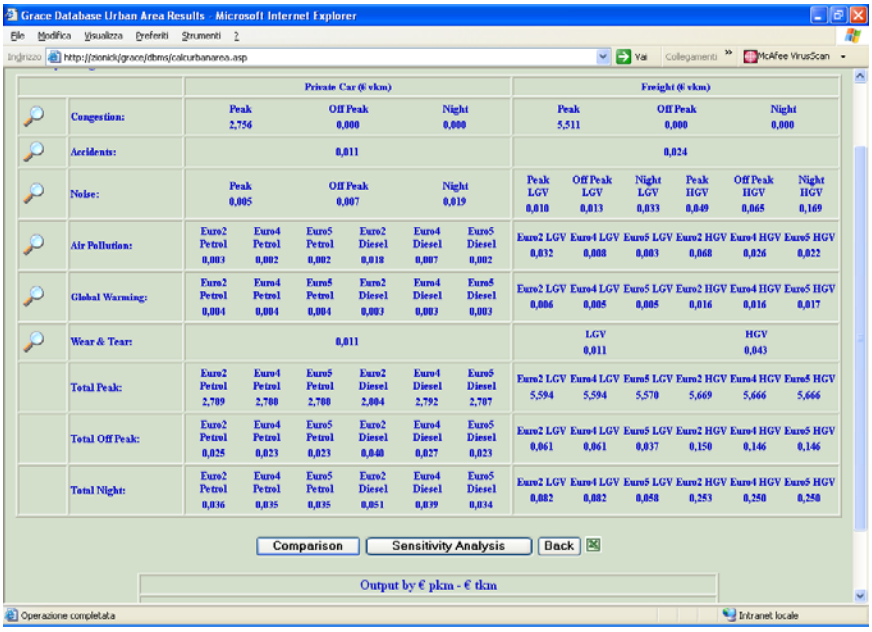


From this screen it is possible to modify the data (for example the population density) of the network and compare the results:



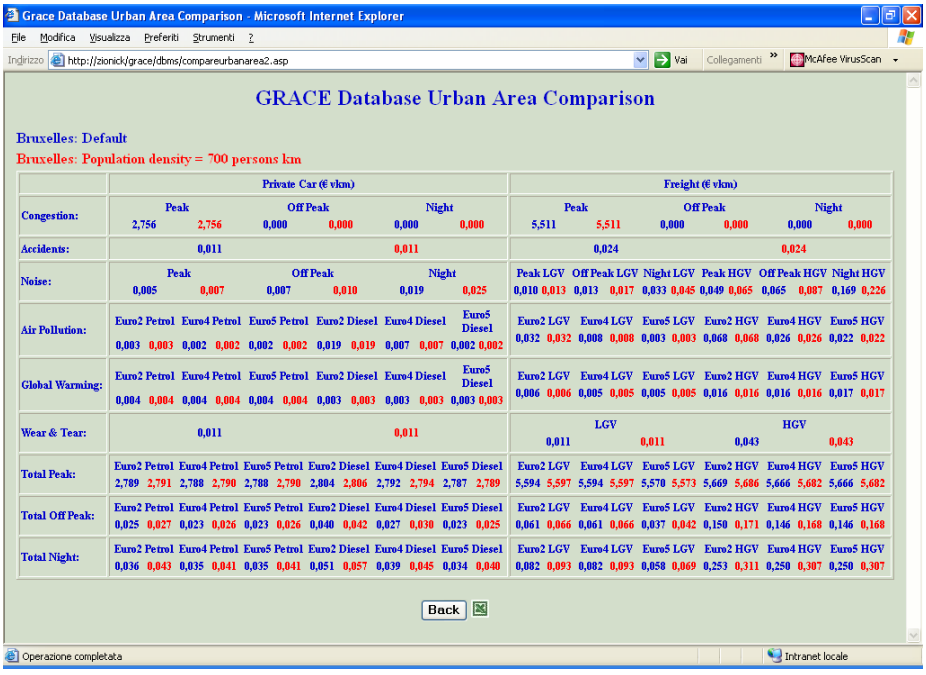
Only authorized user may save these results pushing the button *SAVE RESULTS*:

Type the description and push the button *CONFIRM*



Push the button *COMPARISON* to compare these values with the saved values from the sensitivity analysis or with the values of another network sections:

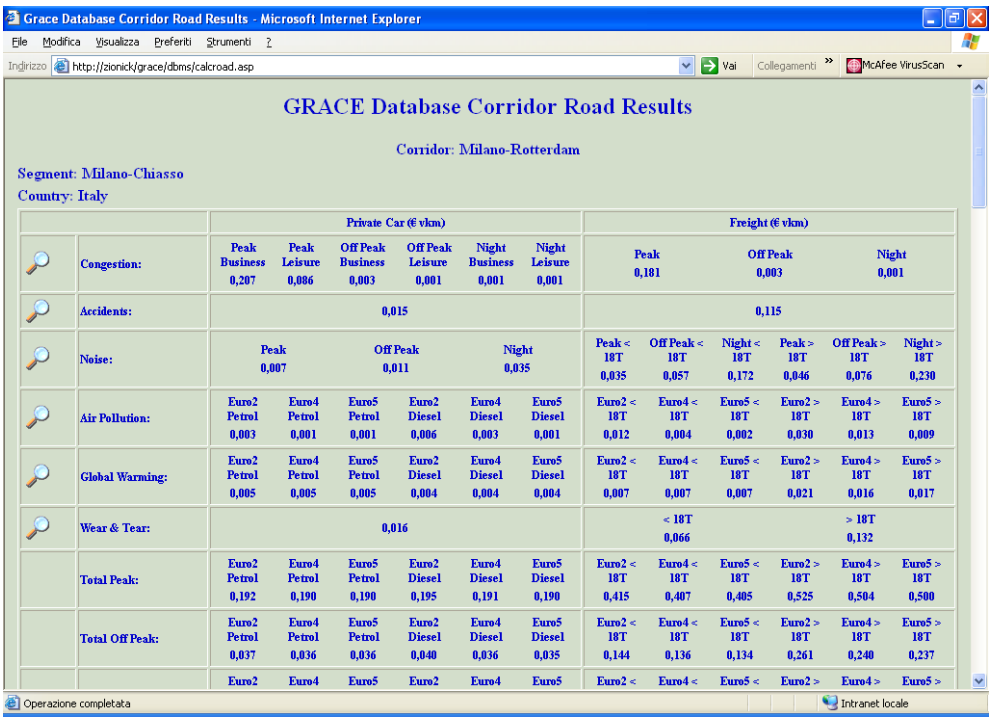
Select from one of the lists another network section or a previously saved simulation for the same network section, then push the button *CONTINUE* below the list:



The procedure is the same for all types of network sections.
From each output screen it is possible to export the data to MS Excel.

CORRIDORS

The corridors are divided in segments, the totals for each segment show marginal costs by cost category, while the total of the corridor show, for each cost category, the average weighted by the segment length (km).



Grace Database Corridor Road Results - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indirizzo http://zionick/grace/dbms/calcroad.asp

Vai Collegamenti McAfee VirusScan

GRACE Database Corridor Road Results

Corridor: Milano-Rotterdam

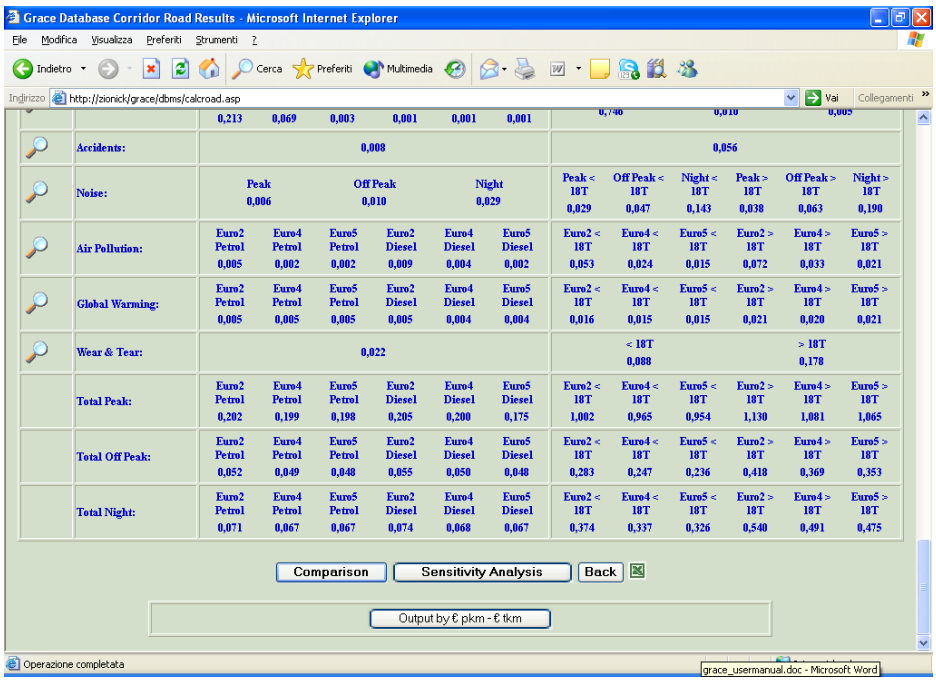
Segment: Milano-Chiasso

Country: Italy

		Private Car (€ vkm)						Freight (€ vkm)					
	Congestion:	Peak Business 0,207	Peak Leisure 0,086	Off Peak Business 0,003	Off Peak Leisure 0,001	Night Business 0,001	Night Leisure 0,001	Peak 0,181		Off Peak 0,003		Night 0,001	
	Accidents:	0,015						0,115					
	Noise:	Peak 0,007		Off Peak 0,011		Night 0,035		Peak < 18T 0,035	Off Peak < 18T 0,057	Night < 18T 0,172	Peak > 18T 0,046	Off Peak > 18T 0,076	Night > 18T 0,230
	Air Pollution:	Euro2 Petrol 0,003	Euro4 Petrol 0,001	Euro5 Petrol 0,001	Euro2 Diesel 0,006	Euro4 Diesel 0,003	Euro5 Diesel 0,001	Euro2 < 18T 0,012	Euro4 < 18T 0,004	Euro5 < 18T 0,002	Euro2 > 18T 0,030	Euro4 > 18T 0,013	Euro5 > 18T 0,009
	Global Warming:	Euro2 Petrol 0,005	Euro4 Petrol 0,005	Euro5 Petrol 0,005	Euro2 Diesel 0,004	Euro4 Diesel 0,004	Euro5 Diesel 0,004	Euro2 < 18T 0,007	Euro4 < 18T 0,007	Euro5 < 18T 0,007	Euro2 > 18T 0,021	Euro4 > 18T 0,016	Euro5 > 18T 0,017
	Wear & Tear:	0,016							< 18T 0,066			> 18T 0,132	
	Total Peak:	Euro2 Petrol 0,192	Euro4 Petrol 0,190	Euro5 Petrol 0,190	Euro2 Diesel 0,195	Euro4 Diesel 0,191	Euro5 Diesel 0,190	Euro2 < 18T 0,415	Euro4 < 18T 0,407	Euro5 < 18T 0,405	Euro2 > 18T 0,525	Euro4 > 18T 0,504	Euro5 > 18T 0,500
	Total Off Peak:	Euro2 Petrol 0,037	Euro4 Petrol 0,036	Euro5 Petrol 0,036	Euro2 Diesel 0,040	Euro4 Diesel 0,036	Euro5 Diesel 0,035	Euro2 < 18T 0,144	Euro4 < 18T 0,136	Euro5 < 18T 0,134	Euro2 > 18T 0,261	Euro4 > 18T 0,240	Euro5 > 18T 0,237
		Euro2	Euro4	Euro5	Euro2	Euro4	Euro5	Euro2 <	Euro4 <	Euro5 <	Euro2 >	Euro4 >	Euro5 >

Operazione completata Intranet locale

The detail of congestion costs is differentiated according to trip purpose: business, leisure. Total costs, however, are not differentiated according to purpose, but are calculated (and shown) as the average weighted by the percentage of people travelling by business and leisure.



Grace Database Corridor Road Results - Microsoft Internet Explorer

File Modifica Visualizza Preferiti Strumenti ?

Indietro Cerca Preferiti Multimedia

Indirizzo http://zionick/grace/dbms/calcroad.asp

Vai Collegamenti

		0,213	0,069	0,003	0,001	0,001	0,001	0,748		0,010		0,005	
	Accidents:	0,008						0,056					
	Noise:	Peak 0,006		Off Peak 0,010		Night 0,029		Peak < 18T 0,029	Off Peak < 18T 0,047	Night < 18T 0,143	Peak > 18T 0,038	Off Peak > 18T 0,063	Night > 18T 0,190
	Air Pollution:	Euro2 Petrol 0,005	Euro4 Petrol 0,002	Euro5 Petrol 0,002	Euro2 Diesel 0,009	Euro4 Diesel 0,004	Euro5 Diesel 0,002	Euro2 < 18T 0,053	Euro4 < 18T 0,024	Euro5 < 18T 0,015	Euro2 > 18T 0,072	Euro4 > 18T 0,033	Euro5 > 18T 0,021
	Global Warming:	Euro2 Petrol 0,005	Euro4 Petrol 0,005	Euro5 Petrol 0,005	Euro2 Diesel 0,005	Euro4 Diesel 0,004	Euro5 Diesel 0,004	Euro2 < 18T 0,016	Euro4 < 18T 0,015	Euro5 < 18T 0,015	Euro2 > 18T 0,021	Euro4 > 18T 0,020	Euro5 > 18T 0,021
	Wear & Tear:	0,022							< 18T 0,088			> 18T 0,178	
	Total Peak:	Euro2 Petrol 0,202	Euro4 Petrol 0,199	Euro5 Petrol 0,198	Euro2 Diesel 0,205	Euro4 Diesel 0,200	Euro5 Diesel 0,175	Euro2 < 18T 1,002	Euro4 < 18T 0,965	Euro5 < 18T 0,954	Euro2 > 18T 1,130	Euro4 > 18T 1,081	Euro5 > 18T 1,065
	Total Off Peak:	Euro2 Petrol 0,052	Euro4 Petrol 0,049	Euro5 Petrol 0,048	Euro2 Diesel 0,055	Euro4 Diesel 0,050	Euro5 Diesel 0,048	Euro2 < 18T 0,283	Euro4 < 18T 0,247	Euro5 < 18T 0,236	Euro2 > 18T 0,418	Euro4 > 18T 0,369	Euro5 > 18T 0,353
	Total Night:	Euro2 Petrol 0,071	Euro4 Petrol 0,067	Euro5 Petrol 0,067	Euro2 Diesel 0,074	Euro4 Diesel 0,068	Euro5 Diesel 0,067	Euro2 < 18T 0,374	Euro4 < 18T 0,337	Euro5 < 18T 0,326	Euro2 > 18T 0,540	Euro4 > 18T 0,491	Euro5 > 18T 0,475

Comparison Sensitivity Analysis Back

Output by € pkm - € tkm

Operazione completata grace_usermanual.doc - Microsoft Word