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

Walter Neu [1,2], Lukas Eschment [1], Heiko Duin [3], Thomas Nobel [4], Jurijs Tolujevs [5], Stephan Wurst [6], Irina Yatskiv [5], Thomas Schüning [1,2]

[1] University of Applied Sciences Emden/Leer, IHT, [2] University Oldenburg, School of Mathematics and Science, [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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alice Alliance for Logistics Innovation through Collaboration in Europe

Expanding the logistics Scope

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Institute of Hyperloop Technology
Emden | Leer | Oldenburg | Lathen

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

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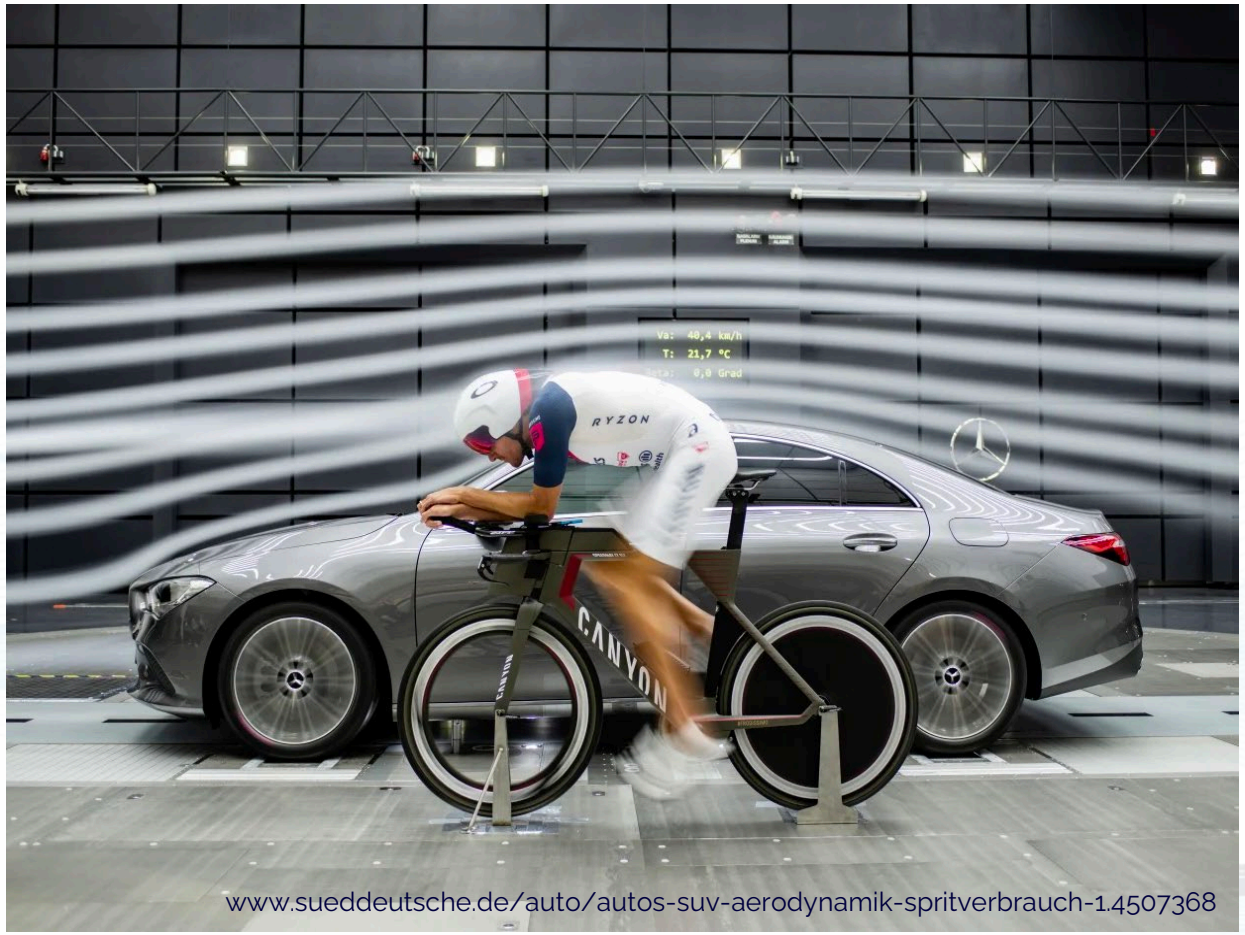
Institute of Hyperloop Technology

The nub of the matter

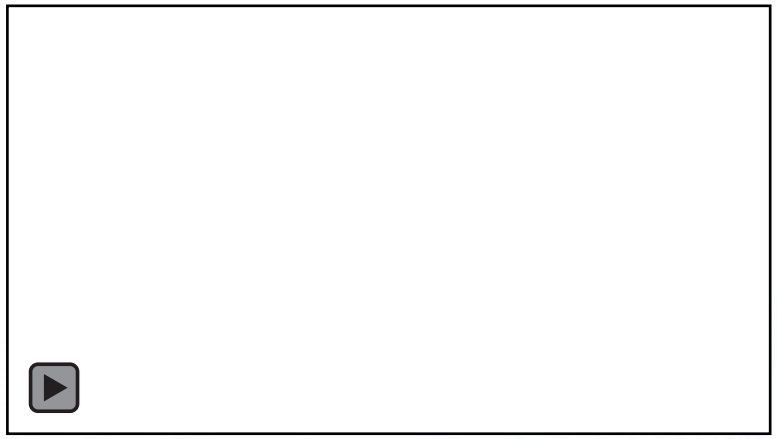


www.sueddeutsche.de/auto/autos-suv-aerodynamik-spritverbrauch-1.4507368

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/

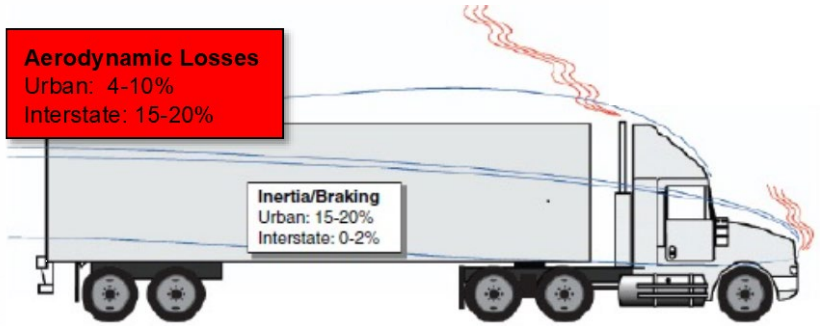
$$F_D \quad / \quad \rho C_D A \cdot v^2$$

$$P_D \quad F_D \cdot v$$

$$^1/_2 \rho C_D A \cdot v^3$$

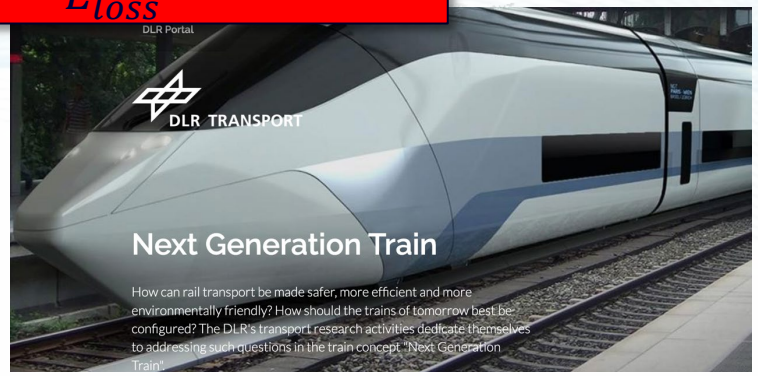
$$v_{Maglev} \quad ^{km}/_h \Rightarrow E_{loss}$$

Energy budgets



v_{NGT} $km/_h \Rightarrow$

E_{loss}



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

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

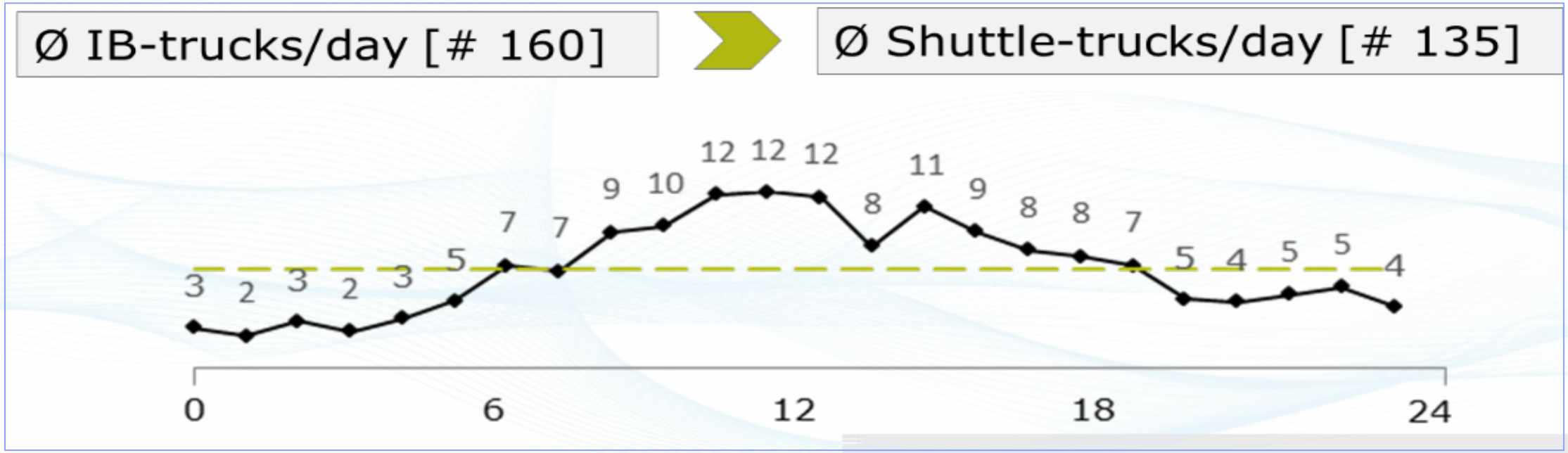
CargoTube in production logistics

Logistics hub relocated out

- Standardized containers
- Automated operation 24
- Reduction of
  - Public road traffic load &
  - Green House Gases, CO_2
  - Pollutants
  - Noise & light
  - Energy consumption

Demand Planning

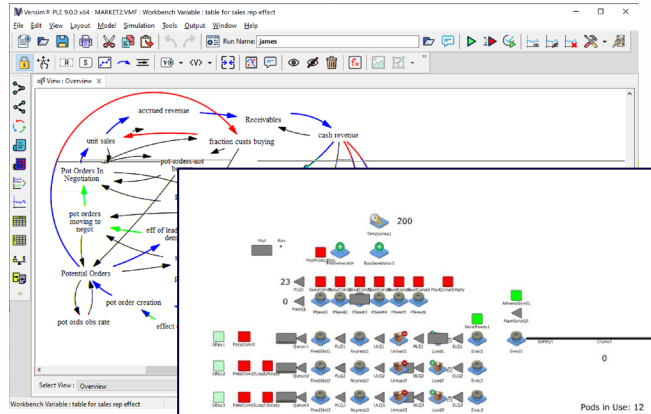
- 9-12 km distance
- 11.000 m^3 per day

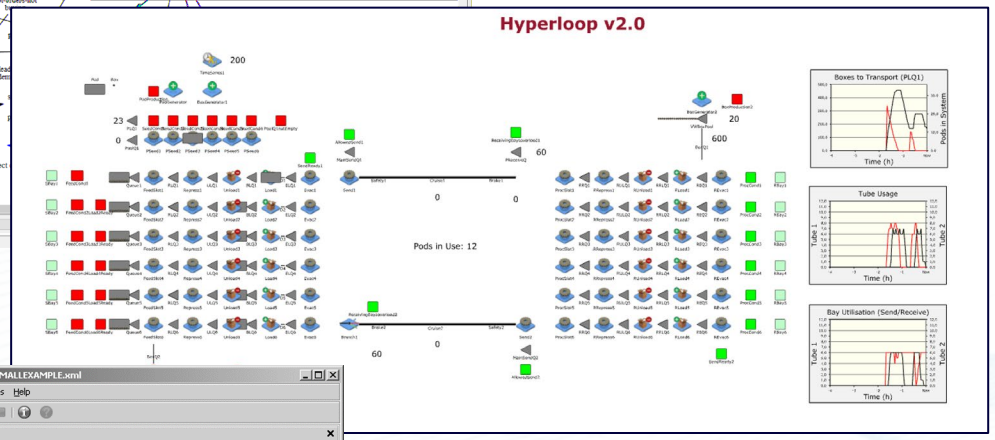


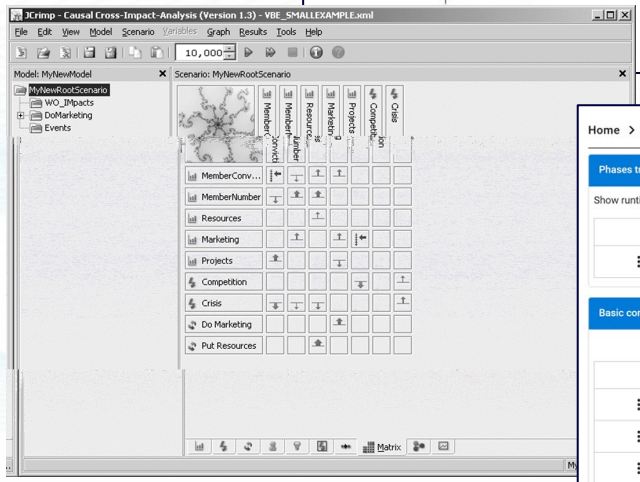
(Source: GVZe Wolfsburg & tbnlr-gmbh)

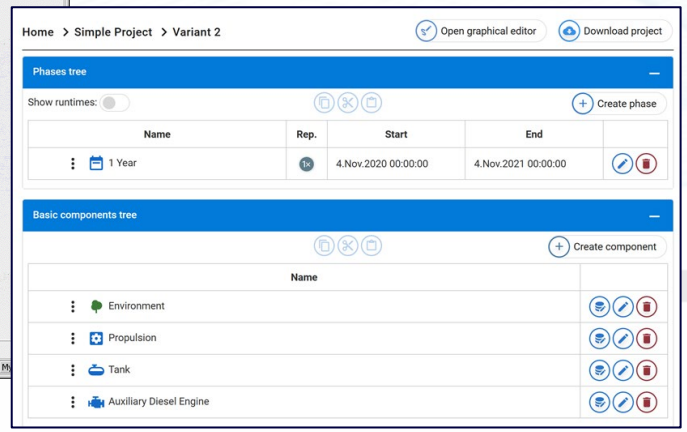
Modelling and simulation approaches

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



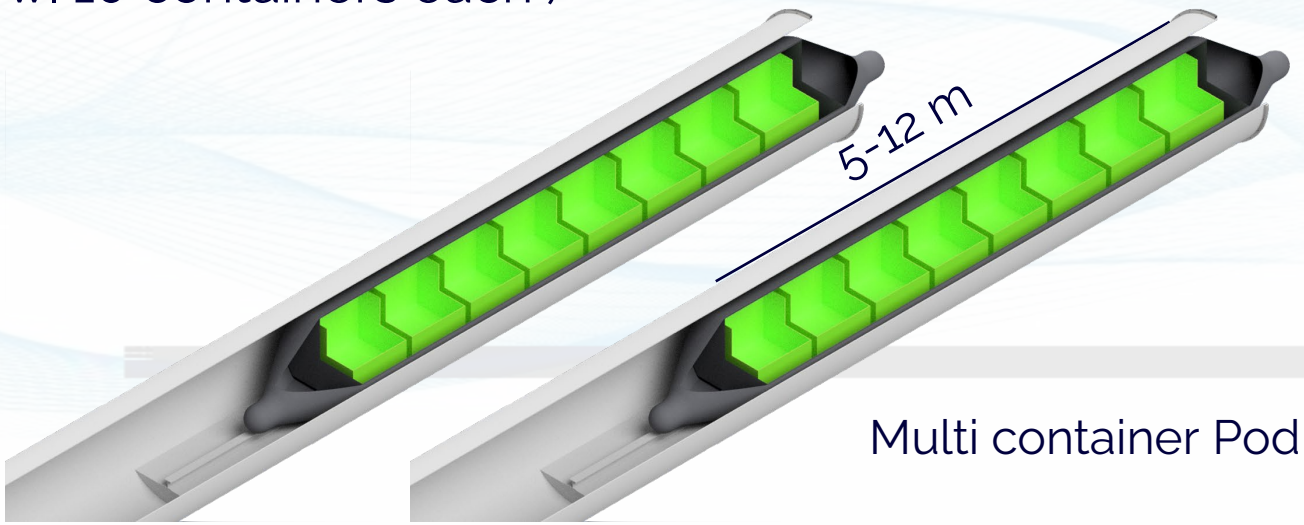






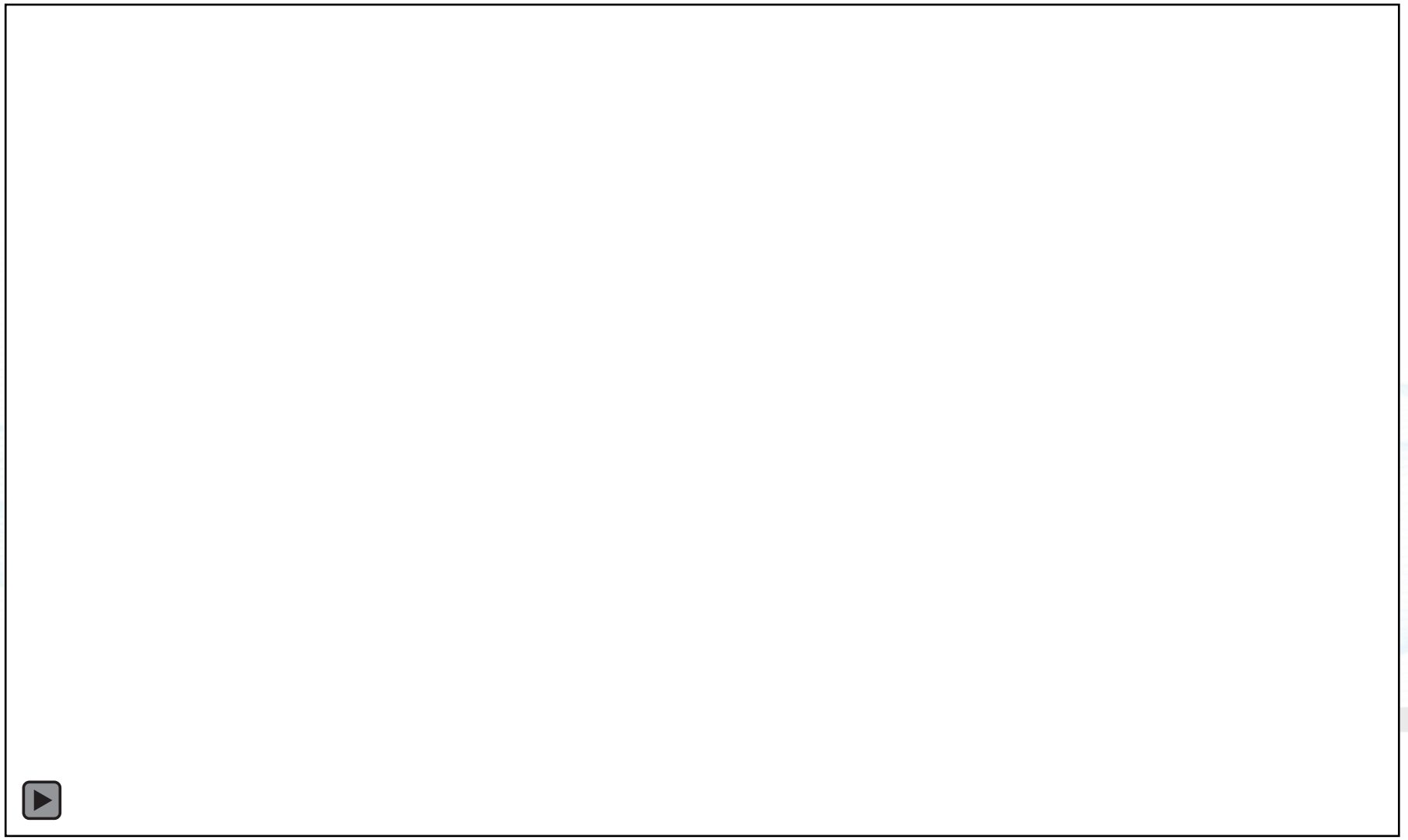
Production plant scenario

- ~ 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

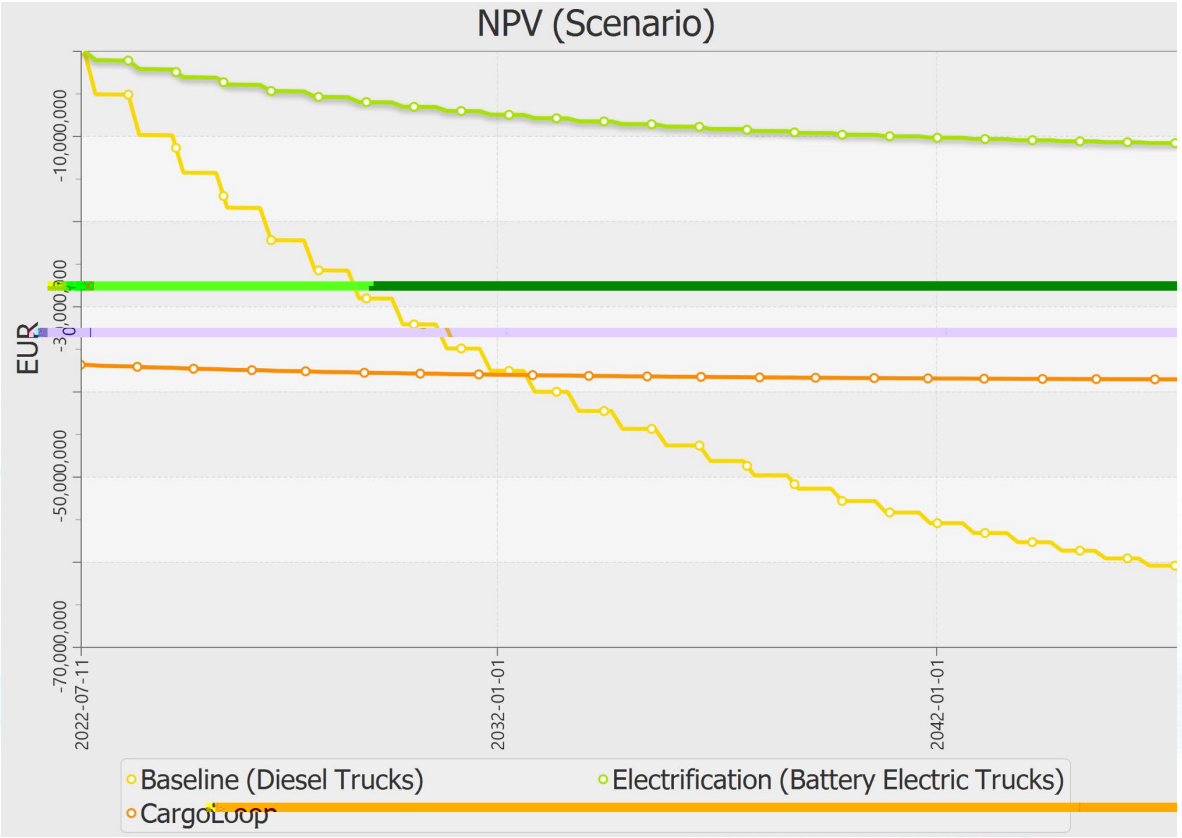


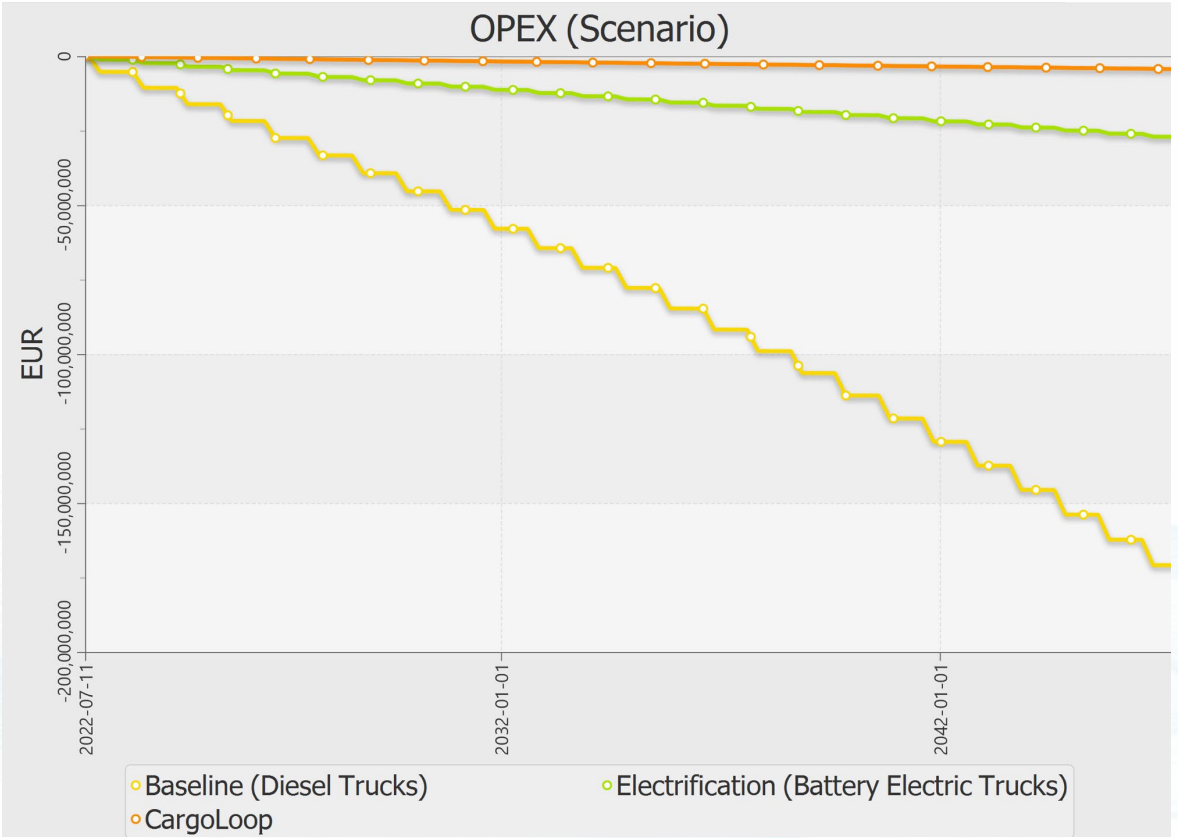
Multi container Pod

Hyperloop Competition, LA



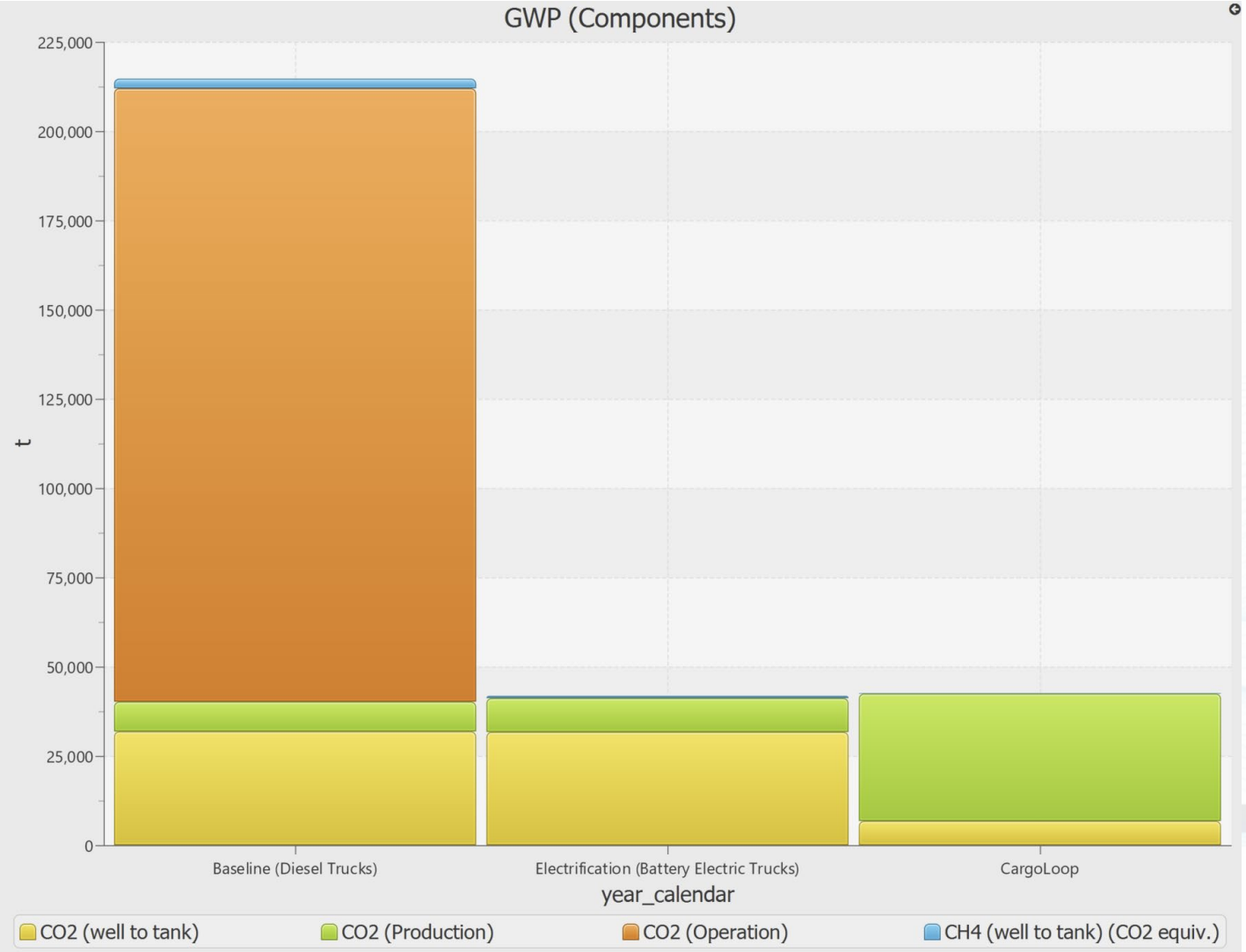
Life cycle performance assessment (LCPA)





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

Life cycle performance assessment (LCPA)



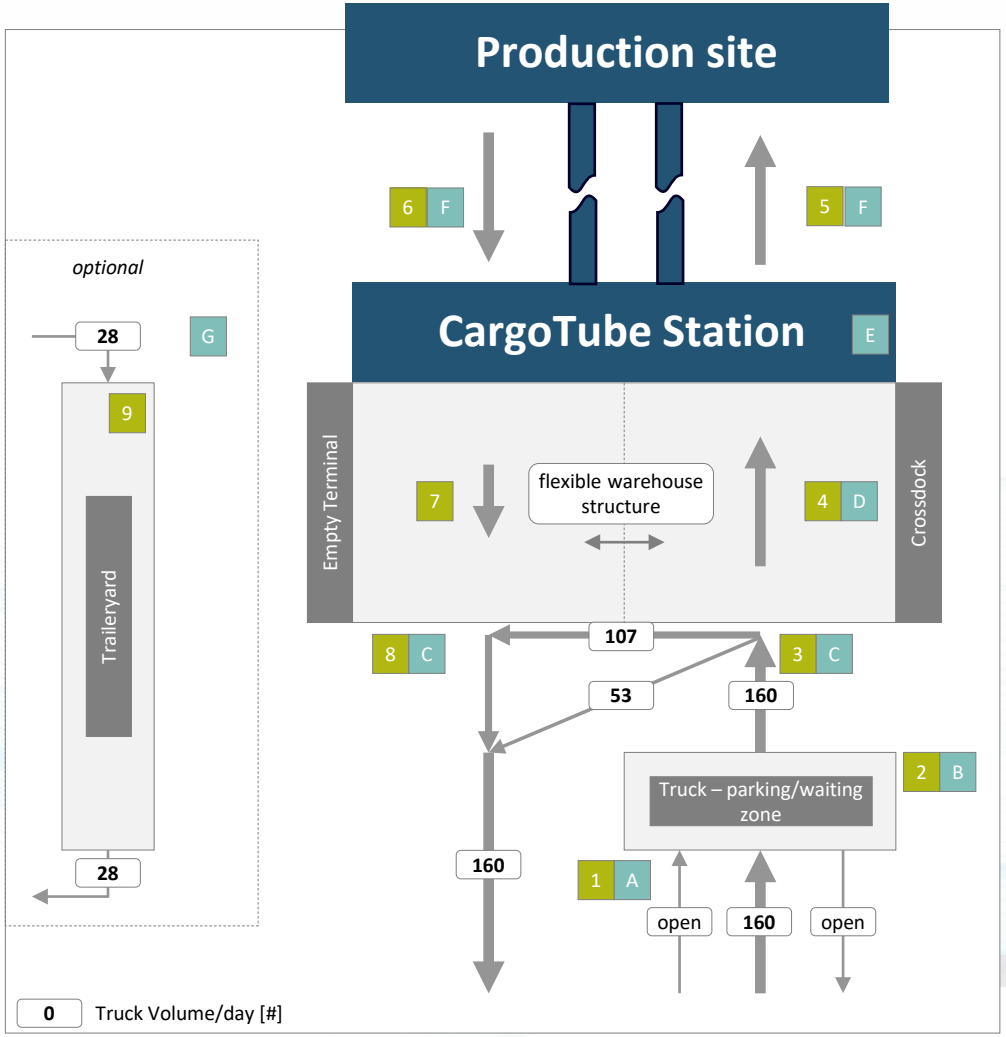
Lifetime emissions (CO_2 equivalent):

- Hyperloop
- Diesel truck
- electric truck

Cross Docking – CargoTube integration

Processes

1	Entry LSP via automatic barrier
2	30 parking spaces as buffer and waiting areas
3	Side unloading of full loading trucks
4	Checking and sorting the supplier parts volumes
5	Full equipment loading and transfer to the factory
6	Empty equipment unloading coming from the factory
7	Sorting and preparation of empty equipment
8	Side loading with empty equipment
9	Optional handling of trailer traffic



Functional layout & material flow

Technology/Equipment

A	Fully automatic access control via truck license plate recognition
B	Automatic control via app or telematics system.
C	Unloading and loading of the trucks
D	Intra-transport via forklift or other technology
E	CargoTube station: automated loading and unloading of pods
F	Fully automated CargoTube transport system
G	Fully or partially automatic control of trailer traffic

Source: GVZe WOB – modification by tbnlr-gmbh

Intermodal CargoTube Logistics Service Park

Pod Storage

Fully Automated High-bay storage

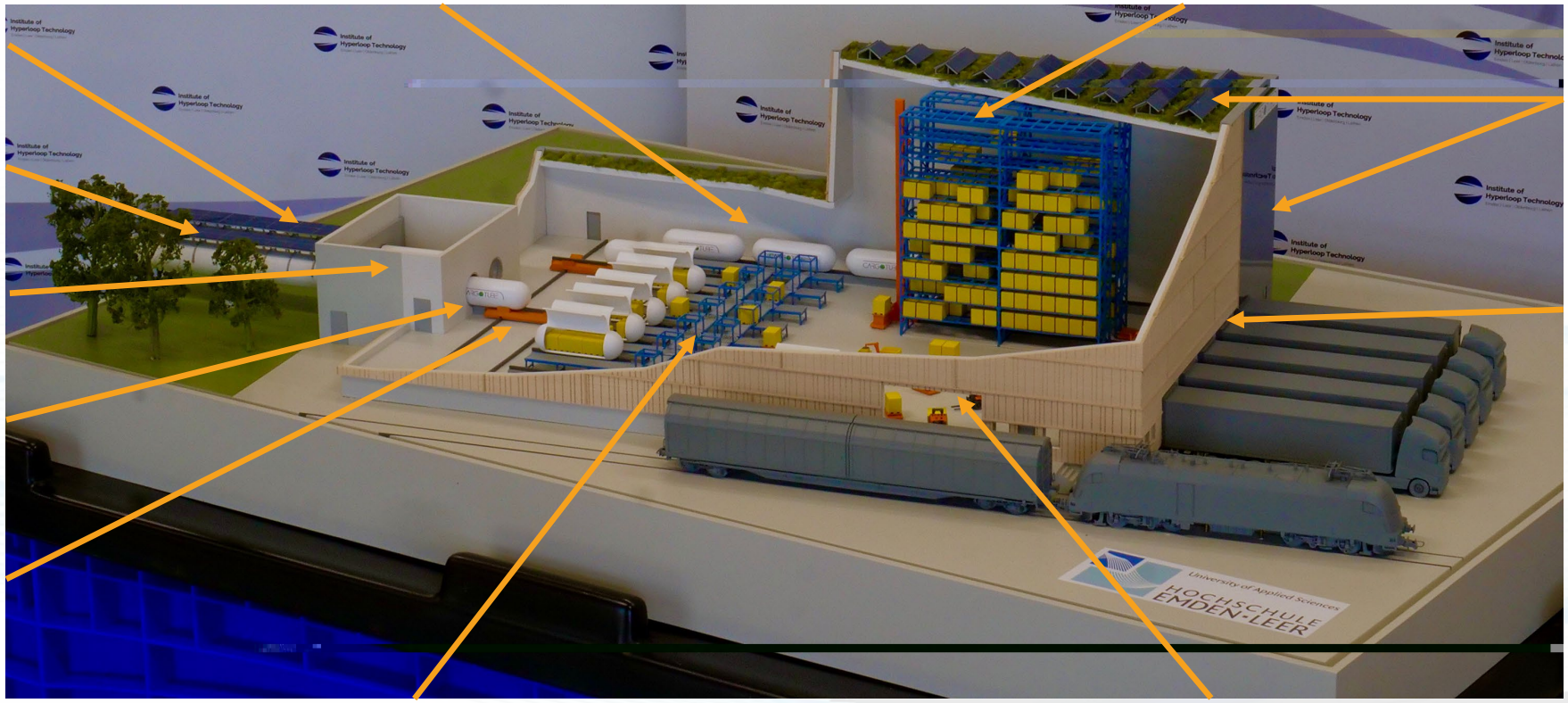
Solar panels

Hyperloop Tube

Airlock & Vacuum pumps

CargoTube Pod

Pod travel carriage



Solar panels

Cross Docking with E-Truck Charging

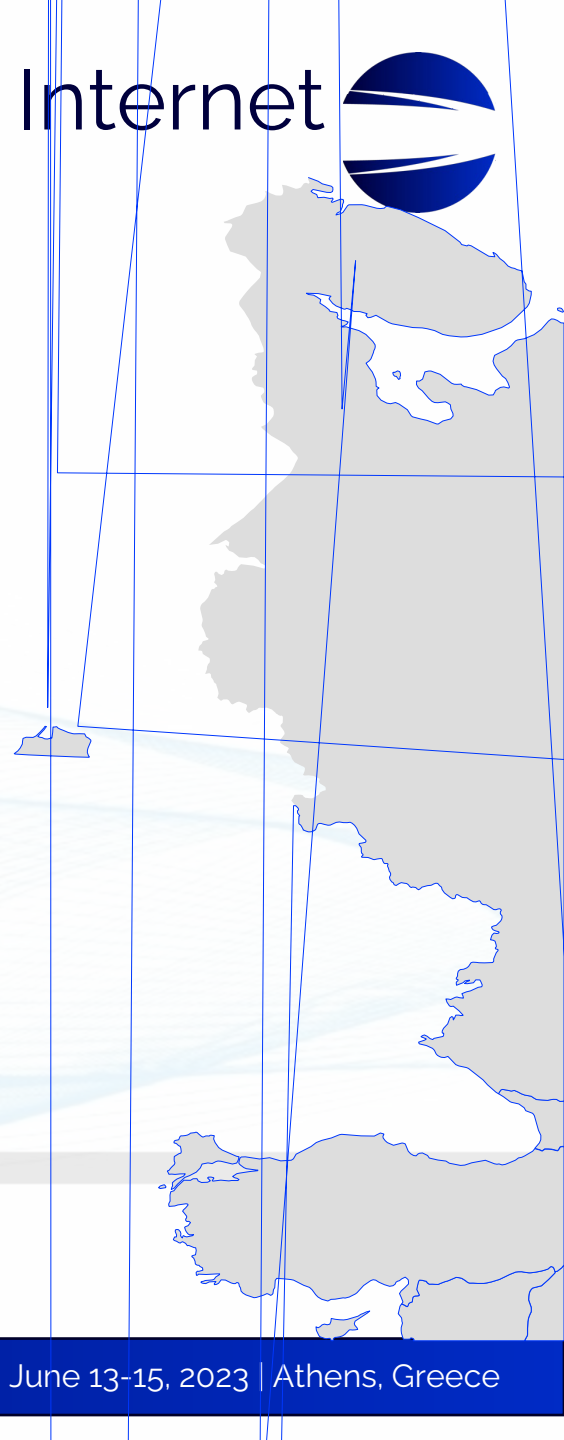
Automated pallet transport

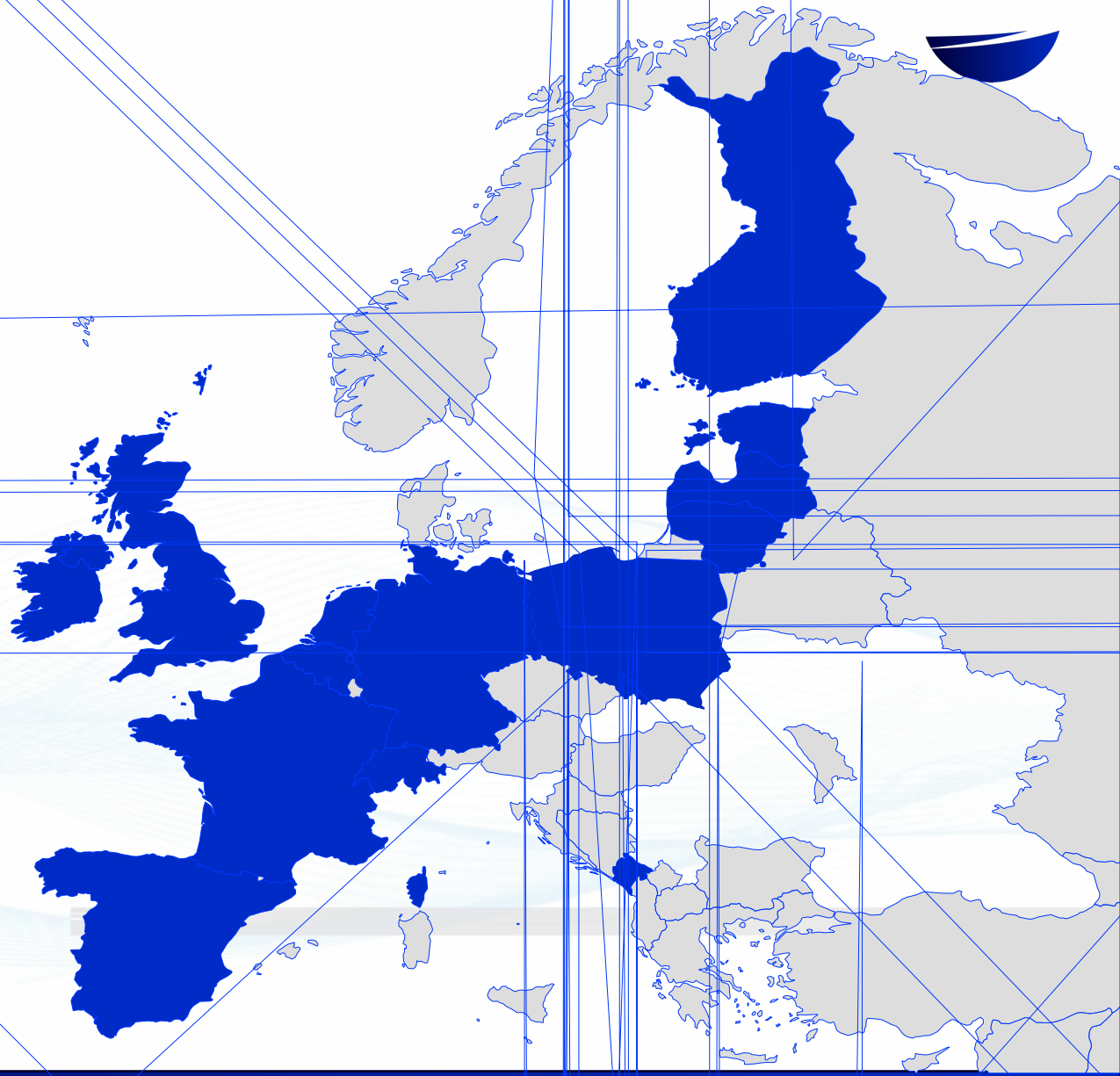
ATVs and Pick and Place Robots

Hyperloop test facility @ IHT Emden

Interconnected CargoTube in the EU Physical Internet

- Hub:
  - LSRI at Lathen, Germany





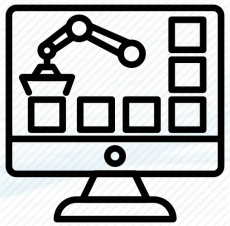
Interconnected CargoTube in the EU Physical Internet

- 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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Carl von Ossietzky Universität Oldenburg

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Board of IHT:

Prof. Dr. Walter Neu
Prof. Dr.-Ing. Thomas Schüning

Members of IHT:

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M. Eng. Marcel Stamm
Kristina Bachmann

BA/MA Thesis Students:

Renske Gärner
Geert Petrin

Project Students:

Angela Gupta
Ned Whitesell