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INSTITUT FÜR SCHIFFSTECHNIK, MEERESTECHNIK UND TRANSPORTSYSTEME

GPS Geofencing for Location-based CO_2 Calculation within Port Areas

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Agenda

1. Introduction
2. Location-based CO_2 Calculation
3. CO_2 Calculation for Logistics Units
4. GPS Geofencing
5. Case Study: CO_2 Emissions of Port of Duisburg
6. Conclusion

Development/Trend towards ‚Green Ports'

- Green Port Congress in HH this year
- Sustainable design of e.g. container terminals
- Port of Rotterdam: World's greenest port
- EcoPort Foundation with 150 European ports
- Concept of shore-based electricity

Why emission calculation within port areas?

- Intermodal nodes where several logistics units emit GHG
- First measure – second reduce
- A challenge for inland ports near inner cities (particulate matter)

Questions for location-based CO_2 calculation within port areas

- What are the boundaries?
  a) Emissions
  b) Geographic
- Which transport modes should be included?
- What about CO_2 emissions of fixed installations as e.g. cranes?
- What about streets crossing the port area?
- …

2. Location-based CO_2 Calculation

Terms and Definitions

- ‚*Ecological Footprint*‘
  introduced by WACKERNAGEL and REES in 1996
- *Carbon Footprint*
  total amount of GHG emissions during PLC of product/ service
- Measurement unit: *Carbon equivalent CO_2-e*
  describes the global warming potential of GHG
- Emission scopes of GHG protocol
  - *Scope 1*: Direct emissiones – fuel consumption
  - *Scope 2*: Purchase of energy
  - *Scope 3*: Transport associated emissions

2. Location-based CO_2 Calculation

Methodology

Selection of greenhouse gases → Boundary of emission scopes → Collection of greenhouse gas data (measurement vs. model-based)

Idea based on carbon accounting of

- *Organizations (e.g. universities)*
- *Events (e.g. Olympic Games 2012 in London)*
- *Large areas (e.g. cities)*

2. Location-based CO_2 Calculation

Working Definition

'A location-based carbon footprint contains ***all greenhouse gas emissions*** *which are* ***caused by activities taking place in a specified area*** *including* ***direct emissions as well as indirect emissions*** *caused by the production process of fuel, electricity or other energy sources used in these activities.'*

3. CO_2 Calculation for Logistics Units

a. Trucks

$$CO_2\ [kgCO_2] = FC_{actual}\ [\frac{l}{100\ km}] \cdot CO_2factor[\frac{kg\ CO_2}{l}] \cdot \frac{distance}{100\ km}$$

FC = Fuel Consumption | CO_2*factor = 3.175 kg* CO_2*-e*

- If FC is not known, suggestion of HBEFA

b. Cargo Handling Equipment

- *Fuel-driven* handling equipment calculation similar to trucks
- *Electric driven* handling equipment by multiplying energy consumption data (technical specifications) with electric CO_2e-factor

3. CO_2 Calculation for Logistics Units

c1. E-railways

- Accountable for indirect emission (power generation)
- Electric mix of the country is essential
- Germany: 0.592 g CO_2-e/Wh

c2. Diesel-railways

- Comparable to calculation of emissions caused by trucks
- Energy consumption of a train: 0.5665 g diesel/Ntkm
- In production plants and port areas only diesel-driven railways

3. CO_2 Calculation for Logistics Units

d. Ships

Emissions influenced by

Type of waterway	Speed above water	Ship type	Capacity [t]
Free flow river	Min speed (13 km/h)	Gustav Koenigs	1,100
Regulated river	Max speed (12 km/h)	Johann Welker	1,500
Canal	Max speed (11 km/h)	GMS	3,000
		Ship + lighter	[ship]+2,400
		Pushing unit (4 lighters)	9,600

3. CO_2 Calculation for Logistics Units

d. Ships

Ship Type	Cap. [t]	Power [kW]	Utilization Ratio of Engine Power [%]						Rhine River Fleet [%]
			Free flow		Regulated Flow		Canal		
			empty	loaded	empty	loaded	empty	loaded	
Gustav Koenigs (long)	1,100	750	70	80	20	40	20	40	29.5
Johann Welker (long)	1,500	1,000							44.6
GMS	3,000	1,100							15.2
Ship + lighter	[ship] + 2,400	1,200							5.8
Pushing unit (4 lighters)	9,600	3,000							4.9

- Specific fuel consumption: **0.200 kg marine-diesel/kWh**
- CO_2-e factor for marine-diesel: **3.772 kg CO_2e/kg**
- Interpolation of utilization ratio with proportionate capacity
- Calculation of emissions/tkm with travelled distance per time

3. CO_2 Calculation for Logistics Units

e. Terminal energy consumption

- Container transfer process: **4.4 kWh**
- Liquid cargo: **0.4 kWh/t**
- Bulk cargo: **1.3 kWh/t**
- General cargo: **0.6 kWh/t**

➢ Multiplied with the CO_2-e factor of the electric mix of the country

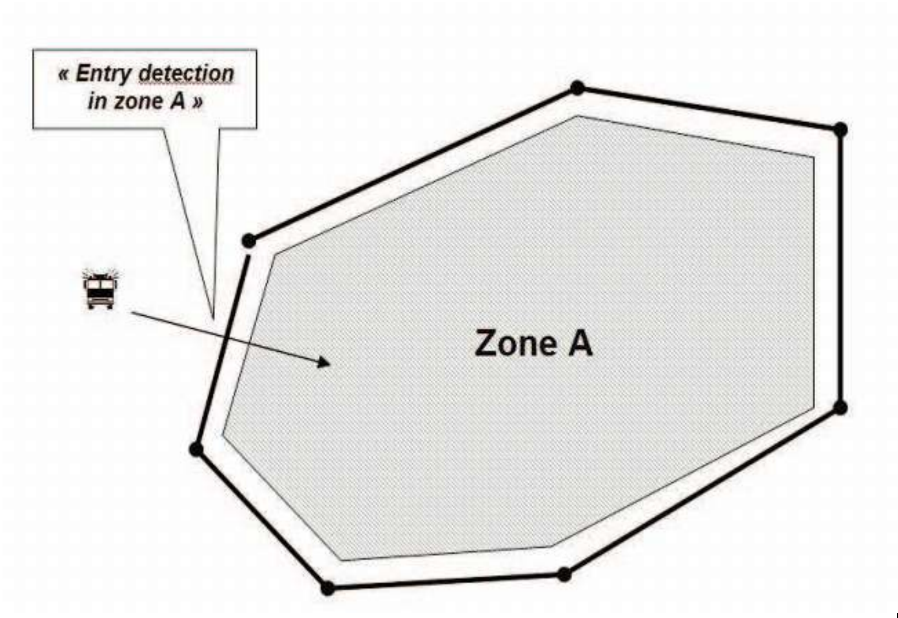
➢ *Consideration of energy consumptions of buildings, warehouses, etc. for an overall location-based emission calculation*

4. GPS Geofencing

Geofence is a virtual perimeter for a real-world geographic area

Geofence technique

- Mobile object tracked by GPS
- Set of geographic coordinates for constitution of virtual boundary
- Geofence system determines whether a tracked object is located inside or outside the geofenced area
- Generation of alert when tracked object crosses geofence
- Shape and size of the geofenced area can vary
- Calculation algorithmus enables the computing of alerts



Active geofence (black perimeter) around an area (Zone A)

Port areas

a. Valencia
b. Duisburg
c. Rotterdam

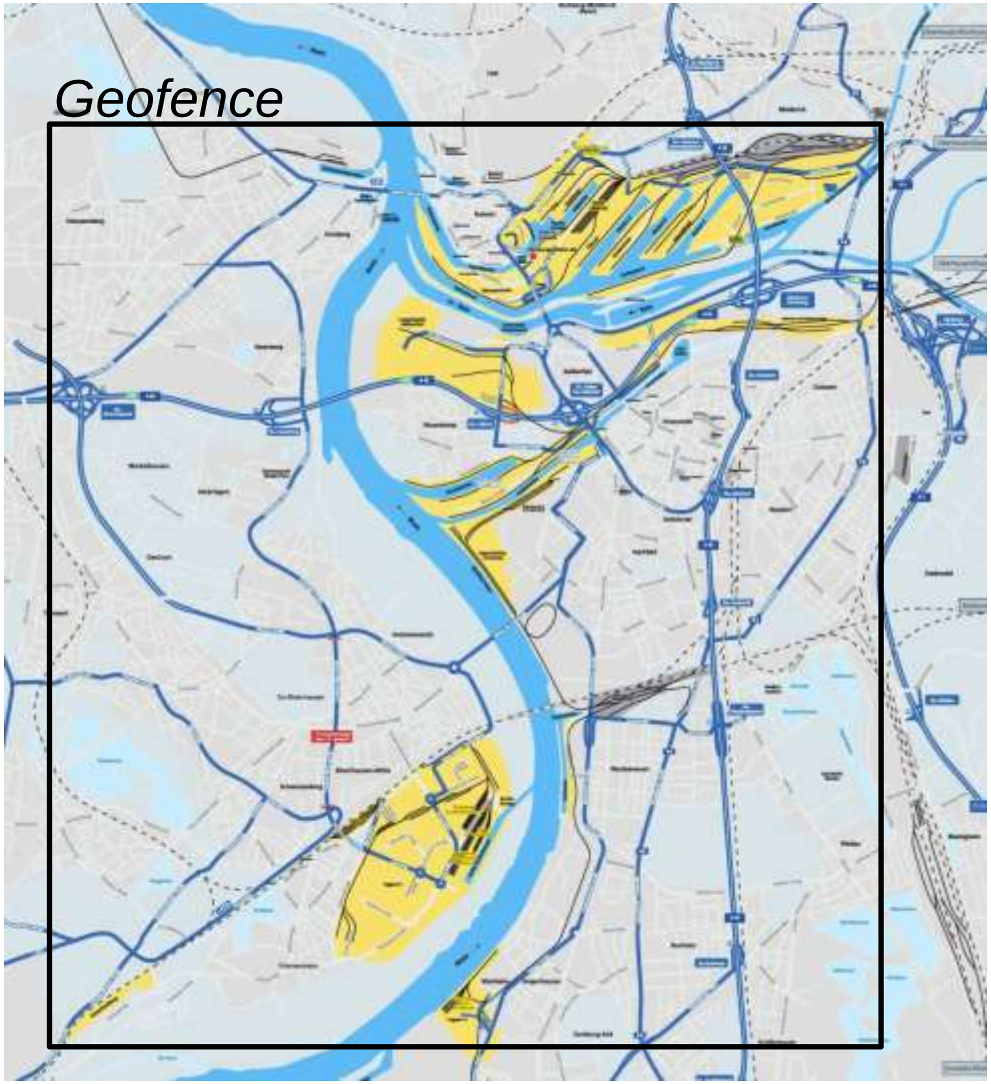
b.

a.

c.

Port of Duisburg

- Biggest inland port in Europe, located where river Ruhr crosses river Rhine
- Hinterland hub for Zeebrugge, Antwerp, Rotterdam, Amsterdam
- New container terminals logport I and II gain in importance
- Port authority offers facilities, packaging services and railway traffic
- Geofence as rectangle



Basic data for CO_2 calculation

- Data of 2009, business report of port authority
- Coordinates in northeast and southwest define the rectangular geofenced area
  - NO: 51°27‘44“, 6°47‘54“
  - SW: 51°22‘28“, 6°40‘24“

Transport Mode	Cargo Weight [t]	Number of Units
Ship	12,100,000	8,564
Train	10,700,000	14,267
Sum	**22,800,000**	
Truck	21,600,000	1,756,098
sum	44,400,000	

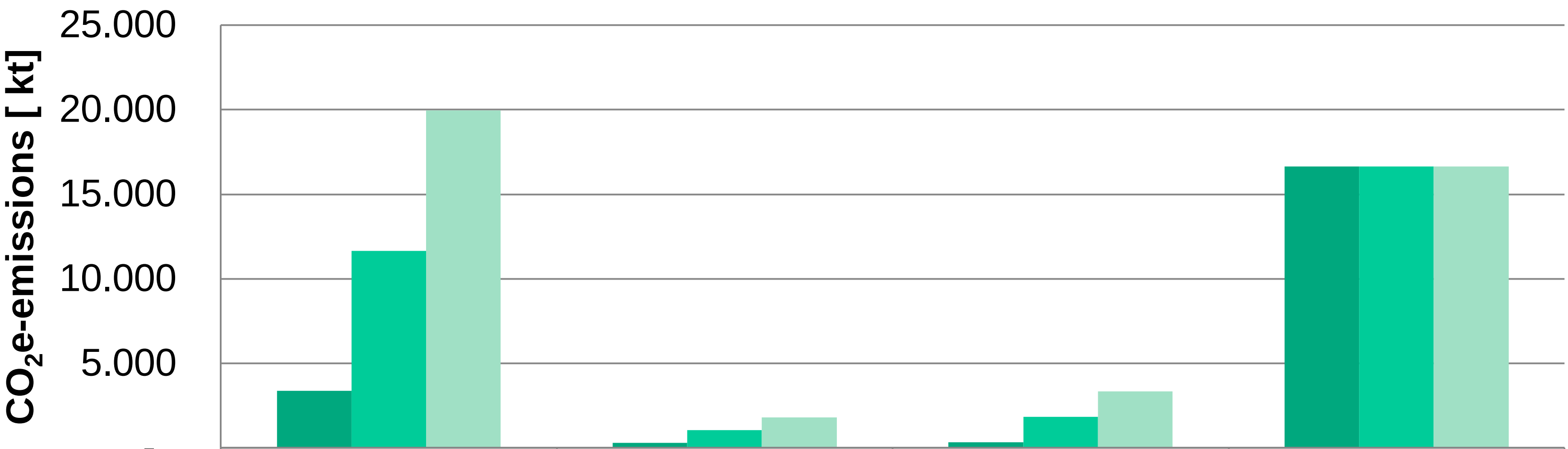
Type	Turnover [t]
liquid	4,400,000
bulk	5,600,000
container*	9,600,000
groupage	3,200,000
sum	**22,800,000**

**) 953,000 TEU*

Travelled distances within port area

km	Truck	Train	Ship
Low (GPS based)	2.10	1.30	1.30
Ø (Average)	7.25	4.55	6.90
High (GPS-based)	12.40	7.80	12.50

Total emissions of port of Duisburg 2009



	Truck	Train	Ship	Transshipment
low	3.380	301	349	16.643
Ø	11.670	1.052	1.853	16.643
high	19.959	1.803	3.356	16.643

- Short distance: 20,672.74 t CO_2-e in 2009
- Average distance: 31,217.15 t CO_2-e in 2009
- Long distance: 41,761.56 t CO_2-e in 2009

6. Conclusion

- Carbon reduction and management crucial for whole logistics industry
- General idea of area-based carbon emission calculation for logistics hubs (e.g. ports) is possible
- Results only an orientation according to several crude assumptions
- Turnover/ transshipment account for a major part of total emissions
- Further research approaches:
  - ✓ Enlargement of real data set
  - ✓ Development of carbon reduction activities for port-areas

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Thanks for your attention!

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Assumptions for calculation

1. Rhine river ship fleet identical with ship fleet in port
2. Ship speed 13 km/h above water in geofenced area
3. Ship utilization of 90 %
4. Distance of ship half in port (canal), half on rhine (free flow)
5. Only diesel trains within port area
6. Large trains < 1,500 t
7. Truck load of 12.3 t
8. Truck fuel consumption 240.33 g/km (urban area) based on HBEFA
9. Density of diesel 0.8325 kg/l
10. Average container load 10.1 t
11. Turnover of truck cargo as general cargo