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Green corridors in European surface freight logistics and the SuperGreen project

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Abstract

"Green corridors" is an EU concept introduced in 2007 that aims at developing integrated, efficient and environmentally friendly transportation of freight between major hubs and by relative long distances. SuperGreen is a project co-financed by the European Commission to assist in further defining and developing the green corridor concept. A central activity of the project is the development of a corridor benchmarking methodology using a set of Key Performance Indicators that are suitable for monitoring the sustainable development goals of the European Union. The purpose of this paper is to present the SuperGreen project and the results achieved so far.

Keywords: Green corridors; green logistics; freight transportation; key performance indicators; co-modality

1. Introduction

According to EU (2007), which introduced the concept of green corridors, "... transport corridors are marked by a concentration of freight traffic between major hubs and by relatively long distances ... Industry will be encouraged along these corridors to rely on co-modality and on advanced technology in order to accommodate rising traffic volumes, while promoting environmental sustainability and energy efficiency. Green transport corridors will … be equipped with adequate transhipment facilities at strategic locations … and with supply points initially for bio-fuels and, later, for other forms of green propulsion. Green corridors could be used to experiment with environmentally-friendly, innovative transport units,

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and with advanced Intelligent Transport Systems (ITS) applications… Fair and non-discriminatory access to corridors and transhipment facilities should be ensured in accordance with the rules of the Treaty."

The Swedish Logistics Forum (Tetraplan 2011) has advanced this definition by stating that "Green Corridors aim at reducing environmental and climate impact while increasing safety and efficiency. Characteristics of a green corridor include:

- sustainable logistics solutions with documented reductions of environmental and climate impact, high safety, high quality and strong efficiency,
- integrated logistics concepts with optimal utilisation of all transport modes, so called co-modality,
- harmonised regulations with openness for all actors,
- a concentration of national and international freight traffic on relatively long transport routes,
- efficient and strategically placed transhipment points, as well as an adapted, supportive infrastructure, and
- a platform for development and demonstration of innovative logistics solutions, including information systems, collaborative models and technology."

It is apparent that an explicit and workable definition of the term is still required. The EU-financed SuperGreen project aims at assisting the European Commission in further defining the green corridor concept through a corridor benchmarking exercise using Key Performance Indicators (KPIs). The purpose of this paper is to present the methodology and the KPIs as they have been applied in benchmarking a set of selected corridors.

2. The SuperGreen project

SuperGreen is a Coordination and Support Action, in the context of the European Commission's 7th Framework Programme of Research and Technological Development (RTD). The objectives of the SuperGreen project concern supporting the development of sustainable transport networks by fulfilling requirements covering environmental, technical, economical, social and spatial planning aspects. This will be achieved by:

- giving overall support and recommendations on green corridors to EU's Freight Transport Logistics Action Plan,
- conducting a programme of networking activities between stakeholders (public and private),
- providing a schematic for overall benchmarking of green corridors based on selected KPIs,
- delivering policy recommendations at a European level for the further development of green corridors, and
- providing the Commission with recommendations concerning new calls for RTD proposals to support development of green corridors.

The project involves 22 partners from 13 European countries. They include transport, logistics and infrastructure operators, shippers, environmental organisations and authorities responsible for social and spatial planning, consultants, academia and RTD institutions. Altogether, they have committed to mobilise resources of more than € 3 million, with the European Commission contributing on the order of € 2.6 million. The timetable of the project is January 2010 to January 2013.

The project covers all surface transport modes: road, rail, short sea shipping (SSS), deep sea shipping (DSS), inland waterway transport (IWT), as well as intermodal transport.

Project work is organised in 7 work packages: Project management; Benchmarking green corridors; Sustainable green technologies & innovations; Smart exploitation of Information and Communication Technology (ICT) flows; Recommendations for R&D calls; Policy implications; and Dissemination & awareness raising. Only the corridor benchmarking activities had been completed at the time of writing this article, which focuses on the results of this work package. The relevant tasks concerned: the selection of corridors; definition of the benchmarking methodology and indicators; identification of changes in the operational and regulatory environment that may enhance or hamper green corridor development; the actual corridor benchmarking; and definition of areas for improvement. It is stressed that issues related to green technologies and ICT applications are essential in greening transport corridors and no benchmarking exercise can be considered complete without paying attention to these aspects. In this sense, the results presented here are only partial.

3. Corridor selection

An initial list of 60 potential corridors was compiled on the basis of the trans-European transport network (TEN-T) priority projects, the pan-European transport network and proposals made by the project's industrial partners. After two consolidation rounds, the number of candidate corridors was reduced to 30. A survey was carried out to gather information on these 30 corridors. Based on the information gathered and criteria like corridor length, population affected, freight volume, types of goods and multimodality, number and seriousness of bottlenecks, geographical preconditions, transport and information technology used, and assessment of the supply chain management, a pre-selection of 15 corridors was made. A geographic and modal balance was ensured among these pre-selected corridors. The aim at this stage was to select the ones with the highest "greening potential" rate.

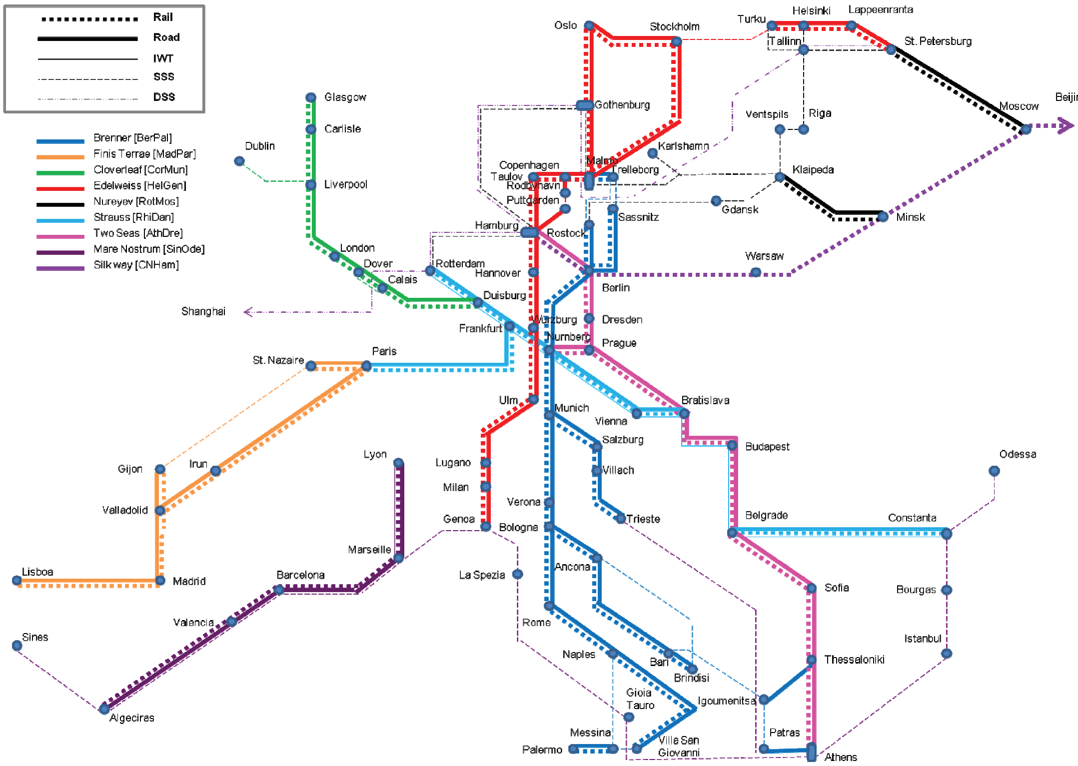

Fig. 1. The SuperGreen corridors in metro format [Source: Ilves et al. (2010)]

Further information was collected on these 15 pre-selected corridors and a deeper analysis was performed taking into consideration land use aspects like the percentage of corridor surface comprising urban and environmentally sensitive areas. The analysis resulted to a recommendation of 9 corridors for final selection, which was presented to a stakeholder workshop especially arranged for this purpose. In line with comments received during the workshop, the selected corridors were modified by adding segments that exhibit advanced "greening" characteristics. Figure 1 presents this set in metro format.

In addition to being geography- and mode-wise balanced, the resulting set of corridors comprises a mix of environmentally advanced ones on one hand, and those exhibiting a high "greening potential" on the other, thus constituting a suitable field for testing the benchmarking methodology and KPIs.

It should be made clear that the selection of these corridors was made only for the purposes of the SuperGreen project and by no means has this implied any direct or indirect endorsement, either by the SuperGreen consortium or by the European Commission, of these corridors vis-à-vis any other corridor, with respect to any criteria, environmental, economic, or other. More details on SuperGreen corridor selection can be found at Salanne et al. (2010).

4. Benchmarking methodology and KPIs

No corridor benchmarking exercise was identified in the literature. The closest case concerns benchmarking of transport chains and was studied by the BE Logic project (Kramer et al. 2009). Based on this experience, the project developed a methodology that consisted of decomposing the corridor under examination into transport chains, benchmarking these chains using a set of KPIs, and then aggregating the chain-level KPIs to corridor-level ones using proper weights for the averaging.

The initial set of KPIs resulted from a process that included the compilation of a gross list of performance indicators, their categorisation into different groups and their filtering during detailed discussions. These KPIs, grouped in five areas (efficiency, service quality, environmental sustainability, infrastructural sufficiency, and social issues), are presented in Table 1 below along with their respective definition.

With the aim of soliciting feedback, the methodology and initial set of KPIs were presented in three events: two regional stakeholder workshops and a meeting of the project's Advisory Committee. The general consensus was that the methodology was in broad terms acceptable and that the KPIs proposed by the project cover all basic facets of the problem. However, there was also a general sense that KPIs as proposed were too ambitious and there was a need to simplify them so that the set be useful. In that sense, reducing the set of KPIs to a more manageable one was considered as a desirable outcome.

Table 1. Initial set of KPIs

KPI AREA	INDICATOR	UNIT
Efficiency	Absolute cost	€/tonne
	Relative cost	€/tonne-km
Service quality	Transport time	hours
	Reliability (time precision)	% of shipments delivered within acceptable window
	Frequency of service	number per year
	ICT applications - cargo tracking - other ICT services	graded scale (1-5)
	Cargo security	number of incidents per total number of shipments
	Cargo safety	number of incidents per total number of shipments
Environmental sustainability (*)	CO_2-eq	g/tonne-km
	SOx	g/1000 tonne-km

	NOx	g/1000 tonne-km
	PM_{10}	g/1000 tonne-km
Infrastructural sufficiency	Congestion	average delay (h) / tonne-km
	Bottlenecks	graded scale (1-5)
	- geography	
	- capacity of infrastructure	
	- condition of infrastructure	
	- administration	
Social issues	Corridor land use	
	- urban areas	% of buffer zone (**)
	- sensitive areas	% of buffer zone (**)
	Traffic safety	fatalities & serious injuries per year and per million tonne-km
	Noise	% of corridor length above 50/55 dB

(*) well-to-wheel approach
(**) shaped by a radius of 20 km around the median line of the corridor

Following an internal round of KPI screening, a revised set was presented to a third regional SuperGreen workshop, organised in Malmö, Sweden and hosted by the Swedish Transport Administration. The aim was to set a basis for collaboration with the numerous green corridor initiatives in the Baltic region and take advantage of an audience directly or indirectly exposed to the green corridor concept. The KPI set that resulted from this process is the one of Table 2 below. This set was reaffirmed at the fourth regional stakeholder workshop of the project in Sines, Portugal.

Table 2. Revised set of KPIs

INDICATOR	UNIT
Relative cost	€/tonne-km
Transport time (or speed)	hours (or km/h)
Reliability (time precision)	% of shipments delivered within acceptable window
Frequency of service	Number of services per year
CO_2-eq	g/tonne-km
SOx	g/tonne-km

5. Benchmarking results

The Brenner corridor, extending from Malmö (SE) to Palermo (IT) with branches from Salzburg (AT) to Trieste (IT) through the Tauern axis, and from Bologna (IT) to Athens/Thessaloniki (GR) through the Italian and Greek Adriatic ports, was selected to be examined first as a pilot case for testing the methodology. The following steps were followed:

- the Brenner pass (Munich – Verona) was selected as the corridor's critical segment;
- the cargo flows along this critical segment were identified in literature;
- a small number (15) of typical transport chains concerning typical cargoes were selected;
- detailed information concerning these transport chains (type of vehicles used, load factors, etc.) was collected from studies and interviews with transport service providers; and
- the selected KPIs were evaluated for each one of these transport chains (emissions were estimated through the EcoTransIT World web based tool).

The chains examined for the Brenner corridor and the corresponding KPI values are presented in Table 3 below.

Table 3. The Brenner corridor chains

Transport chain identity				Key Performance Indicators (KPIs)										
No	Origin-Destination	Mode	Annual vol. (t)	Cost (€/tkm)	Time (h)	Reliab. (%)	Freq. (no/year)	ICT (%)	Sec. (%)	Saf. (%)	Emissions (g/tkm) CO_2	NOx	SOx	PM_{10}
1	Verona-Naples	Train	61.000	-	12	92	260	100	0	0	17.61	0.02	0.09	0.006
2	Verona-Nurnberg	Train	500.000	0.80	9	50	260	100	0	0	14.87	0.01	0.05	0.004
3	Verona-Nurnberg	Train	2.700.000	0.05	9	100	572	100	0	0	14.87	0.01	0.05	0.004
4	Verona-Berlin	Road	1.100	0.07	25	50	2.600	0	0	0	71.86	0.51	0.08	0.013
5	Rome-Nurnberg	Road	32.000	0.05	48	80	104	100	0	0	62.08	0.47	0.07	0.013
6	Rome-Palermo	SSS	1.500	0.04	24	100	52	100	0	0	16.99	0.25	0.12	0.018
7	Verona-Trelleborg	Interm.	13.000	0.04	50	98.8	624	100	0.5	2	10.62	0.01	0.02	0.002
8	Bari-Athens	Interm.	10.000	0.04	72-96	95	52	100	< 0.5	0	27.28	0.18	0.08	0.008
9	Bari-Thessaloniki	Interm.	3.000	0.03	72-96	95	26	100	< 0.5	0	42.11	0.29	0.10	0.011
10	Trieste-Munich	Train	81.000	-	12	85	416	100	1	1	12.53	0.01	0.04	0.003
11	Trieste-Salzburg	Train	652.500	-	8	90	208	100	1	1	9.49	0.01	0.05	0.003
12	Trieste-Villach	Train	135.600	-	4	95	364	100	1	1	16.36	0.02	0.09	0.006
13	Berlin-Thessaloniki	Interm.	437	0.09	76	99	104	0	< 1	1	27.11	0.19	0.06	0.006
14	Bari-Berlin	Road	24.000	0.05	72	99	1.040	100	0	0	46.51	0.11	0.05	0.004
15	Bari-Athens	Interm.	8.500	0.05	24	99	520	100	0	0	25.41	0.25	0.14	0.024

Two levels of aggregation were foreseen in the initial methodology. The first one concerned the estimation of one set of KPI values for each and every segment of the corridor by aggregating all flows that involve the relevant segment. Weighted averages would be used for this aggregation. The respective transport work (tonne-km), cargo volumes (tonnes) or other flow characteristics (e.g. number of consignments) were to be used as weights depending on the definition of each KPI. However, the reliability of such an estimate was questioned due to the fact that:

- the sample was very thin (for some segments there was only one observation) and the resulting figure would have limited statistical value, if any;
- not all of the chains reflected the entire door-to-door transport as needed to ensure comparability; some of them covered only terminal-to-terminal operations; and
- most data was collected through interviews and reflected personal assessments without strict validation.

It was, thus, decided to express corridor benchmarks as ranges of values that resulted from the transport chain data, i.e. minimum and maximum values of all transport chain level KPIs. Table 4 below summarises the KPI values of the Brenner corridor presented by transport mode.

Table 4. KPI values for the Brenner corridor

KPIs	Intermodal	Road	Rail	SSS
Cost (€/tkm)	0.03 – 0.09	0.05 – 0.07	0.05 – 0.80	0.04
Av. speed (km/h)	9 – 41	19 – 40	44 – 98	23
Reliability (%)	95 – 99	50 – 99	50 – 100	100
Frequency (no/year)	26 – 624	104 – 2600	208 – 572	52
CO_2 (g/tkm)	10.62 – 42.11	46.51 – 71.86	9.49 – 17.61	16.99
SOx (g/tkm)	0.02 – 0.14	0.05 – 0.08	0.04 – 0.09	0.12

The most important conclusion of this exercise is the width of the range within which some KPI values fluctuate. Even after taking into consideration the drawbacks mentioned above, one would expect more concise estimates.

The second level of aggregation initially foreseen concerned an overall corridor (or corridor segment) rating, that would combine all KPIs into a single numerical value through the use of relative weights assigned to each KPI. The rationale for such a rating was to cope with interactions between different KPI groups, as is for example the case where measures introduced to improve performance in relation to one area might have adverse effects on another. However, this approach was later considered as an unnecessary complication on the grounds that:

- the weights needed for such calculation very much depend on the user (different users will propose different weights),
- it is a political issue best left for policy makers to decide and hence one that we should avoid,
- weights, if assigned, might lead to wrong interpretations,
- weights change over time (e.g. social issues might become more significant in the future), and
- weights would not reflect country specific characteristics of transport operations.

The issue was discussed extensively in a SuperGreen workshop organised in Naples, Italy and a decision was reached to exclude such attempt from the methodology. The decision was later confirmed by the project's Advisory Committee.

The methodology, as it resulted from the pilot exercise, was applied for benchmarking five other corridors (Cloverleaf, Nureyev, Strauss, Mare Nostrum and Silk Way). Lack of data combined with time and resource restrictions did not permit the examination of the remaining three corridors (Finis Terrae, Two Seas and Edelweiss). The results are summarised in Table 5 below.

Table 5. Benchmarking results (all corridors)

Corridor	Mode	Cost (€/tkm)	Av. speed (km/h)	Reliability (%)	Frequency (no/year)	CO_2 (g/tkm)	SOx (g/tkm)
Brenner	Intermodal	0.03-0.09	9-41	95-99	26-624	10.62-42.11	0.02-0.14
	Road	0.05-0.07	19-40	50-99	104-2.600	46.51-71.86	0.05-0.08
	Rail	0.05-0.80	44-98	50-100	208-572	9.49-17.61	0.04-0.09
	SSS	0.04	23	100	52	16.99	0.12
Cloverleaf	Road	0.06	40-60	80-90	4.680	68.81	0.09
	Rail	0.05-0.09	45-65	90-98	156-364	13.14-18.46	0.01-0.02
Nureyev	Intermodal	0.10-0.18	13-42	80-90	156-360	13.43-33.36	0.03-0.15
	SSS	0.05-0.06	15-28	90-99	52-360	5.65-15.60	0.07-0.14
Strauss	IWT	0.02-0.44	-	-	-	9.86-22.80	0.01-0.03

Mare Nostrum	SSS	0.003-0.20	17	90-95	52-416	6.44-27.26	0.09-0.40
	DSS	-	-	-	-	15.22	0.22
Silk Way	Rail	0.05	26	-	-	41.00	-
	DSS	0.004	20-23	-	-	12.50	-

It is important to note that the results of Table 5 are achieved using the EcoTransIT World web emission calculator and self-reported figures from interviewees and literature review. As such, they are only indicative. Using other tools and methods might have led to different results. The accuracy problem identified in the Brenner corridor is confirmed.

The comparison of rail transport attributes across corridors shows very high variance of cost and reliability for the Brenner corridor, which requires further investigation. The very low speed and high emissions of the trans-Siberian service is also noticeable, albeit expected due to the diesel traction and the gauge incompatibility problem along this route. The wide fluctuation of intermodal transport attributes is also impressive and can be explained by the different nature of schemes examined in each case.

Furthermore, the project surveyed the selected corridors to identify common development areas, best practices and most favourable areas for greening freight corridors. The findings are summarised in Figure 2 below.

6. Conclusions

The work performed thus far under the SuperGreen project leads to the following conclusions:

- Corridor benchmarking is possible but we need to standardise the measurement and allocation of emissions if we want to develop operational KPIs used for benchmarking purposes.
- Even then, the definition of acceptable limits for KPI values requires due consideration of corridor specific conditions. This type of risk is eliminated when comparing KPI values over time for the same corridor.
- Data collection proves to be a serious problem. Relevant obligations imposed by the corridor management might be a solution. The formation of corridor specific stakeholder groups can be helpful in this regard. Automated ICT applications, able to provide cargo flow data without causing physical disruptions of the vehicle flows or other administrative bottlenecks, can also be of particular importance.
- Aggregating chain-level KPIs to a single set of corridor- or segment-level ones is possible provided that an adequate sample of transport chains is examined under the same conditions. Otherwise, the use of value ranges is suggested.
- Aggregating corridor-level KPIs to an overall corridor rating should be omitted because:
  - There are problems associated with the weights needed for such calculation.
  - It is a political issue best left for policy makers to decide.
- The multiplicity of actors involved in modern supply chains and the volume of information that needs to be exchanged is one of the most important barriers for co-modal transport operations.
- The harmonisation of transport infrastructure / technology / operations (interoperability), as well as the harmonisation of national policies and regulations is of utmost importance when addressing the fragmented nature of European transport networks; mainly the railroads one.

Work on this project is ongoing and is scheduled to continue in the foreseeable future. What is not included here will be reported in future publications and on the project's web site (www.supergreenproject.eu). In view of important policy implications and of the need of the policy makers to be able to evaluate alternatives in an effective way, methods and tools specifically designed to tackle such problems seem more required than ever. It is hoped that work such as the one described herein will help toward that goal.

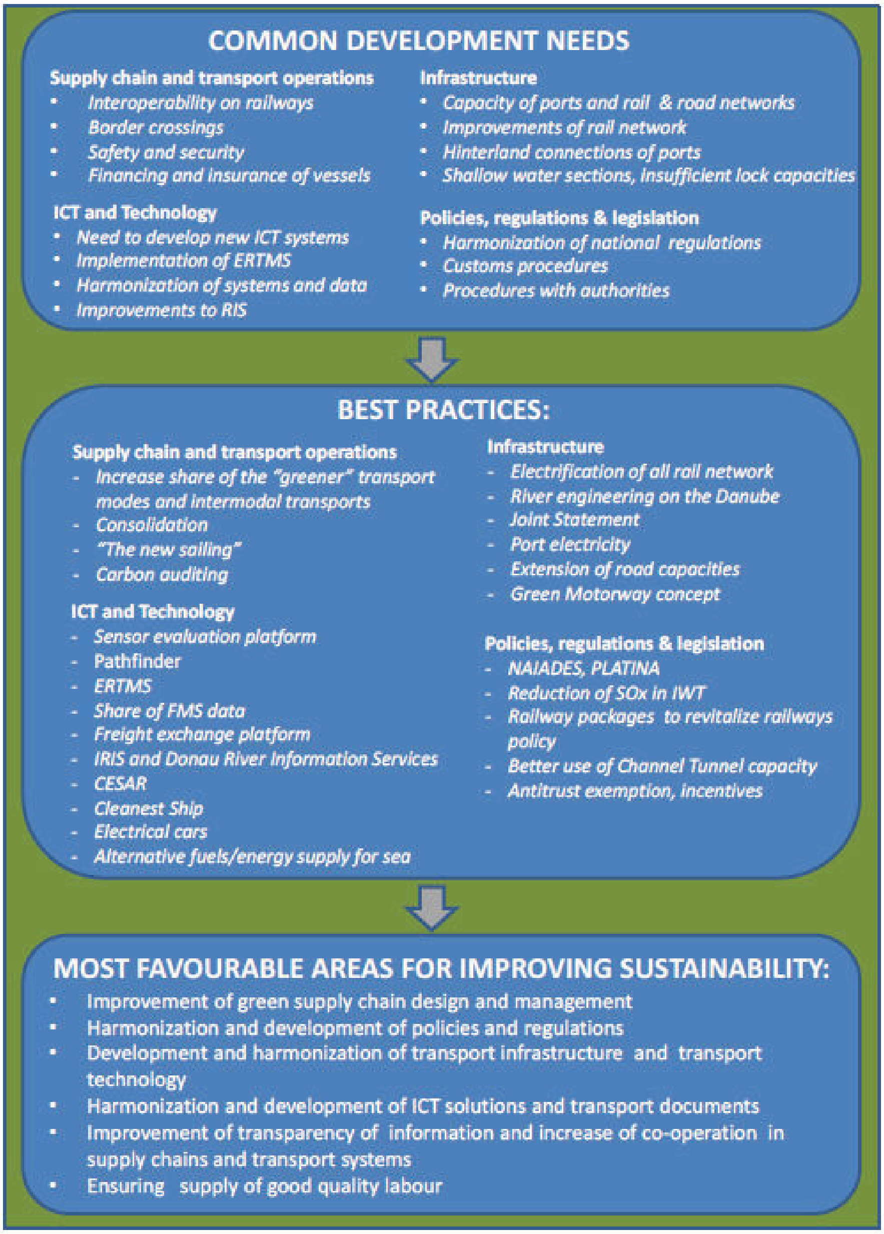

Fig. 2. Most favourable areas for greening transport corridors [Source: Rönkkö et al. (2011)]

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