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KENNISCENTRUM DUURZAME HAVENSTAD

Intralog

Towards an autonomous system for handling inter-terminal container transport




Program

- Introduction
- Problem definition and research question
- Analysis of inter-terminal traffic
- PPP-criteria
- New developments
- Business cases
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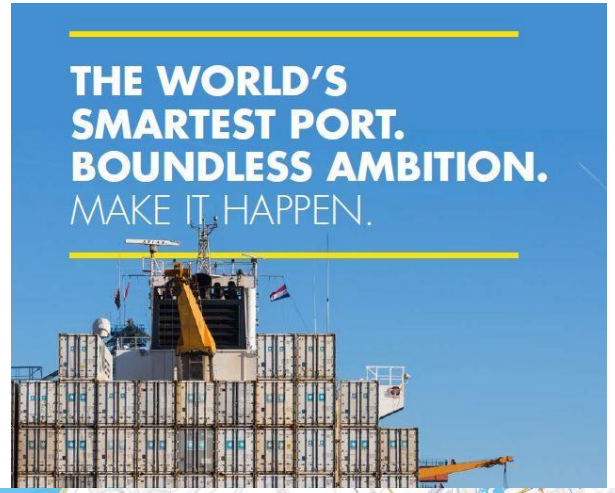
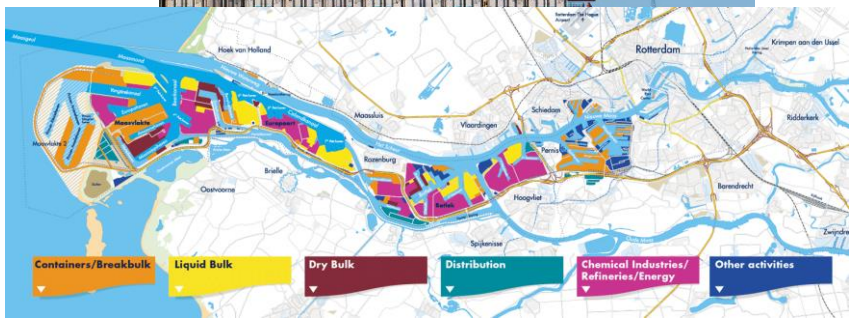
Port of Rotterdam

- Biggest port in Europe
- Port area: 12,500 ha, approximately 6.000 hectares of business areas)
- Employment:> 180.000 jobs.
- In- and outgoing: about 470 million tons per year.
- In 2016 29.022 seagoing and 105.000 inland vessels





Problem definition – Rationale for improving the future position Rotterdam port

- Port
  - Hub function
  - Competitive position
  - Rotterdam Climate Initiative
- Terminal operators
  - High investments
  - Faster inter-terminal transit
  - Improve "standstill" loss of containers
- DCs
  - Efficient and environmental friendly handling
  - Lay out
- Haulage companies
  - Future environmental requirements
  - Efficiency (driving times, waiting hours, faster and more accurate docking)
- General: Congestion in HIC Rotterdam

Planet becomes more important but Profit / Business case remains the major issue!

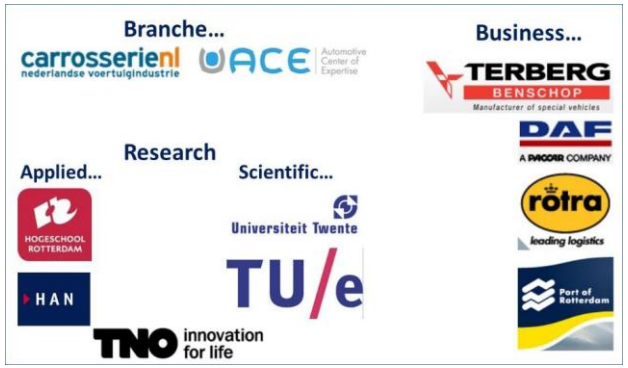
Research question and objective

- Research question:

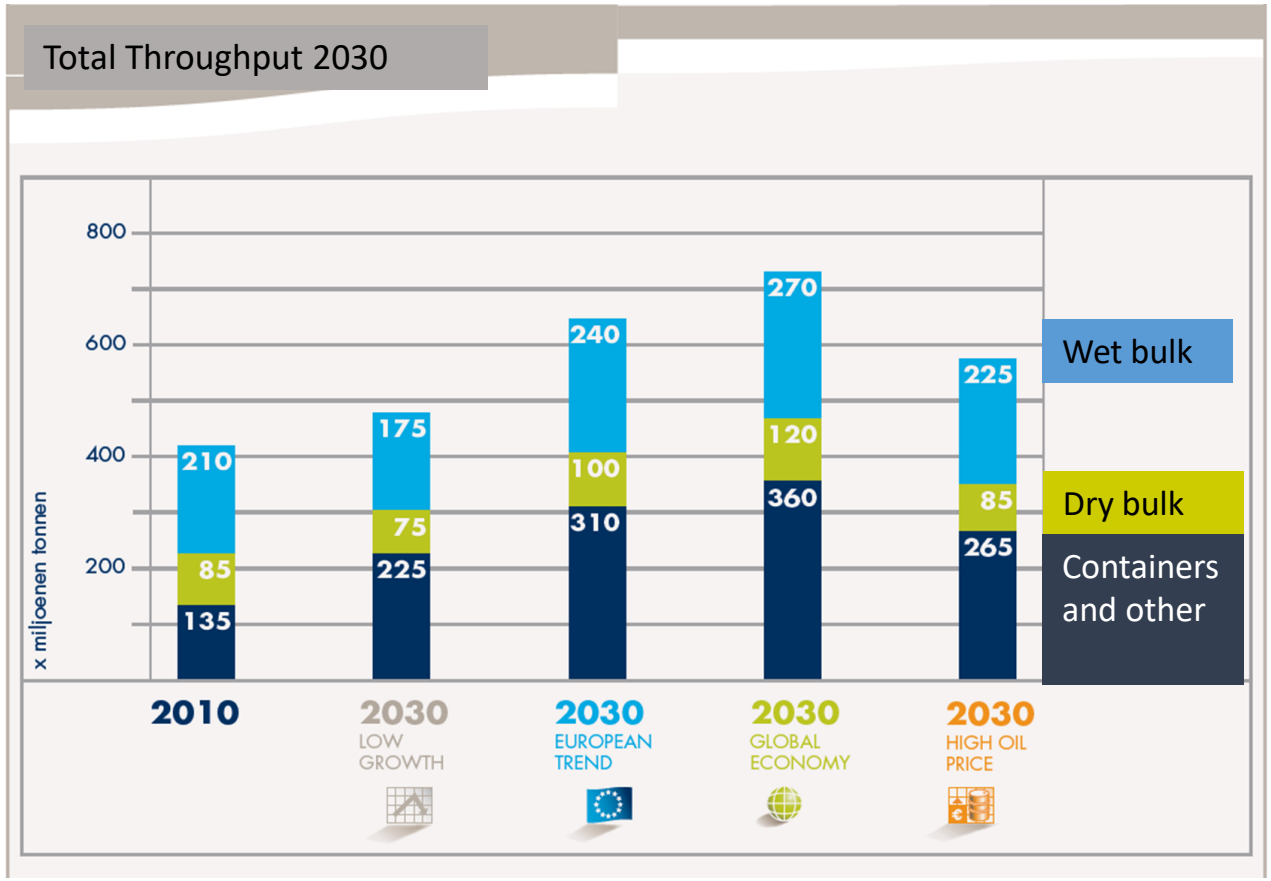
"*How could the establishment of an independent autonomous transport system between terminals and major distribution centres be a sustainable answer to the future container flows*?"

- **Objective**

To examine, on the basis of the PPP values (People, Planet, Profit), how autonomous and sustainable transport system can be used for the transport and handling of containers in logistics operations at the distribution centre and inter-terminal traffic in the port.



In 2010 Port Vision 2030: 4 Scenarios



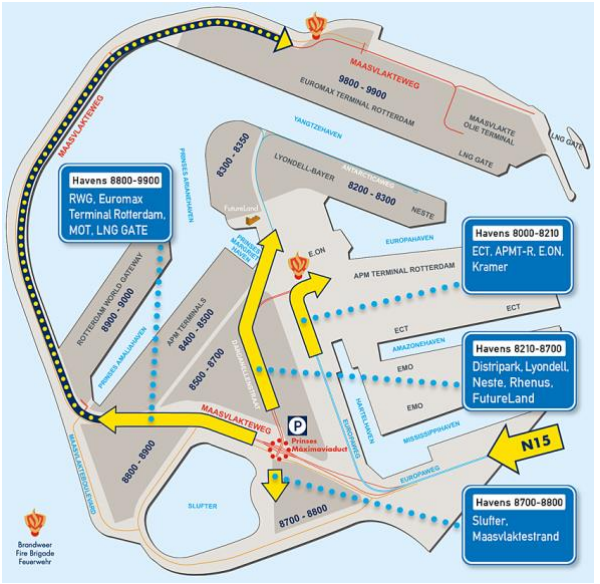
TEU throughput	2010	2016
TEU in mln	11,1	12,4
Metric tonnes in mln	112	127,1

Today Low growth scenario

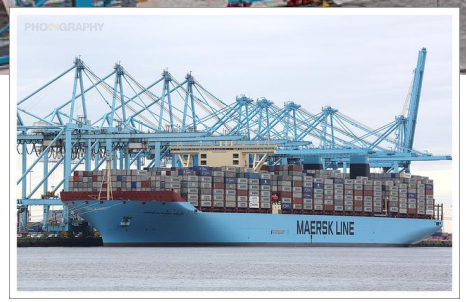
Rotterdam transition port

Growth → Solving bottlenecks & new infrastructure for inter-terminal transport

- Physical bottlenecks on the A 15 are largely solved
- Future growth → additional solutions
- Central Exchange Route (CER) is being established

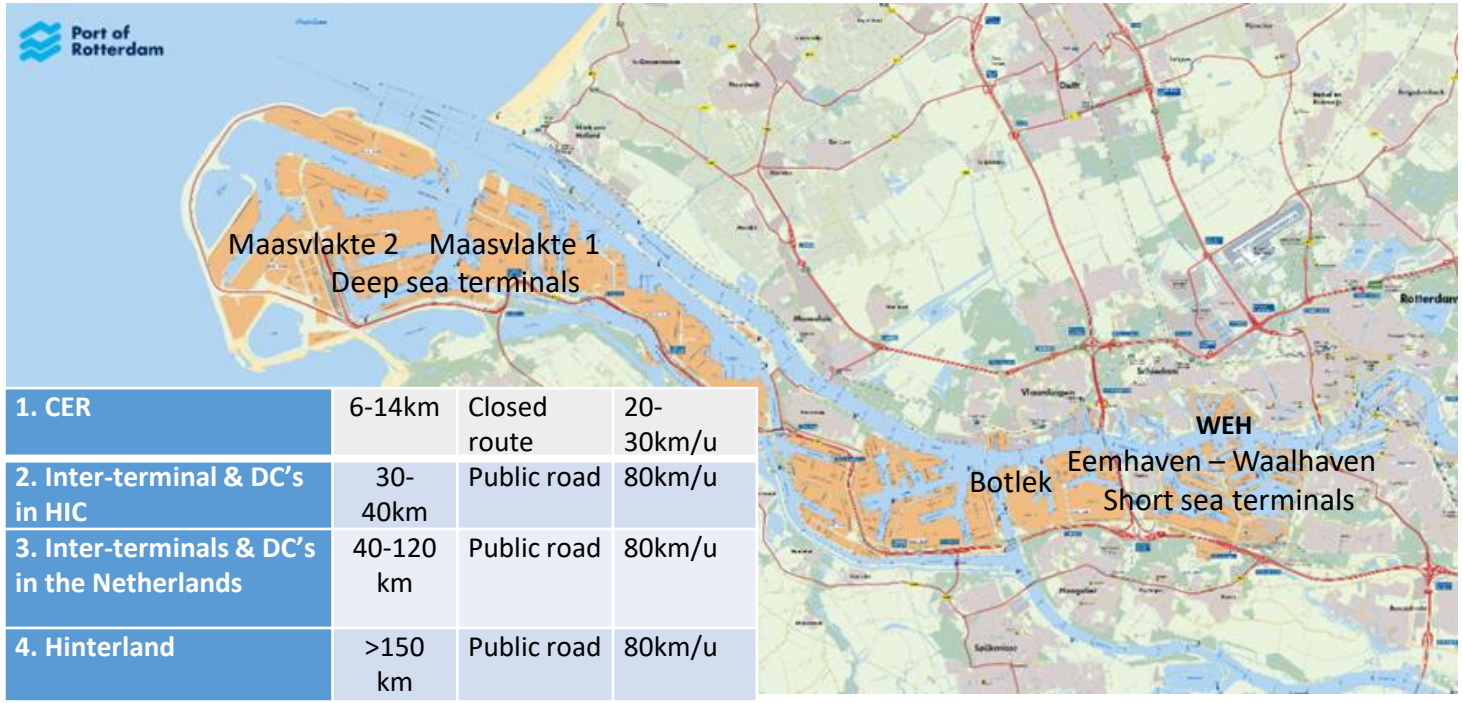


MV2 – APM – Automated & Electric



Costly delays as cargo ships and volumes grow

Less throughput to Hinterland, much more internal traffic than foreseen → congestion



1. CER	6-14km	Closed route	20-30km/u
2. Inter-terminal & DC's in HIC	30-40km	Public road	80km/u
3. Inter-terminals & DC's in the Netherlands	40-120 km	Public road	80km/u
4. Hinterland	>150 km	Public road	80km/u

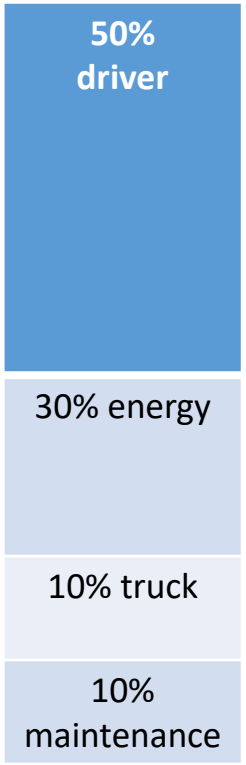
40% of road trips < 30 km

Empty Driving: 40-67%

Source: M@R

PPP-criteria: Profit / Kosten

- Driver costs approx. 50%
- Cost perspective differs by type of application
  - Terminals: Speed of handling deep sea ship primarily, for CER: 24/7 & '100%' up time, no disturbances / errors
  - CER: Transport is port work = significantly higher personnel costs!
  - Transport: km-price dominant, reliable technology, less damage
  - DCs: Shunting time + operations → Auto docking



PPP-criteria: People

New MV2 terminal

"At RWG, only work 180 people, and especially IT specialists. We are in fact an IT company that ships containers, a container company 3.0".

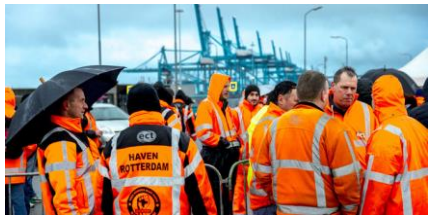
Managing Director Ronald Lugthart

- Job market:
  - Aging and insufficient entrants → lack of drivers;
  - Mobility as a service
  - Limited compensation in ICT jobs
  - Affordable, suitable ICT people are already difficult to get
  - For 10 drivers max 1 ICT employee
- Big differences per situation
  - CER: until 2020 via MTS with driver. About 70 jobs
  - DCs impact autonomous transport is limited to auto docking until 2020.
  - Only after 2025 starts at SAE Level 5 on the public road

Labour Union FNV in 2015

Countermove planned on autonomous driving

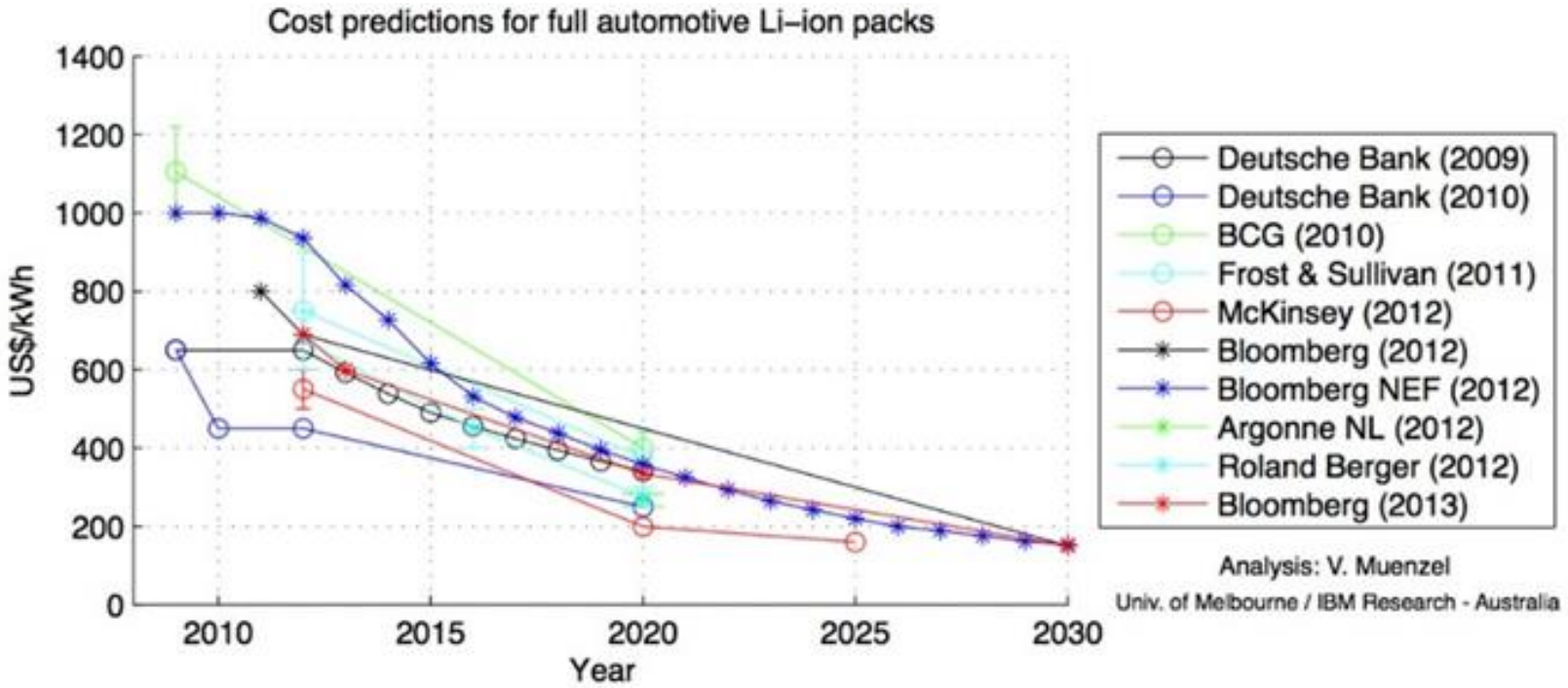
- Transport in the port should he handled by port workers
- Job guarantee for 9 years
- Threat to strike



Planet: zero emission

- Diesel high energy density - CO_2 and particulate matter.
- Truck industry mainly focuses on platoon and LNG
- CNG, Green gas / biogas - availability?
- Batteries
  - Price batteries fall sharply. From $ 1000 in 2010 to $ 100 per kWh in 2022
  - Charging times too long → Battery change at short distances? Pantographs? Inductive charging?
  - Batteries 12.0 kg / km versus diesel 0.4 kg / km →Batteries not suitable for longer distances and higher speeds
  - Charging electrically in time 50-600kW versus H_2 or Diesel 6,800-16,000kW
  - e-Highway - high cost infrastructure
  - H_2 is less efficient than batteries, offers opportunities for long-haul freight, infrastructure lacking

Planet: Price development batteries



- Battery weight remains a major disadvantage
- Not suitable for longer distances or high speeds!
- Chance for fixed routes and short distances with good charging infrastructure

Planet: 0-Emission trucks are feasible → big differences in WtW efficiency

Pathway	Range Cost per km	Efficiency WTW	Example vehicle
Electric Road Systems e⁻ → Grid (incl. catenary) → e⁻ → eTruck (Catenary-Hybrid) 96 kWh, 12 ct/kWh; 1,6 kWh/km	**60 km** 19 ct/km	77%	
Battery e⁻ → Grid → e⁻ → eTruck (Battery) 96 kWh, 10 ct/kWh; 2 kWh/km	**48 km** 20 ct/km	62%	
Hydrogen e⁻ → Electro-lysis η = 70% → H_2 → H_2-network[1)] → H_2 → CH_2- fuel station → $C.H_2$ → Fuel cell truck 2 kWh, 5 kWh 93 kWh; 65 kWh, 15 ct/kWh; 65 kWh, 18 ct/kWh; 65 kWh, 20 ct/kWh; 2.7 kWh/km	**24 km** 55 ct/km	29%	
Power-to-Gas e⁻ → Electro-lysis η = 70% → H_2 → Methanation η = 80% → CH_4 → NG-network[1)] → NG → CNG-fuel station → CNG → Gas-truck 2 kWh 98 kWh; 69 kWh, 15 ct/kWh; 55 kWh, 19 ct/kWh; 55 kWh, 20 ct/kWh; 55 kWh, 22 ct/kWh; 3.2 kWh/km	**17 km** 70 ct/km	20%	

1) Including storage
Source: German Ministry of Environment – Siemens – Brussel – 8-11-2016

Quantitative analysis of autonomous inter-terminal transport container – Simulations TU Delft

Logistics services for different vehicle configurations (Negenborn et al 2014)

Scenario	Configuration / number of vehicles	Non-Performance %	Average time in hours that the container arrives too late
Low growth 1.420.000 TEU	24 Lift AGVs	2,5	0,60
	32 AGVs	21,7	3,83
	9 MTS + 42 trailers	19,3	3,69
	17 TTs + 2 barges	98,7	353,85

Overall non-performance scores relatively high. Lift AGVs score best with 2,5%.
At higher volumes in the medium and high growth scenario, non-performance for AGVs was 11,2 resp. 18,3%.
This is not acceptable for stakeholders.

TBA simulation CER (TBA, 2016)

Essential differences from the study at TU Delft:

- There is central control
- More containers are ordered in one go. Often > 10 TEUs
- There are three service levels. Standard, Premium, Hot Box. Reefer containers and containers for customs → Hotbox (TTs)

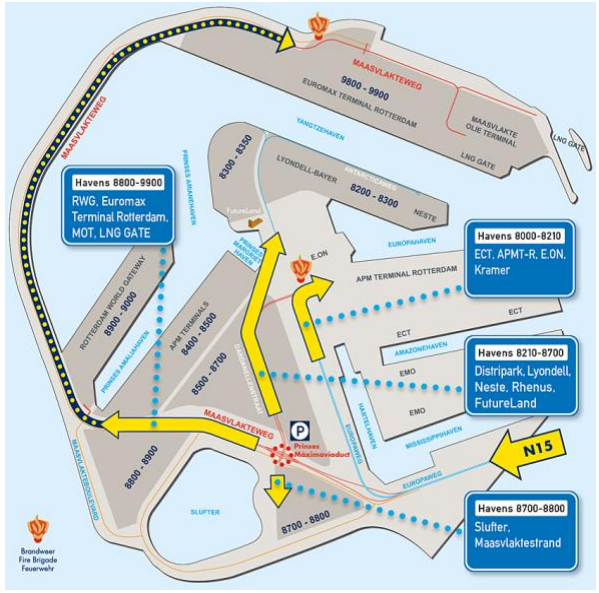
Scenario	Configuration / number of vehicles	Service level	Time of delivery	Non-Performance
500.000 TEU per annum	5 MTSs and 3 TTs	Standard	< 48 hours	5%
		Premium	<16 hours	2%
		Hot Box	<4 hours	1%

Occupancy rate per year	per MTS, max 10TEU
500.000 TEUs	9,7
1.000.000 TEUs	9,8
400 to 500.000 TEU	Break even

Phasing / Time

Situation	Trip distance (km)	Road /Area	Speed	SAE level	Period
1. CER	6-14	Closed route	20-30km/u	4	Till 2020 by MTS with driver, from 2020 autonomous
2. Inter-terminal & DC's in HIC	30-40	Public road	80km/u	5	From 2025
3. Inter-terminals & DC's in the Netherlands	40-120	Public road	80km/u	5	From 2030
4. Hinterland	>150	Public road	80km/u	5	From 2035

Internal Route / Central Exchange Route (CER) offers ideal next step



- Step to level 5 of driving on public roads is very big
- CER is closed route, ready in 2019.
- Start with MTSs
- CER will be autonomous ready
- Relative low speed, 20 – 40km/u
- Energy supply
  - Changing batteries is first option
  - Pantograph at the charging location, from above?
  - Induction too expensive
  - e-Highway not possible because containers cannot be lifted containers in case of calamities
- Connectivity and navigation can be well arranged

Expectation of 500,000 TEU per year - growing to 1,000,000 a year!
99.99% up time 24/7 is in addition to cost key requirement users!

Conclusion

- Autonomous zero emission driving is achievable on the basis of People Planet Profit
- Potential Costs savings (driver, energy, maintenance, handling, limited increase in ICT costs). Increasing occupancy rate, less empty driving!
- No fit-for-all solution → Multiple business cases → Start with CER and auto docking on DCs
- System change with key drivers
  - Changing role of port company - From landlord to whole-chain facilitator
  - OEMs more effort on zero emission, certified production
  - Government to support infrastructure for energy.
  - Digitalization (IoT, Connectivity - Intra and Extranets → Big Data) → New Business Models
  - Adaptation legislation public road from 2020
- Focus on innovators for successful implementation.