Karlsruher Institut für Technologie

ECON

Mobility and Transport 4.0

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Karlsruhe Institute of Technology

- Fourth Industrial Revolution
- Impacts on passenger transport
- Impacts on freight transport
- Limits of IR 4.0
- Role of railways
- Conclusions

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Kondratiev Cycles

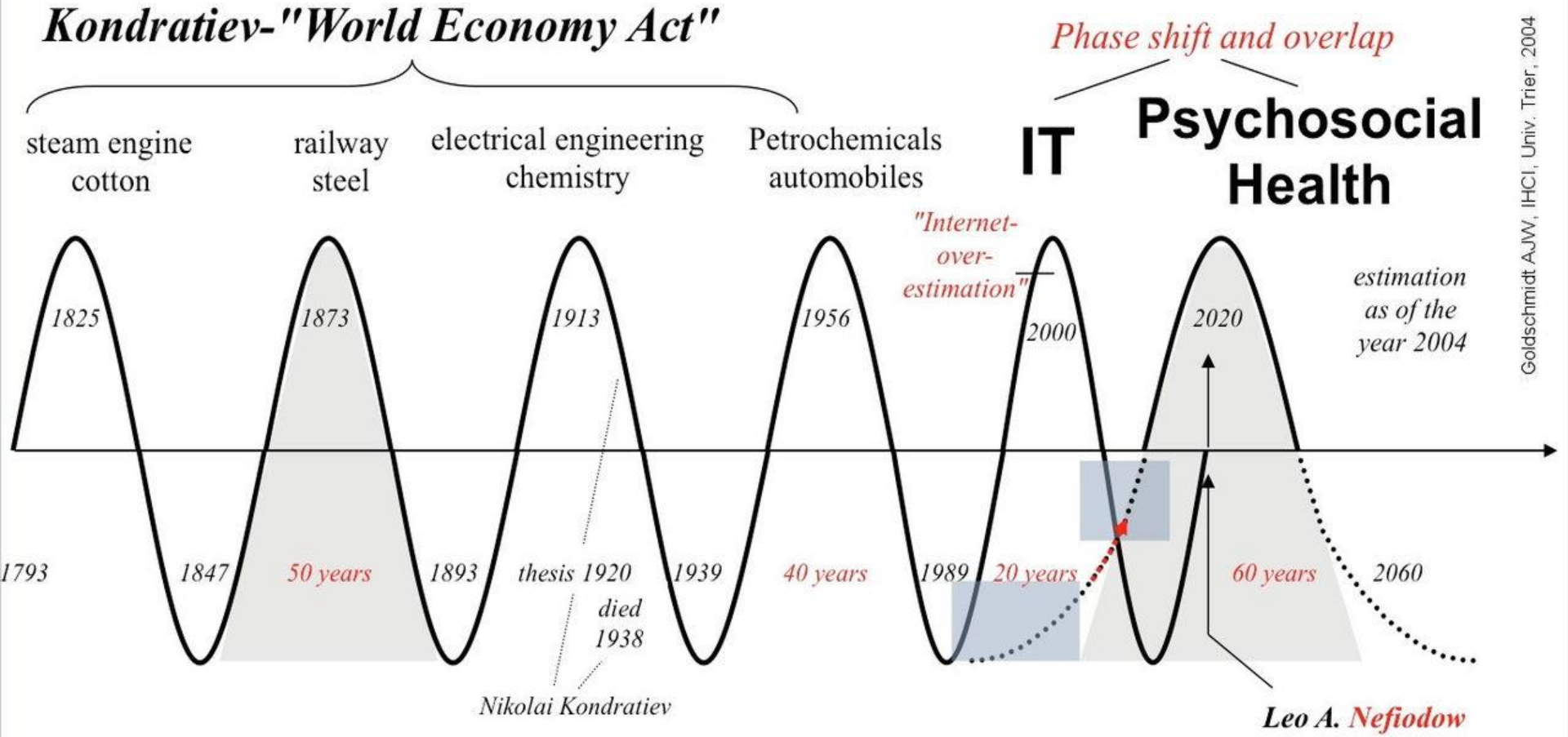
Type of wave	*Start about*
Steam engine, cotton	1770
Railways, steel	1830
Electrical engineering, chemistry	1875
Petrochemicals, automobiles	1910
Information, communication technologies	1970

Kondratieff Zyklen

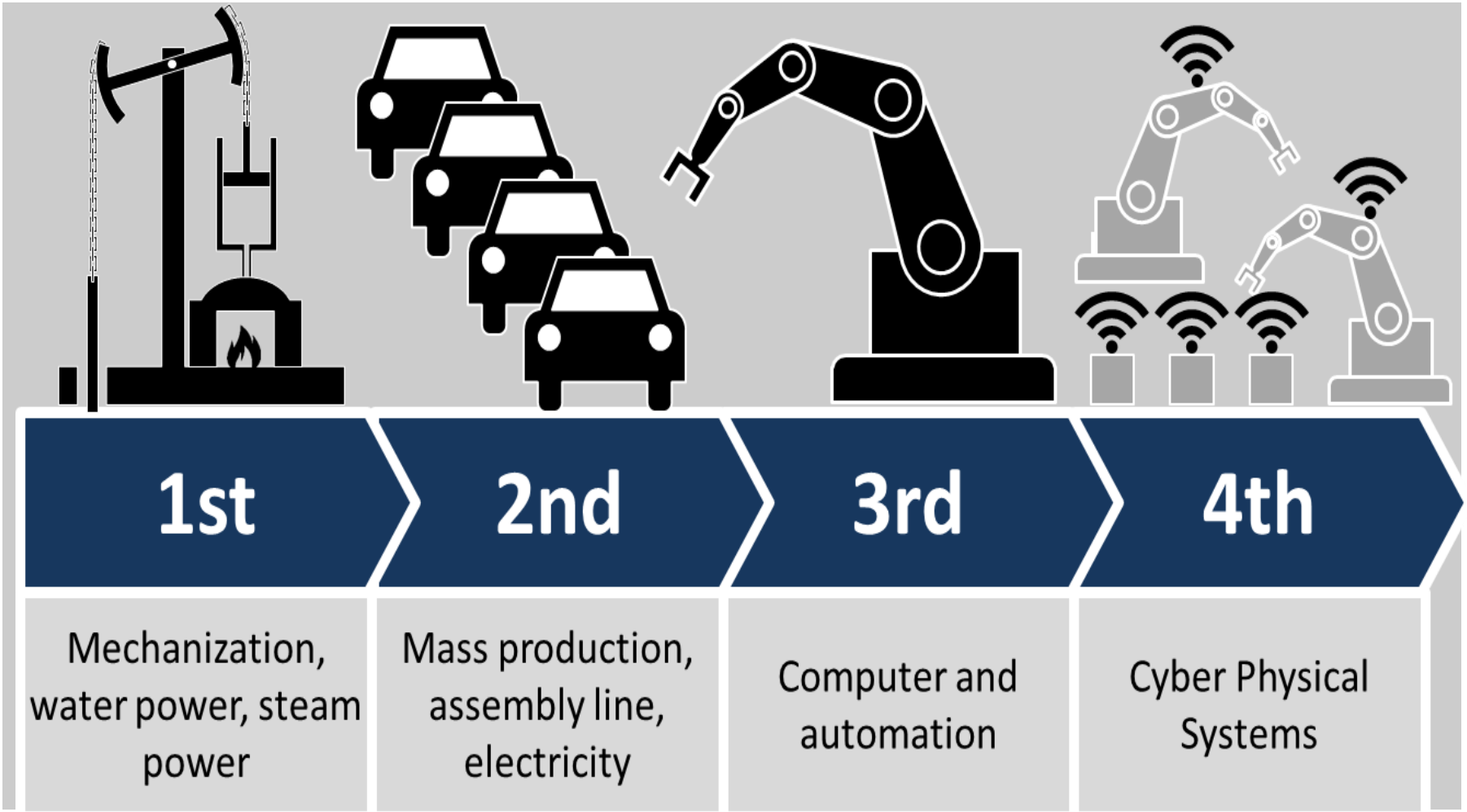
ECON

Nikolai Kondratiev: Anti-Marxist theory about 1920's; empirical study UK/USA
Josef Schumpeter: Definition of a "Kondratiev"-Unit
Leo A. Nefiodow: 6th Kondratiev "Psychosocial Health"

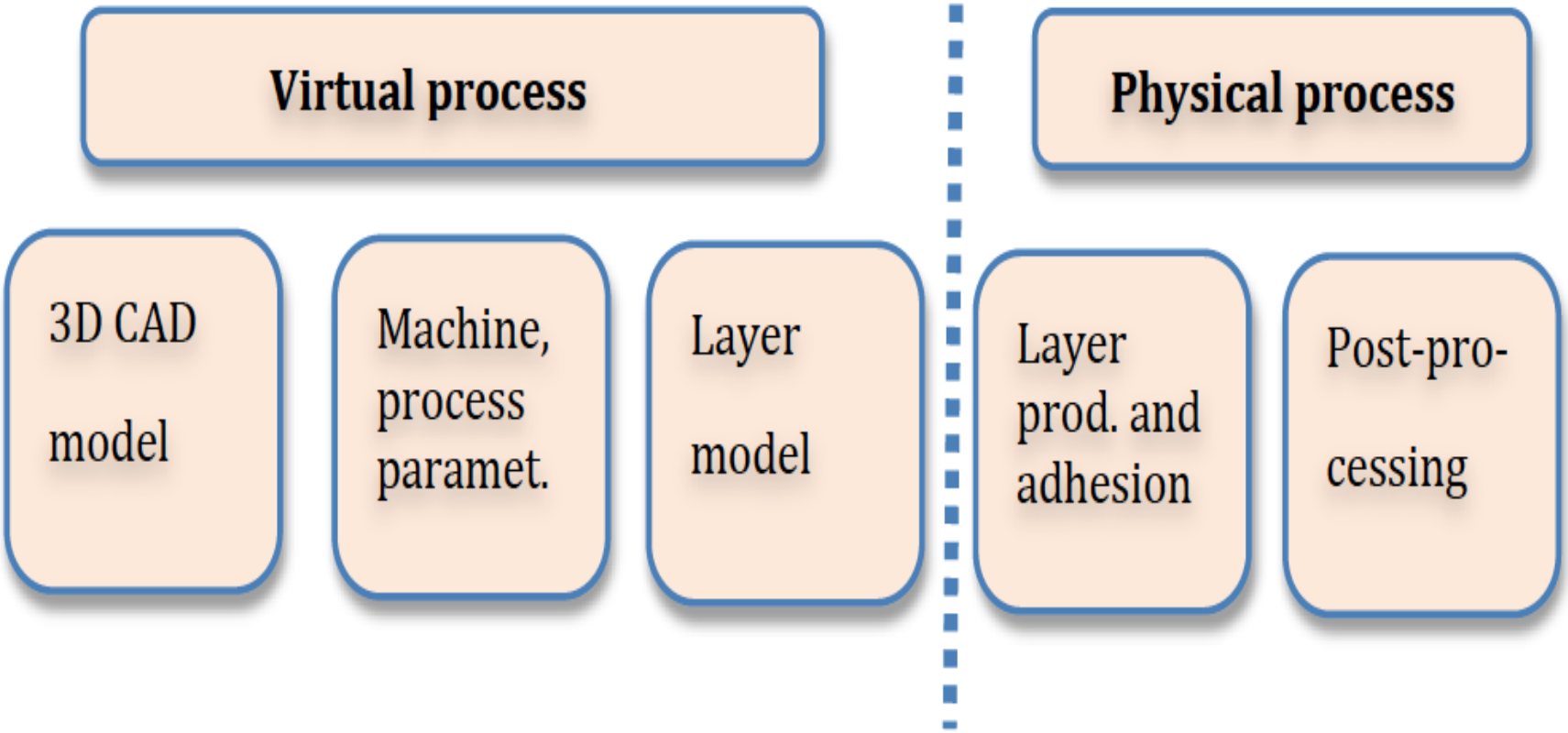
"applicable" to a national economy in general, not applicable to all participants in a "market"



- Initiators: Former CEOs from SAP and Bosch
- First presentation at Hanover Fair 2011; Final Report 2013
- Reinforcement by World Economic Forum Davos; support by German Ministries
- Summarizing of history of industrial development to „4 Industrial Revolutions“


1st
2nd
3rd
4th
Mechanization, water power, steam power
Mass production, assembly line, electricity
Computer and automation
Cyber Physical Systems

- communication systems (real time bus technologies, IT security, self-organizing communication networks, mobile communication channels),
- sensor systems (miniaturization, re-configuration, networking, fusion),
- software systems (multi-agent systems, pattern matching, big data analysis, cloud computing, ontologies, simulation environment, multi-criteria assessment),
- actor systems (intelligent artificial agents, networked agents, security


Virtual process
Physical process
3D CAD model
Machine, process paramet.
Layer model
Layer prod. and adhesion
Post-pro-cessing


Barilla
TNO
Barilla
Barilla
TNO
Barilla

Advantages of 3D Printing

- Savings of material 30-70%
- Savings of tools and casting molds
- Savings of energy
- Free design according to functional performance
- Flexible design changes
- Savings of inventory holding for intermediate and final products

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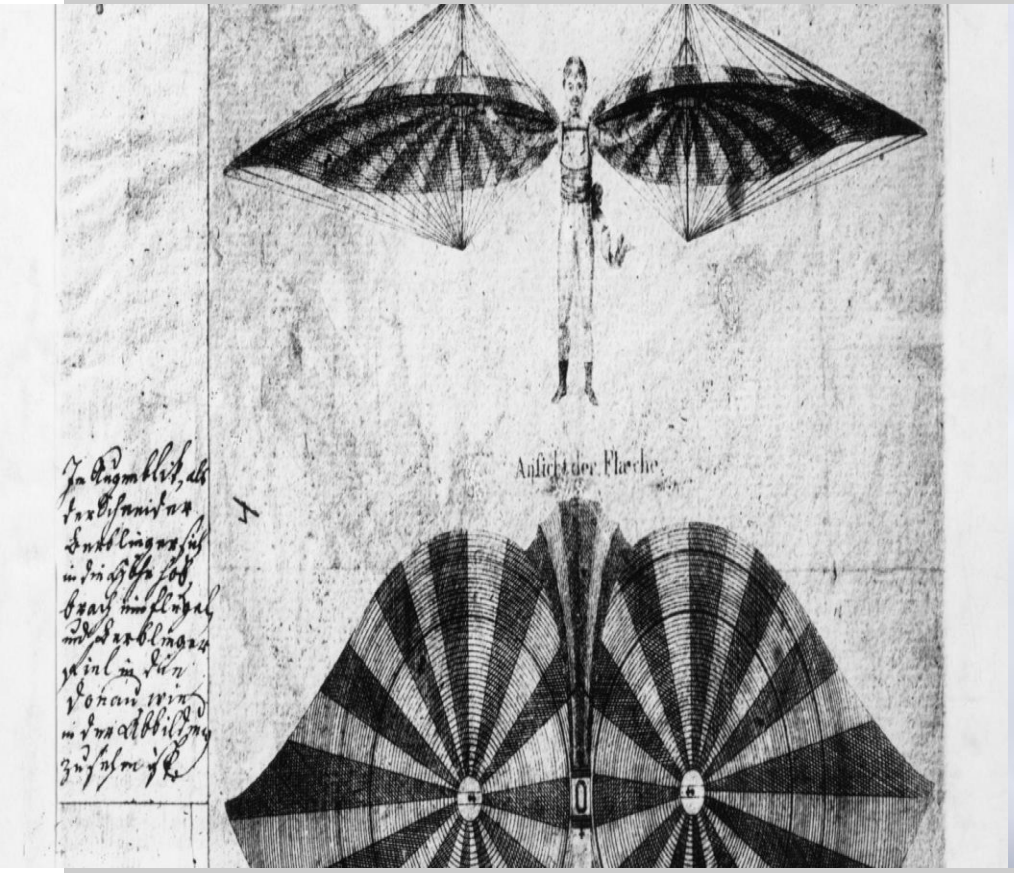
Technology

- Autonomous driving
- Assistant systems, sensor technology
- Individual seamless mobility
- Mobile information exchange and processing
  20 GB/hr and car; 250 mill. cars 2020

Individual aviation
From Ulm‘s taylor to Volocopter



Behaviour and Markets

- Activity patterns on route
- Vehicles as bidirectional information nodes
- Virtual realities
- Sharing economy

- **Agriculture**: garden, harvest, seed
- **Finance:** crowd funding, peer-to-peer lending/banking
- **Real estate:** Airbnb, home exchange, fractional ownership
- **Property:** clothes swapping, fractional ownership
- **Transportation:** car, bike, taxi, bus
- **Digital technology:** cloud computing, open software, volunteer computing

New dimension through internet platforms.
Role of intermediary services.

- Owned cars used for 1.5 hrs of the day
- Shared cars used for 8 hrs of the day
- Shared taxis and mini-buses may substitute cars and buses
- Lisbon study (ITF): dramatic savings of resources and reduction of external costs
- Flexible car use for individual mobility

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Technology

- Autonomous driving
- Automatic processing
- Assistant systems
- Decentral control, intelligent RFIDs
- Maintenance, repair, overhaul


Hapag-Lloyd
CTA


ZPMC
SIEMENS
CTA

Impacts on freight transport

Logistics Organization

- Cyber-physical global supply chain management
- Decentral control of local processes
- Increased collaboration
- Increased integration of logistics companies in manufacturing processes

Impacts on Freight Demand

- Location of production to places of final demand or final assembly
- Reduction of transport of preliminary products
- Reduction of inventory holding
- Decrease of transport weights
- Shift from low-wage countries to countries of final demand or assembly
- Dramatic reduction of labour force in logistics and transport

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Limits of IR 4.0

- Spin-off of the marriage of mechanical and electrical engineering with computer science.
- Focus lies on rationalization of processes and not on innovative products. Huge savings of labour force.
- Human creativity is only needed in the phase of system‘s design.
- Consumers‘ reactions not uniform. Heterogeneous acceptance of digital assistance. Problems with objective functions.
- Ethics Commission: Safety issues. Privacy issues.

Limits of IR 4.0

- Problems with system‘s control if market penetration or automation < 100%. Digital refuseniks.Vigilance problems.
- All relevant information is held in the cloud.
- Security of private data.
- Fake data.
- Data ownership (e.g. digital maps).
- Monopoly problems.
- Finance: Who pays for what?

Limits IR 4.0

- **IR 4.0 does not include radical innovations. Links to promising R&D areas are missing.**

- **Examples: Nano-machines, bio-technology, psycho-social health, energy conservation, energy flow (flow chemistry, super conducting transmission), electro-chemical and photo-chemical syntheses, hydrogen technology.**

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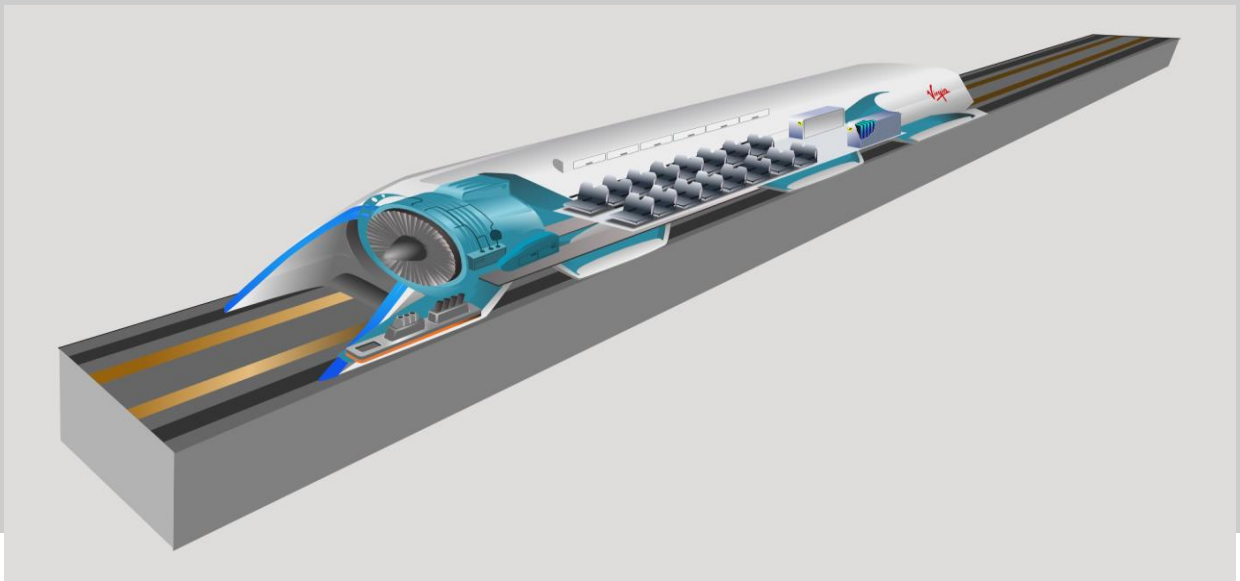
Railways: historical innovations

Railways: radical innovations



IR 4.0 for railways: Prospects

"Digitalisation will reinforce the role of rail as a backbone of mobility in the 21st century"

says **Laurent Troger**, President of Bombardier Transportation

Die Österreichische Verkehrswissenschaftliche Gesellschaft lädt zum

ÖVG-Forum

Hat der Bahngüterverkehr in der Fläche Zukunft?

07. Juni 2017

GEWERBEHAUS (Rudolf-Sallinger-Platz 1, 1030 Wien)

EU railway policy

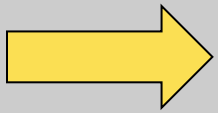
- Trans-european network, core and comprehensive networks, core network corridors (CNC)
- 9 CNC, crossing min. 3 countries, 51,000 km rail, 34,000 km road, 13,000 km IWW
- CNC completition until 2030
- ca 650 bill. EUR, 2/3 for rail

Turku Naantali
Helsinki
Hamina Kotka
Tallinn
Oslo
Örebro
Stockholm
Ventspils
Riga
Gothenburg
Klaipeda
Vilnius
Kaunas
Copenhagen
Malmö
Trelleborg
Glasgow
Edinburgh
Belfast
Dublin
Liverpool
Manchester
Birmingham
Cork
Gdynia/Gdansk
Rostock
Szczecin/Swinoujscie
Bremen
Hamburg
Berlin
Poznan
Warsaw
Amsterdam
Utrecht
Osnabrück
Rotterdam
Magdeburg
Hannover
Frankfurt/Oder
Felixstowe
London
Zeebrugge
Antwerp
Düsseldorf
Dover
Southampton
Calais
Gent
Cologne
Dresden
Wroclaw
Lille
Brussels
Liege
Prague
Katowice
Ostrava
Le Havre
Frankfurt
Würzburg
Nuremberg
Brno
Zilina
Luxembourg
Mannheim
Paris
Metz
Stuttgart
Regensburg
Passau
Vienna
Bratislava
Strasbourg
Munich
Wels/Linz
Dijon
Basel
Innsbruck
Klagenfurt
Graz
Budapest
Arad
Brasov
Sulina
Timişoara
Bucharest
Constanţa
Udine
Trieste
Ljubljana
Zagreb
Lyon
Novara
Verona
Craiova
Turin
Milan
Venice
Koper
Rijeka
Sarajevo
Belgrade
Bordeaux
Genova
Bologna
Ravenna
Sofia
Burgas
Bilbao
Vitoria
La Spezia
Ancona
Podgorica
Livorno
Marseille
Ploce
Pristina
Valladolid
Perpignan
Bar
Tirana
Skopje
Porto
Durres
Aveiro
Zaragoza
Rome
Barcelona
Bari
Tarragona
Madrid
Thessaloniki
Lisbon
Naples
Taranto
Valencia
Igoumenitsa
Sines
Seville
Murcia
Gioia Tauro
Antequera/Bobadilla
Palermo
Athens/Piraeus
Patras
Lefkosia
Cartagena
Limassol
Algeciras
Valletta
TENtec

Railways: major challenge interoperability

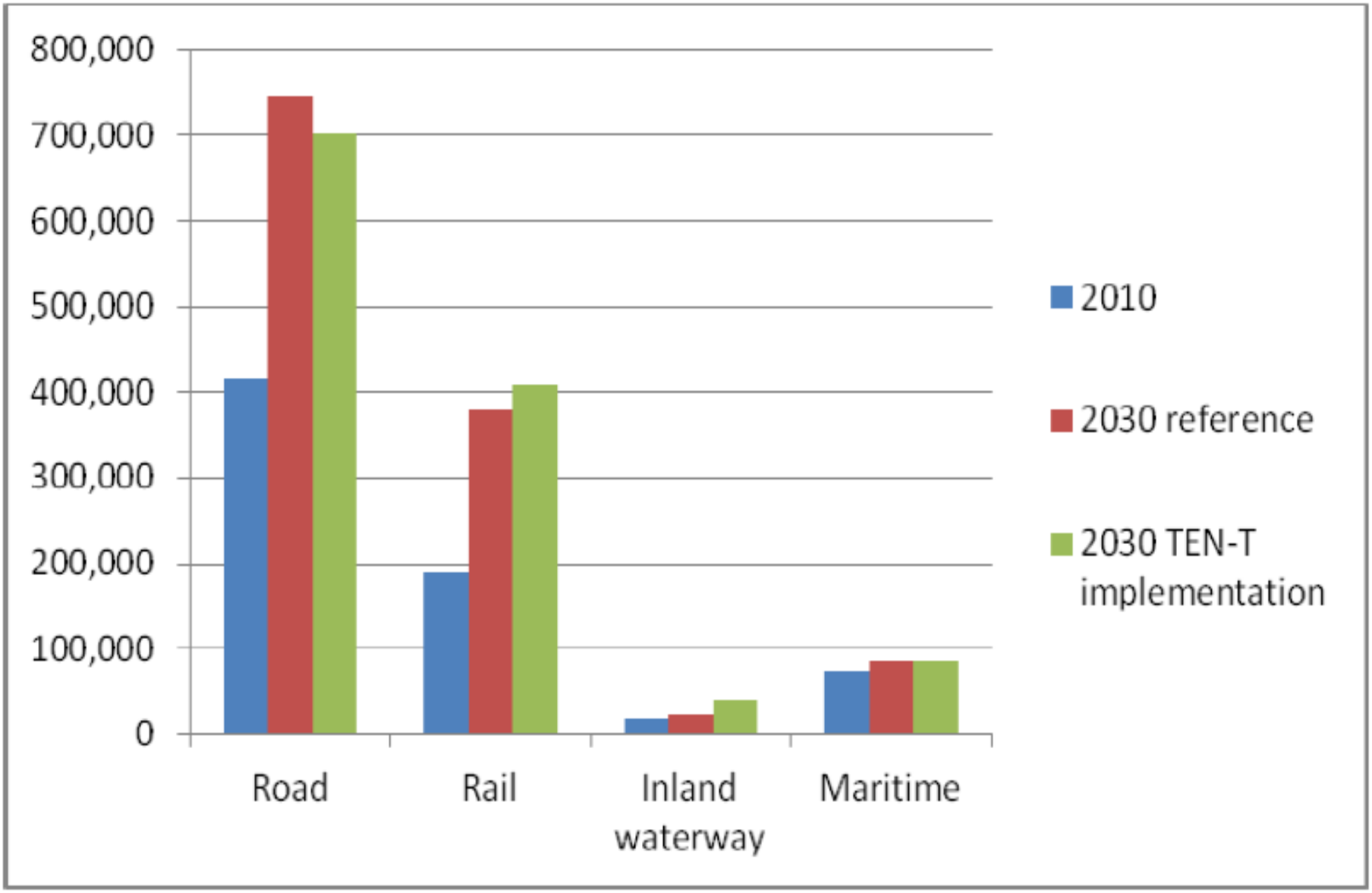
Key Performance Indicators for rail freight (KPI)

- Standard gauge, 1435 mm
- 2 tracks
- Electrified
- Max. train length: 740 m
- Max. speed 120 km/h
- Max. axle load 22.5 t
- ERMTS control system



interoperability

CNC freight transport forecast Rhine-Danube corridor



ERTMS 2030

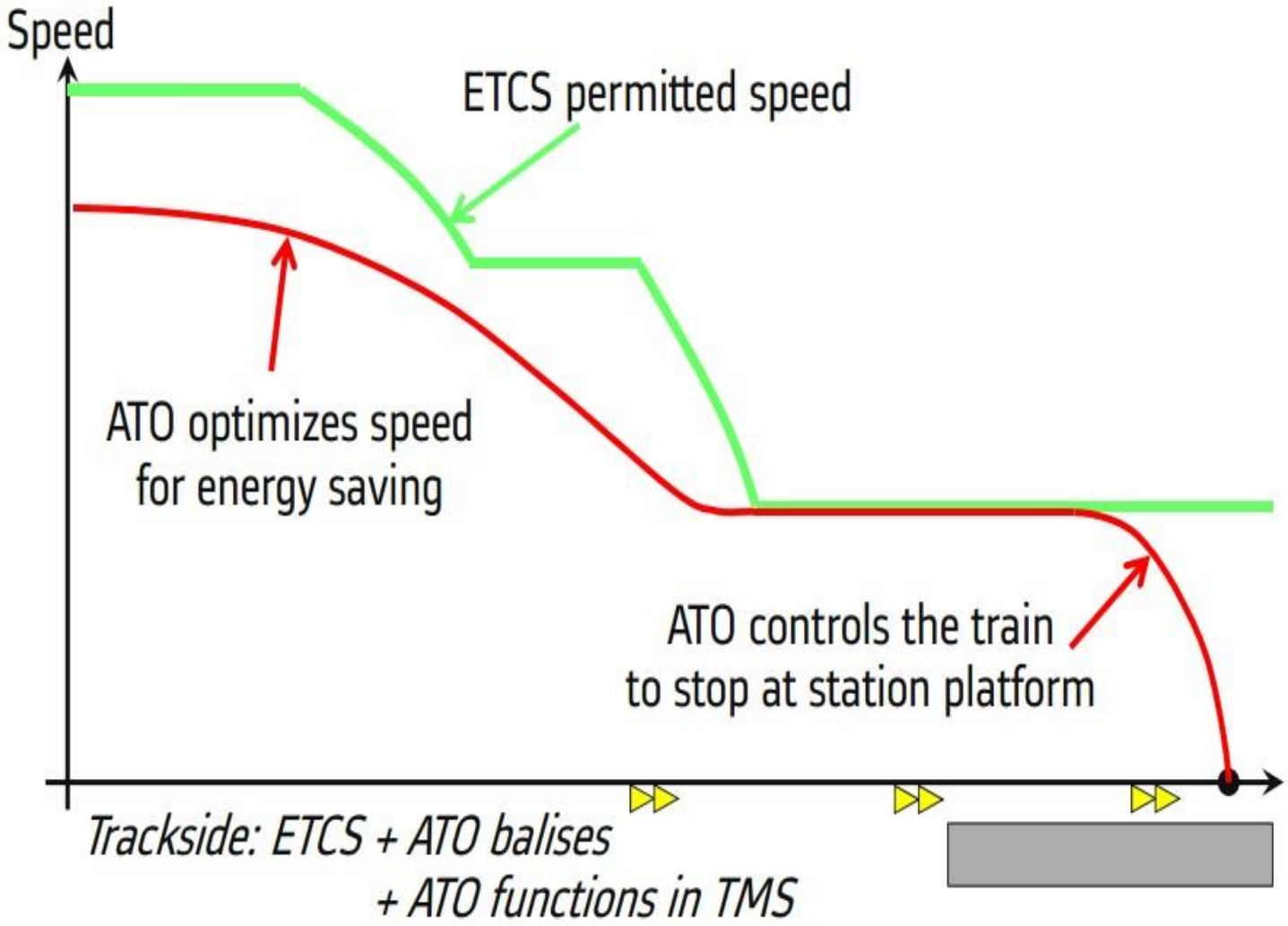
- Functional specification 2000
- Memorandum of understanding 2005: Introduction in 10-12 years on relevant network parts
- Agreement on ETCS Baseline 3 2016
- ETCS Level 2 + GSM-R
- Performance in Germany: comparable to LZB
- In principle open for a first step to ATC

- ETCS Level 3 (moving blocks):
- Test sections on regional links; no implementation plan
- Automatic control: only for closed systems

Automation of railway operation: Technical terms agreed, no implementation plan for open systems

ATC

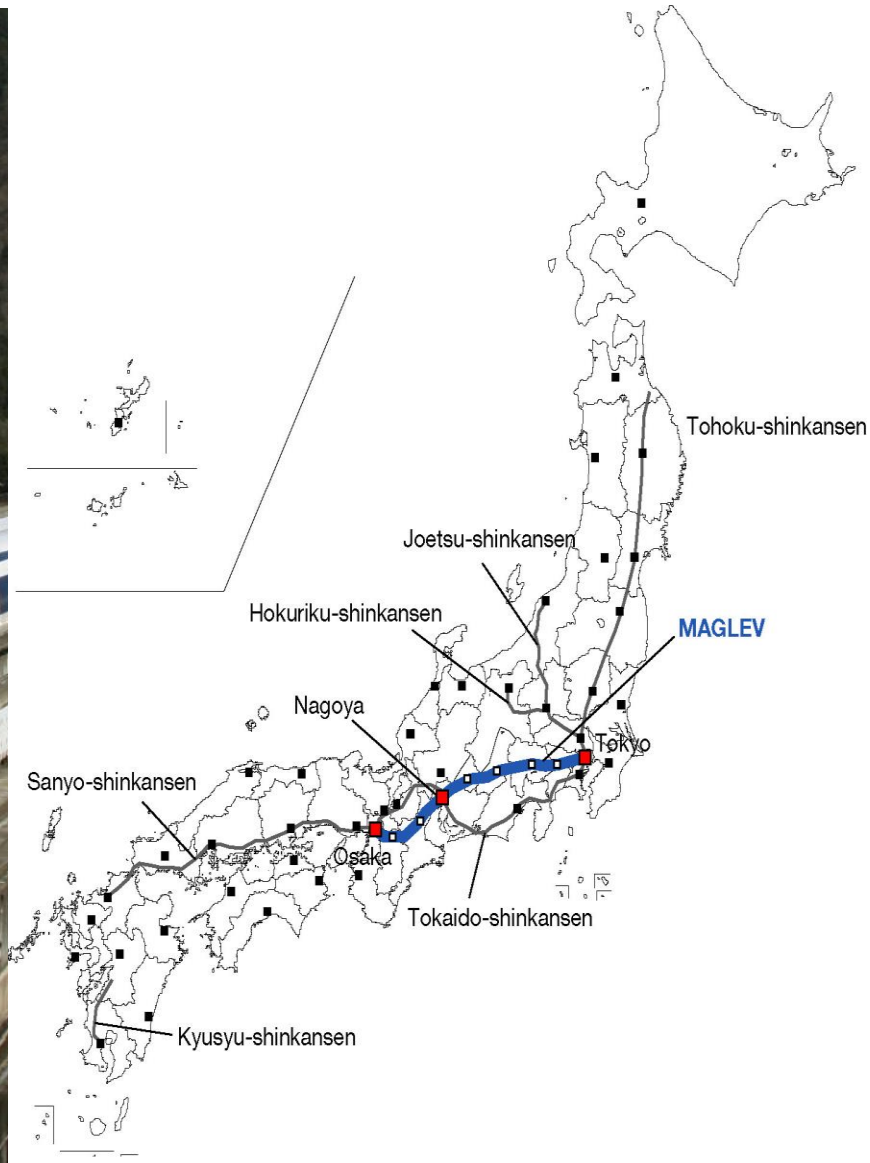
- **ATO**
- **ATP**
- **ATS**
- **STO**
- **DTO**
- **UTO**



IR 4.0 for railways: Barriers to innovation

- Technological lock-in, path dependency
- Innovators‘ dilemma
- Technological deadlock

Flanking strategy of the state for railway innovations



Flanking strategy of the state
The Japanese example

- Technological assistance, R&D (RTRI; industrial cooperation, METI)
- Regulation allowing for profit making or massive state investments
- Railway friendly competition policy

Masterplan Rail Freight Transport
The German example

Nr.	Meilenstein	Beteiligte	Zeithorizont
2.15	Möglichst spezifische Fördermöglichkeiten im Rahmen eines Bundes-programms „Zukunft Schienengüterverkehr“ schaffen	Bund	Anfang nächster Legislatur-periode
2.9	Möglichst spezifische Fördermöglichkeiten im Rahmen eines Bundesprogramms „Zukunft Schienengüterverkehr“ schaffen	Bund	Anfang nächster Legislaturperiode

Conclusions

IR 4.0 not radical innovation rather than radical continuation of existing trends. But: Revival of old dreams ➔ push for inventions.

IR 4.0 will lead to significant changes in production and employment.

In passenger and freight transport some millions of jobs are at stake.

A positive long-term economic cycle may be induced by combining IR 4.0 with radical innovations.

Railways will only profit from IR4.0 if barriers to innovation are removed.

Thank you.

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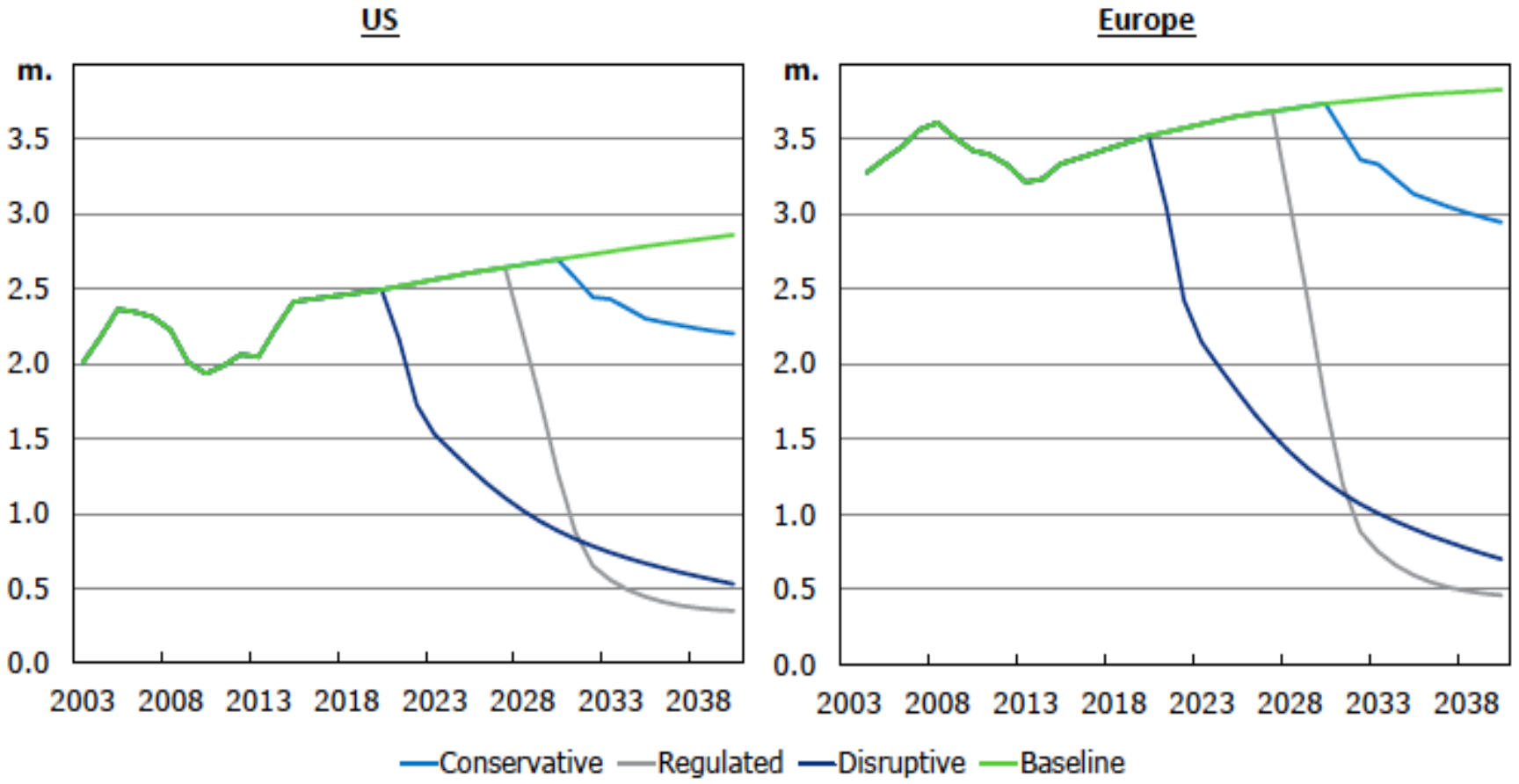
Reduction of truck driver demand through driverless trucking



Source: ITF calculations based on US Bureau of Transport Statistics (2016), Eurostat (2016), IEA (2016).