

Automated high-speed Hyperloop cargo transportation for a sustainable logistics network

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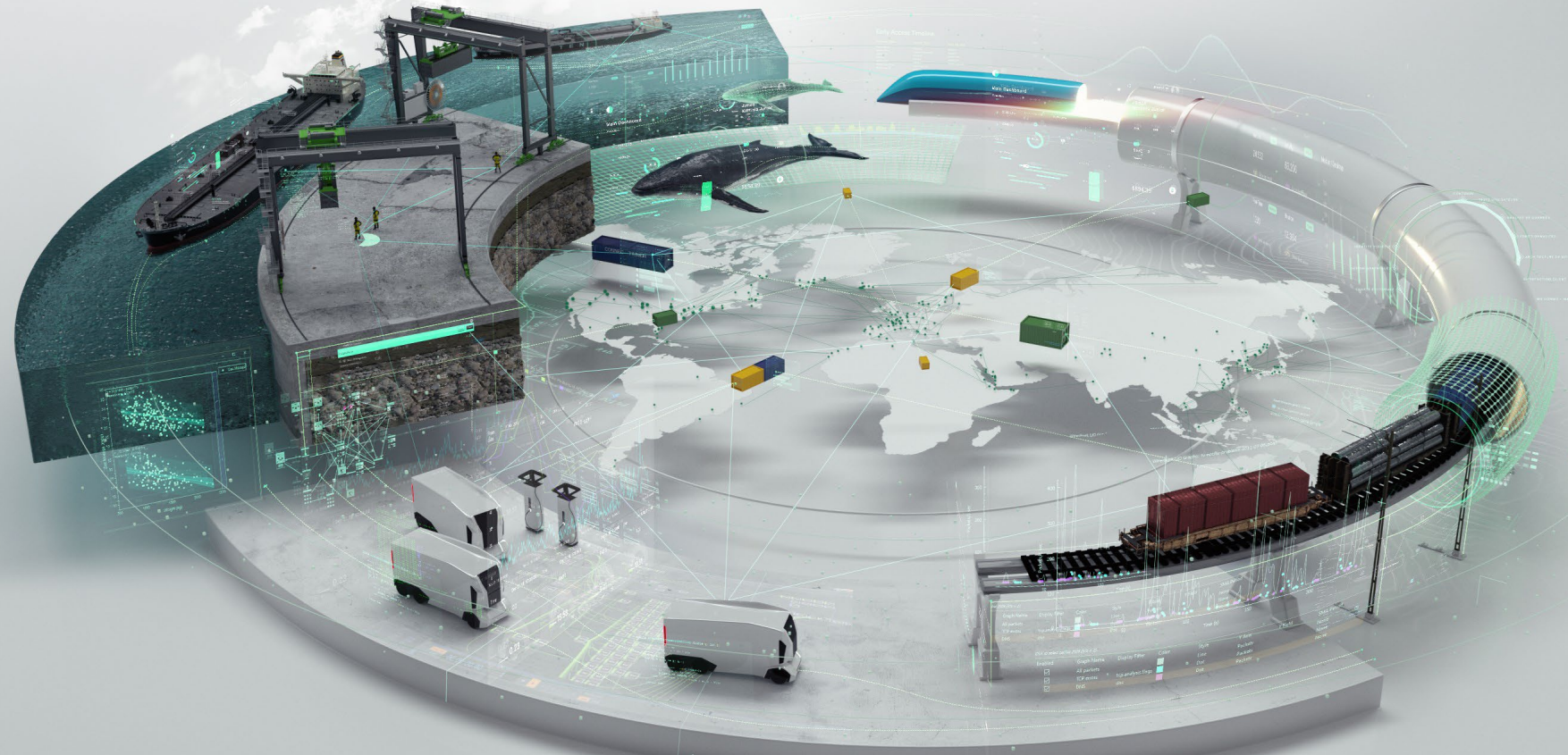
³ Bremer Institut für Produktion und Logistik GmbH (BIBA), ⁴ to-be-now-logistics-research-gmbh, Bremen,

⁵ TSI, Transport and Telecommunication Institute, Riga, ⁶ BALance Technology Consulting GmbH, Bremen

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- Hyperloop & CargoTube Technology
- Production Logistics
- Modelling and Simulation
- Interconnected CargoTube @ EU PI

Institute of Hyperloop Technology



Renewable
Energies



Biomedical
Physics & Acoustics



Laser & Optics

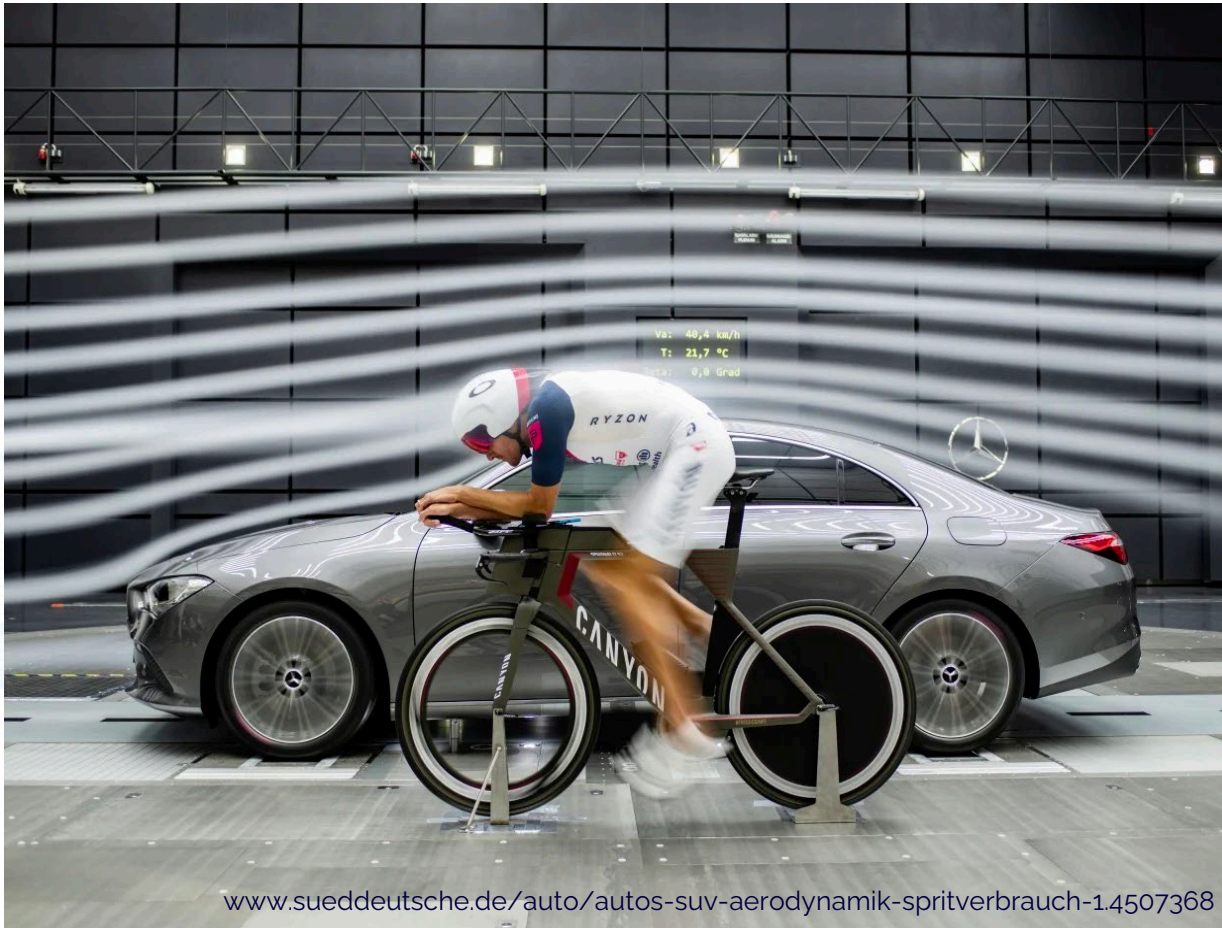


The nub of the matter



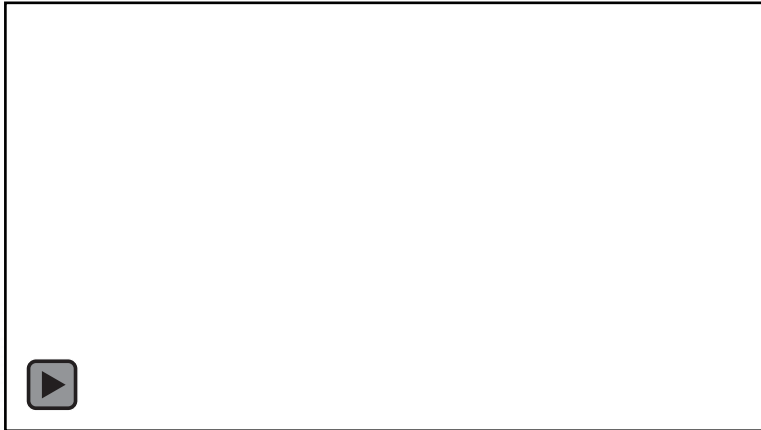
Second law of Thermodynamics:

THE ENTROPY OF A CLOSED SYSTEM ALWAYS INCREASES!





Hyperloop – the bottom line



<https://www.tec-science.com/mechanics/gases-and-liquids/flow-separation-boundary-layer-separation/>

$$F_D = \frac{1}{2} \rho C_D A \cdot v^2$$

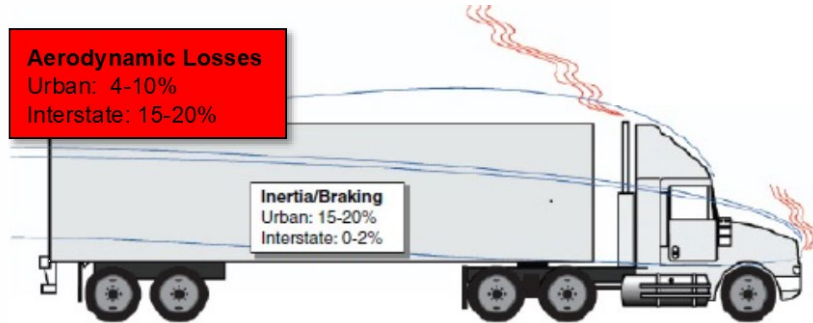
$$P_D = F_D \cdot v$$

$$= \frac{1}{2} \rho C_D A \cdot v^3$$

$v_{Maglev} \sim 400 \text{ km/h} \Rightarrow E_{loss} > 83\% \text{ due to air friction}$



Energy budgets



CargoTube transport – **Hyperloop**

- 10% air friction

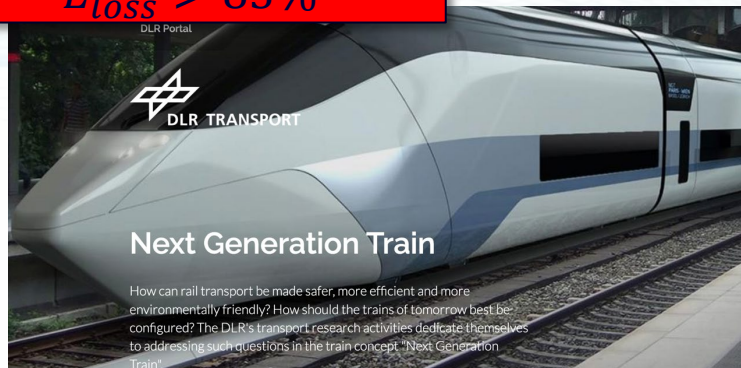
70 TWh

17 million x annual consumption
of a family of four

or

ca. 15% annual consumption
EU population

$v_{NGT} \sim 400 \text{ km/h} \Rightarrow$
 $E_{loss} > 83\%$



<http://de.statista.com/statistik/daten/studie/282301/umfrage/transportsleistung-des-strassengueterverkehrs-in-der-eu>



CargoTube in production logistics

Logistics hub relocated out

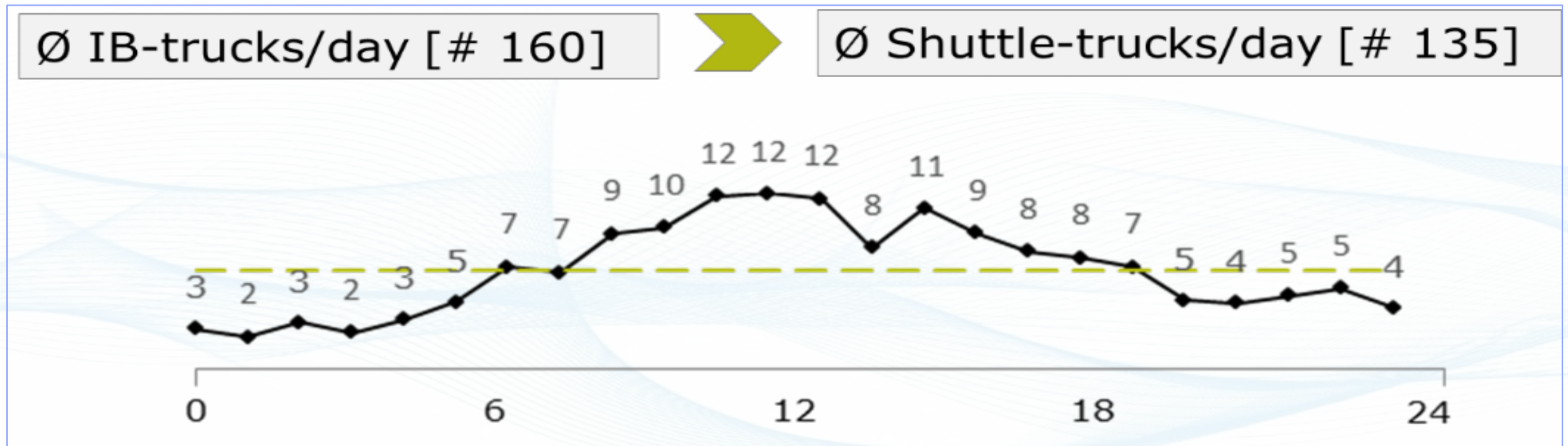
- Standardized containers
- Automated operation 24/7
- Reduction of
 - Public road traffic load &
 - Green House Gases, CO₂
 - Pollutants
 - Noise & light
 - Energy consumption





Demand Planning

- 9-12 km distance
- 11.000 m³ per day

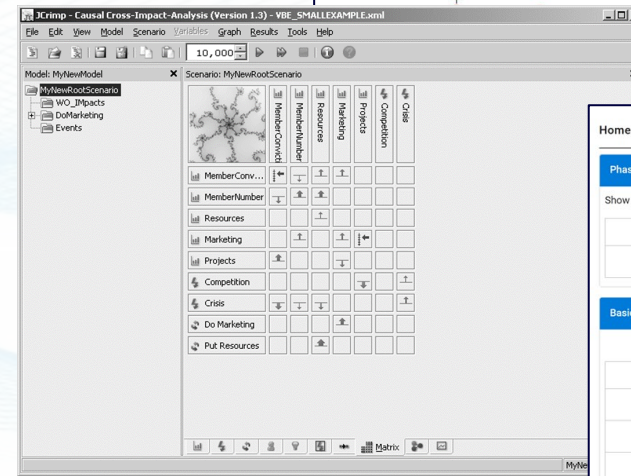
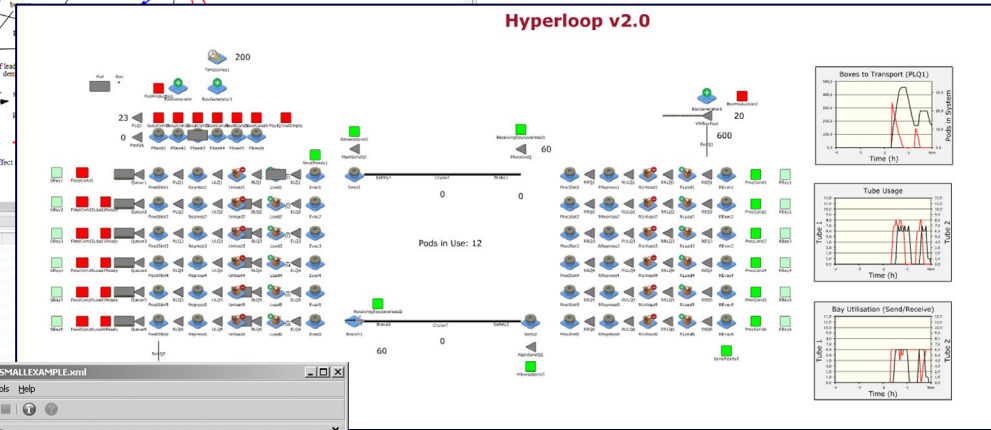
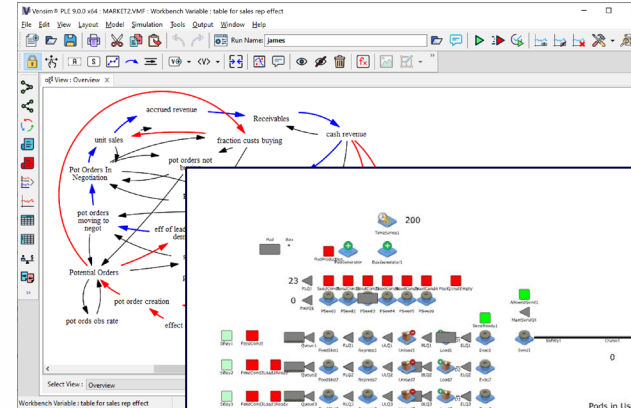


(Source: GVZe Wolfsburg & tbnlr-gmbh)



Modelling and simulation approaches

- Discrete event simulation
- System dynamics
- Cross-Impact analysis
- Life cycle performance assessment
- Synchromodal optimisation
- Electrification analysis



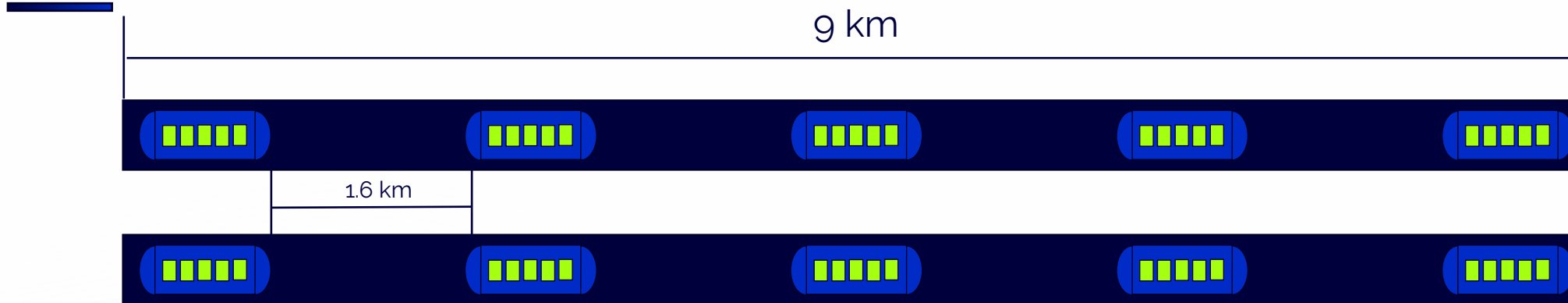
Name	Rep.	Start	End
1 Year	10	4.Nov.2020 00:00:00	4.Nov.2021 00:00:00

Name
Environment
Propulsion
Tank
Auxiliary Diesel Engine

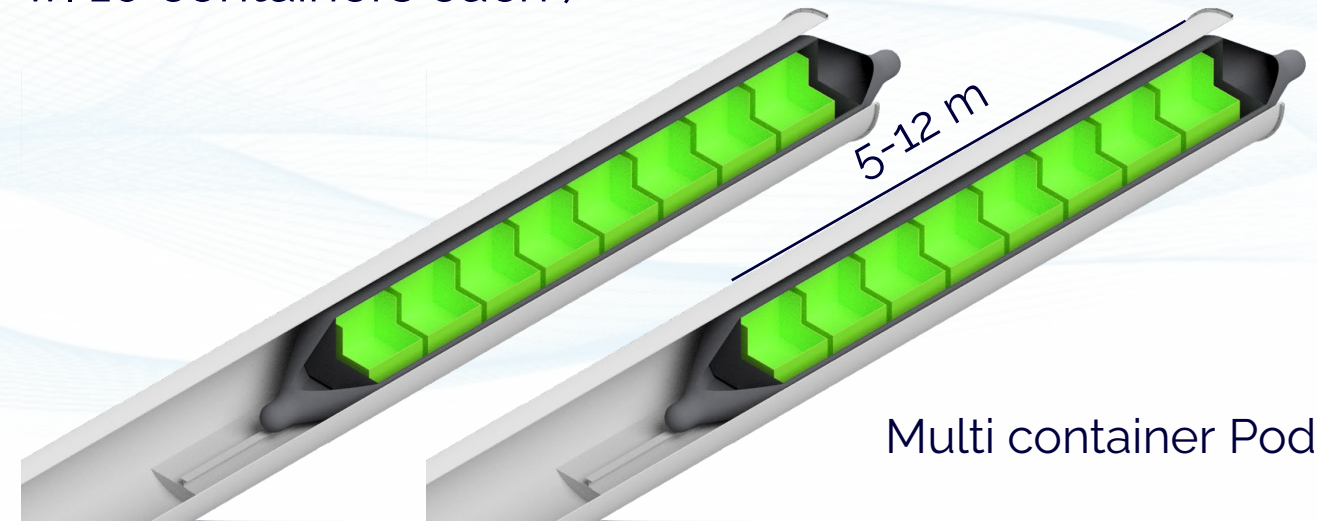
2022 IEEE 28th ICE/ITMC & 31st IAMOT Joint Conference, BIBA, H. Duin



Production plant scenario



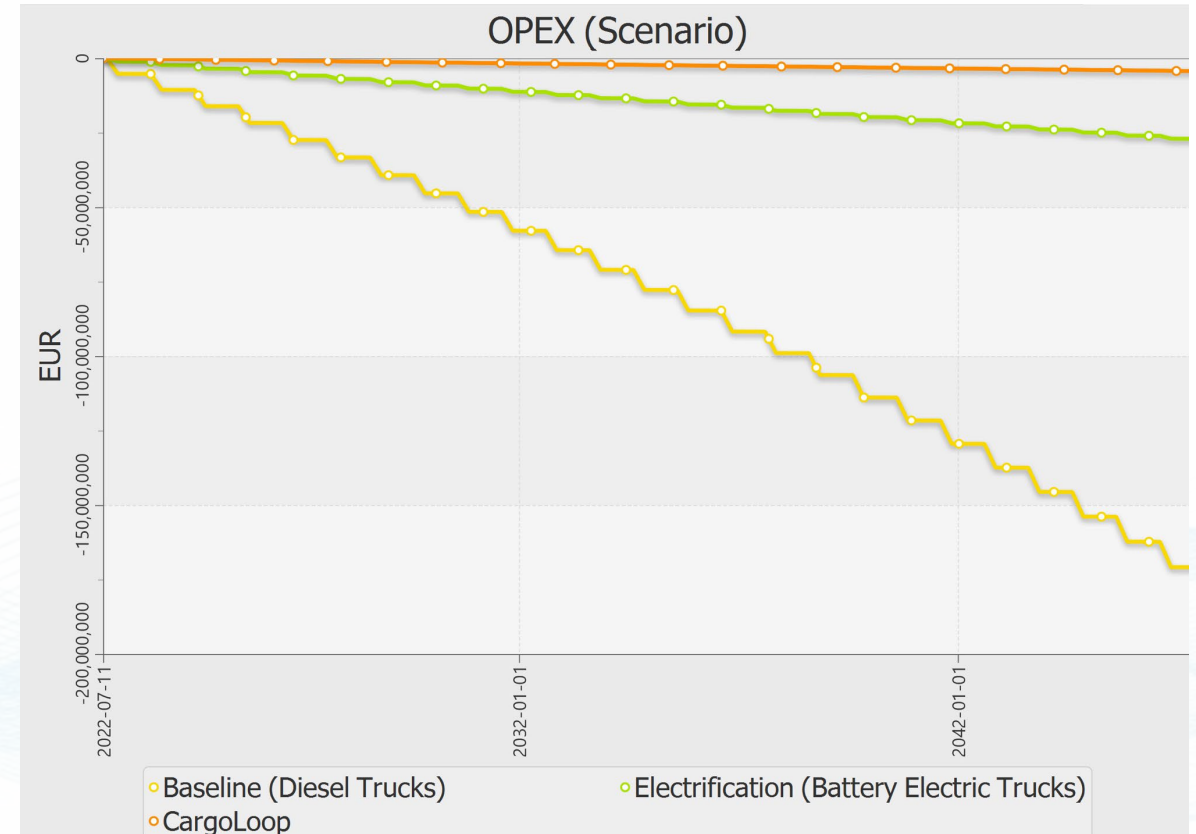
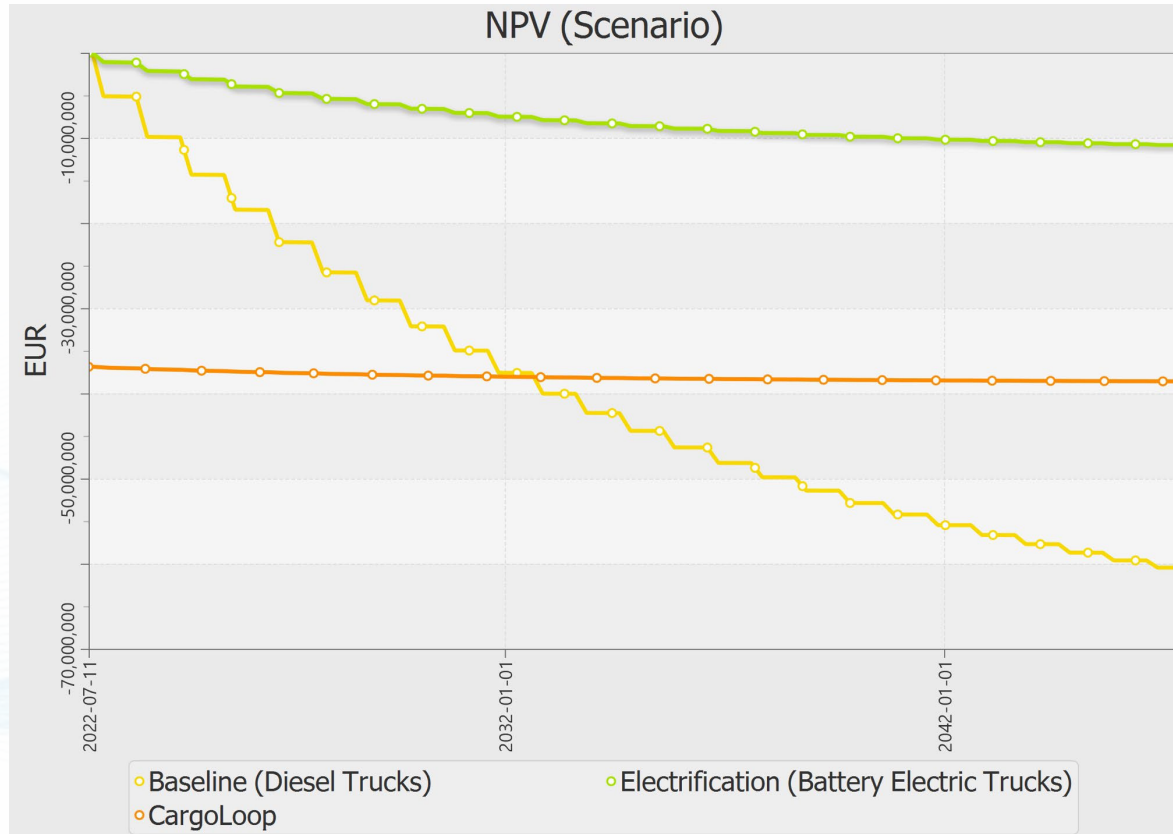
- ~ 10,000 m³ / day
 - Distribution on Pods (1 Pods/minute w. 10 containers each)
- Speed ~ (100 – 150) km/h
 - 16 Pods in tube both ways
- 36 pods in the system
 - 10 min. handling time => 20 Pods
 - Loading & unloading optimisation



Hyperloop Competition, LA

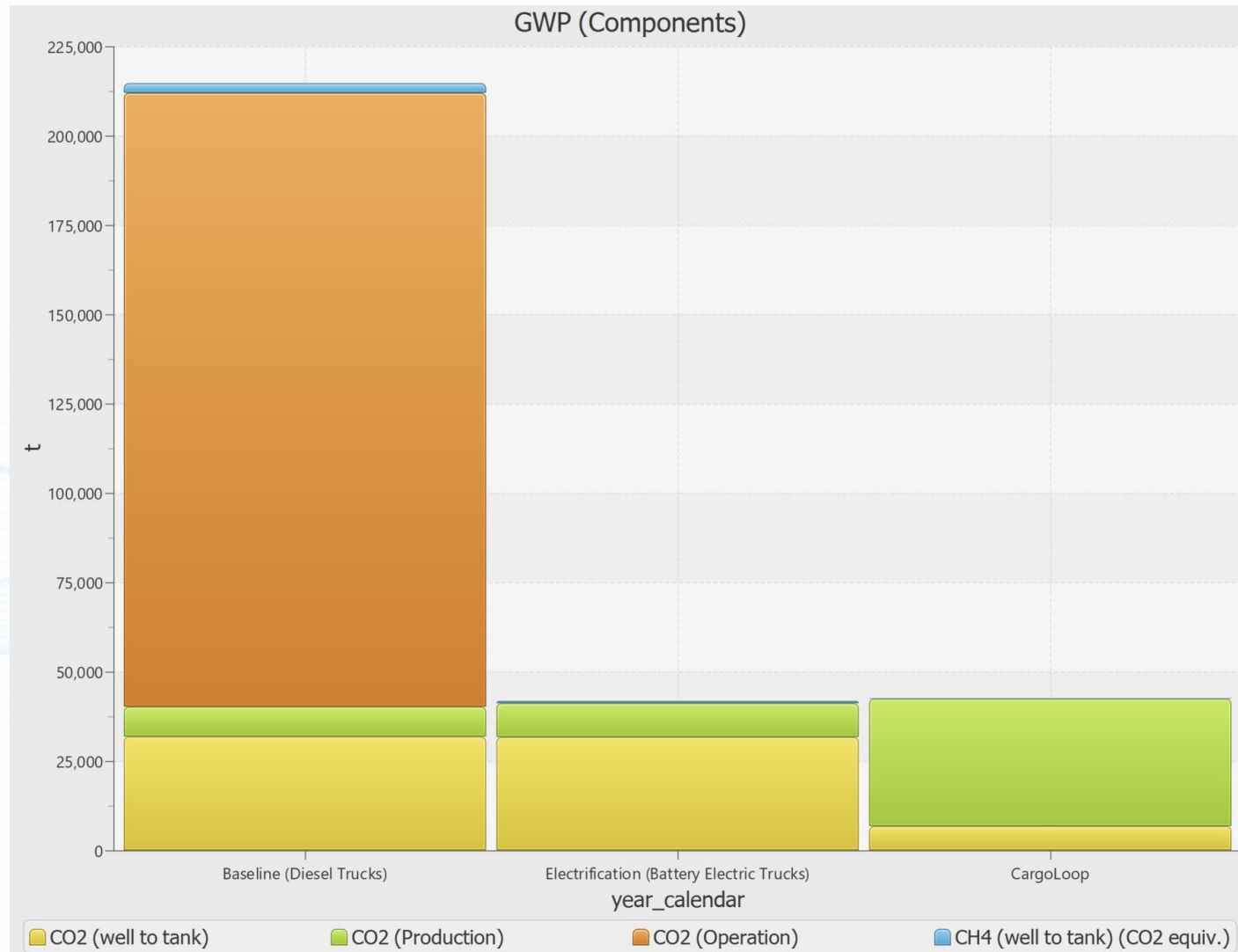


Life cycle performance assessment (LCPA)



NPV and OPEX for CargoTube, diesel & electric truck connections between a LSP and the VW production plant

Life cycle performance assessment (LCPA)

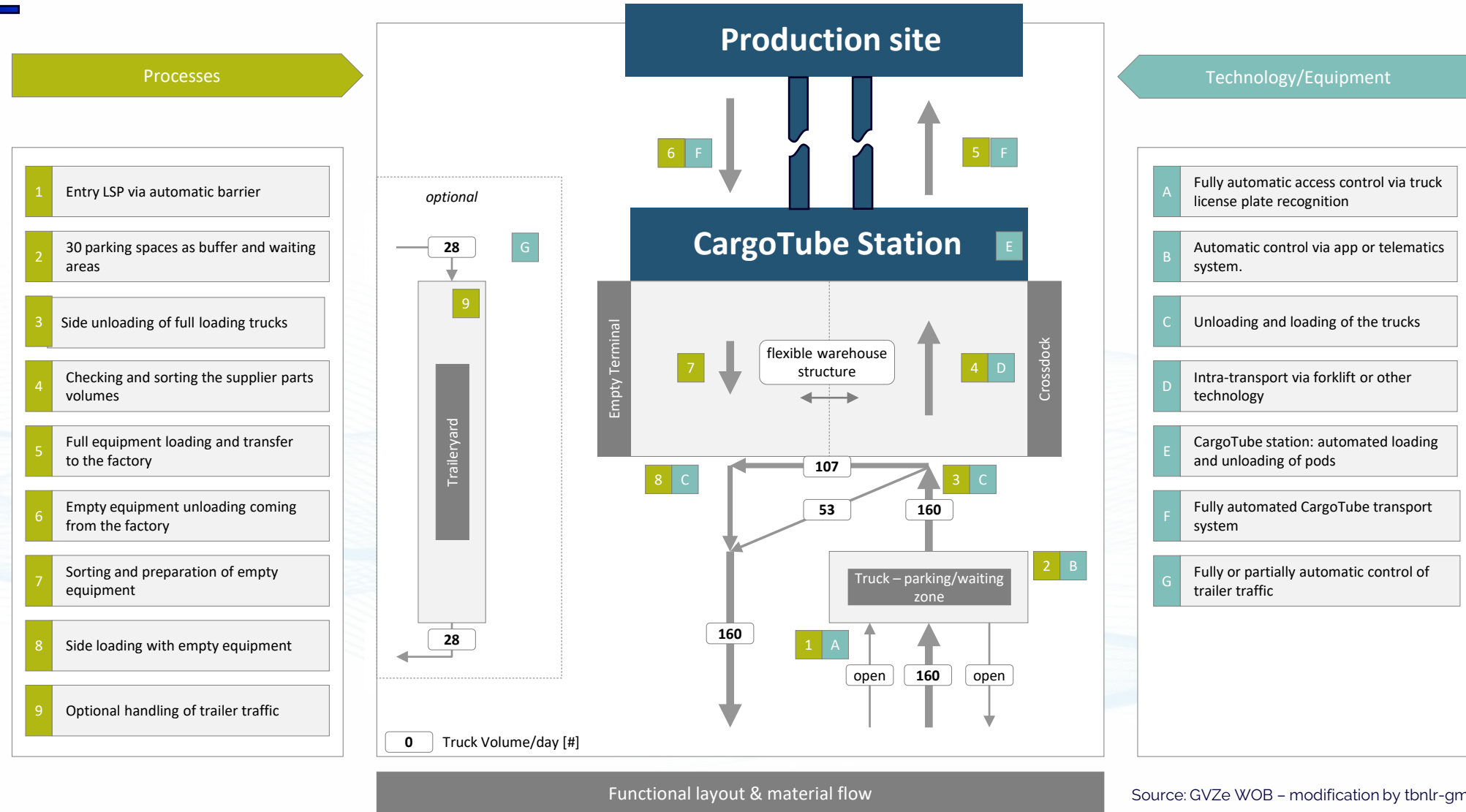


Lifetime emissions
(CO₂ equivalent):

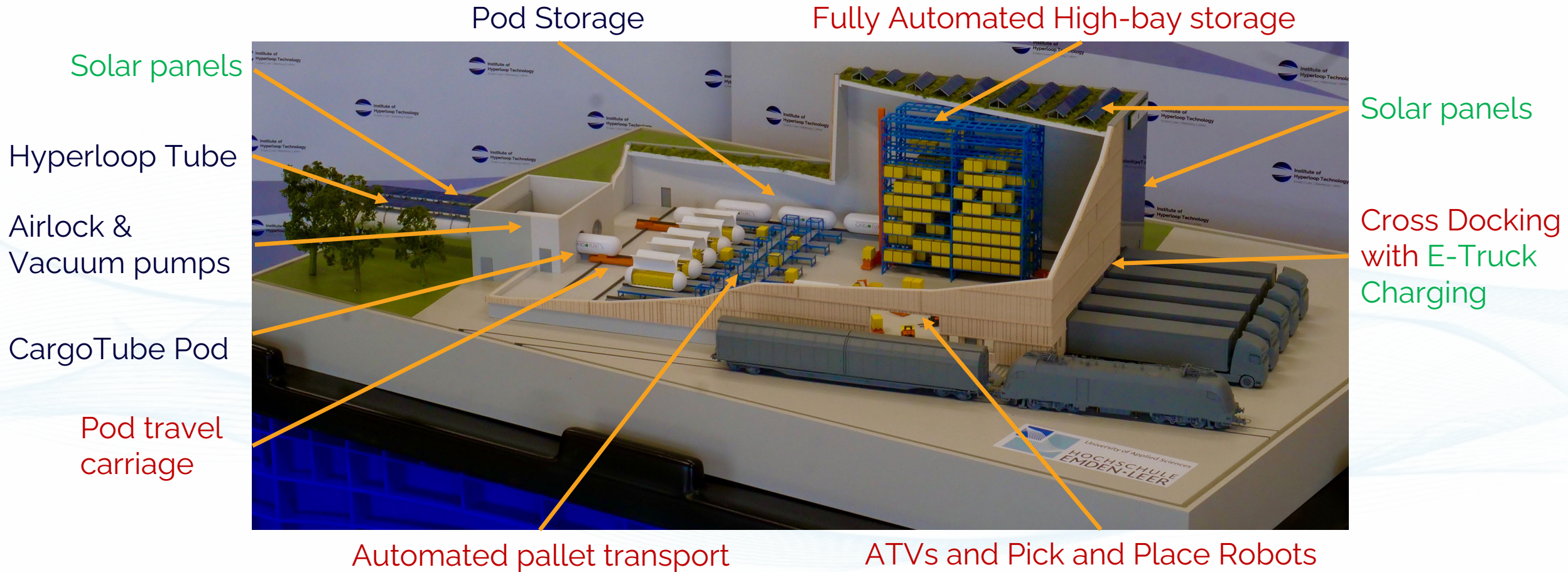
- Hyperloop
- Diesel truck
- electric truck



Cross Docking – CargoTube integration



Intermodal CargoTube Logistics Service Park



Hyperloop test facility @ IHT Emden



Interconnected CargoTube in the EU Physical Internet

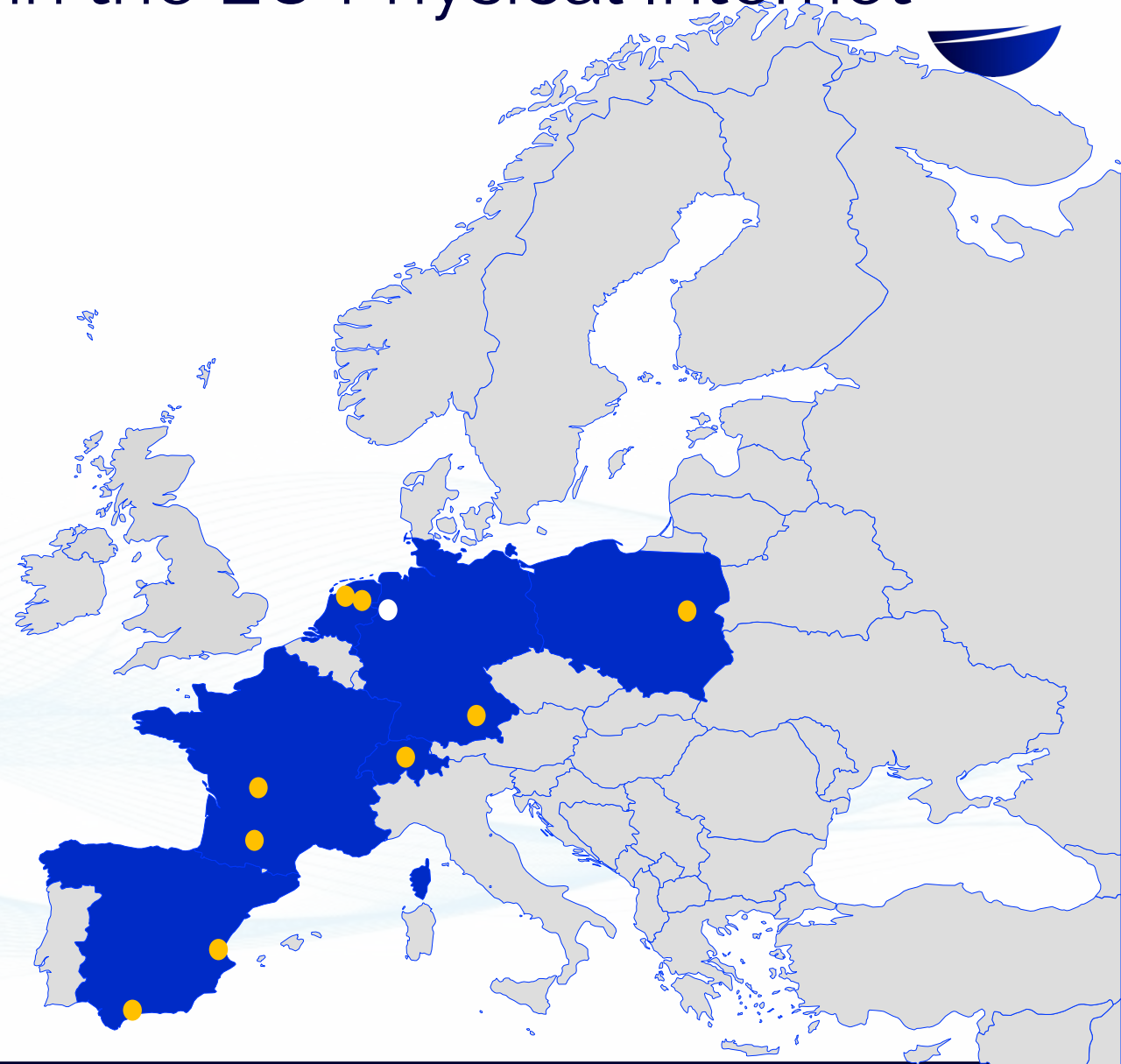


- Hub:

- LSRI at Lathen, Germany

- Satellites

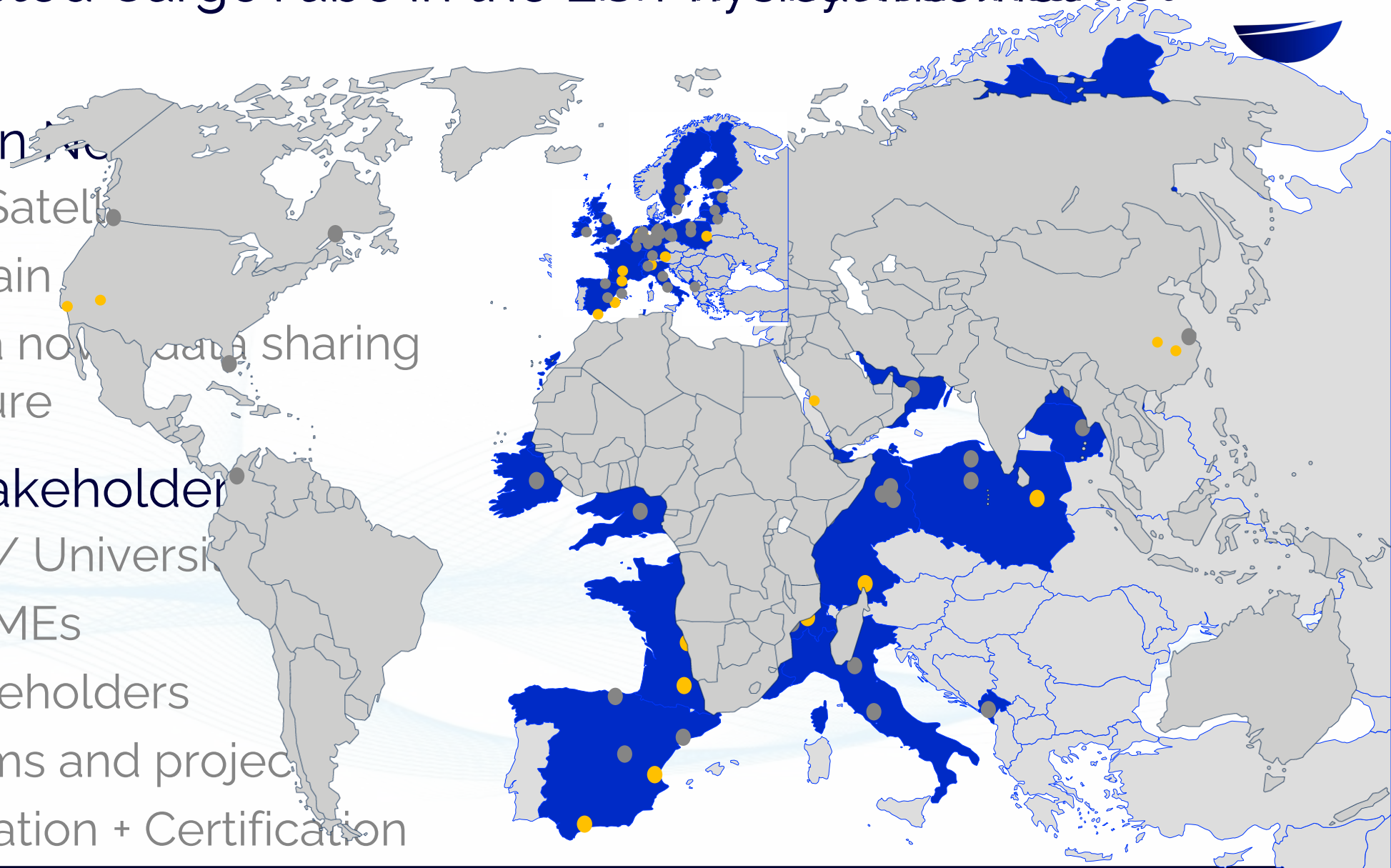
- EHC - Groningen, Netherlands
- EuroTube – Valais, Switzerland
- Hardt - Delft, Netherlands
- HTT – Toulouse, France
- Nevomo - Warsaw, Poland
- TransPod – Droux, France
- TUM – München, Germany
- Virgin Hyperloop – Spain
- Zeleros – Valencia, Spain



Interconnected CargoTube in the EUPW Physical Internet



- LSRI - Open Network
 - Hubs and Satellites
 - cross domain
 - Design of a novel data sharing infrastructure
- Users / Stakeholders
 - Academia / Universities
 - Industry, SMEs
 - Public stakeholders
 - EU platforms and projects
 - Standardization + Certification



Interconnected CargoTube in the EU Physical Internet



- Confined system => high value goods
- Goods that need fast transport (medicine, food)
- Realistic top speeds 2x NTG
- Reliability: Automation, no traffic jam, no delays
- Sustainability: low GHG Emissions



Contributing authors:

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