# Aerodynamic and Flexible Trucks for Next Generation of Long Distance Road Transport

HIGH CAPACITY ROAD TRANSPORT

FOCUSSING INNOVATION ON SMARTER MOBILITY SOLUTIONS FOR SMARTER POLICIES

EUCAR Reception & Conference, 6-7 November 2019


*The AEROFLEX project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 769658*

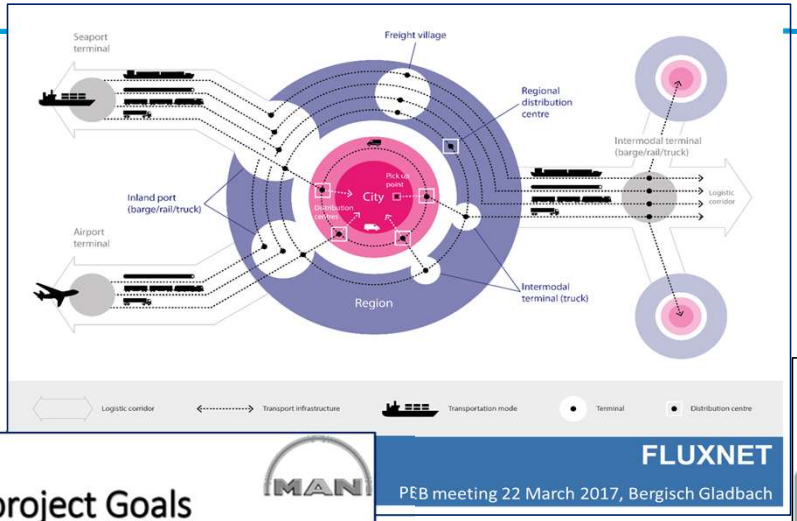
AEROFLEX

# Consortium / Project partners

# Background project

**TRUCK MAKERS CALL FOR EU-WIDE INTRODUCTION OF HIGH-CAPACITY VEHICLES TO BRING DOWN CO2 EMISSIONS, BRUSSELS 7 MAY 2019**

ACEA European Automobile Manufacturers Association




**FLUXNET**

PEB meeting 22 March 2017, Bergisch Gladbach

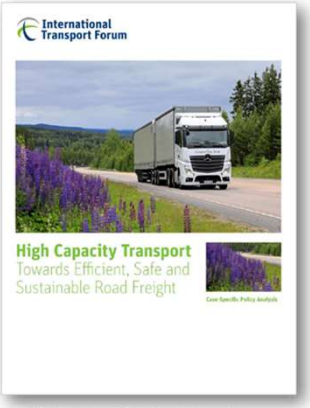
International Transport Forum

**We investigate:**

- Economic and political developments
- Impacts of High Capacity Transport (HCT)
- Regulations and enabling technologies for HCT

**We develop:**

- Package for policy makers



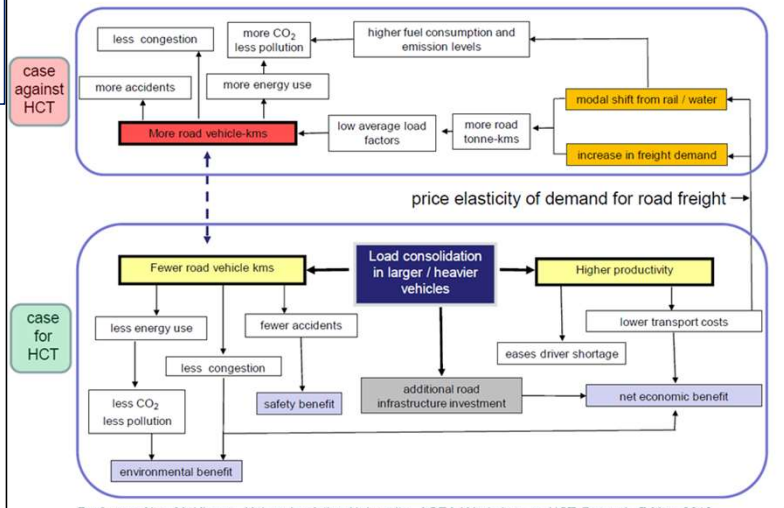

High Capacity Transport: Towards Efficient, Safe and Sustainable Road Freight
Jerker Sjögren, Chairman of the ITF Working Group on HCT, 7 May 2019

## CEDR-FALCON| project Goals

- Define a concept of Smart Infrastructure Access Policy (SIAP) using principles of Performance based Standards, Intelligent Access Programs and Digitalization
- Ensure better fit between the road and the vehicles through vehicle performance and knowledge of vehicle impact on the infrastructure

FALCON Smart Infrastructure Access Policy: a path towards more efficient road freight transport, Brussels 7.5.2019

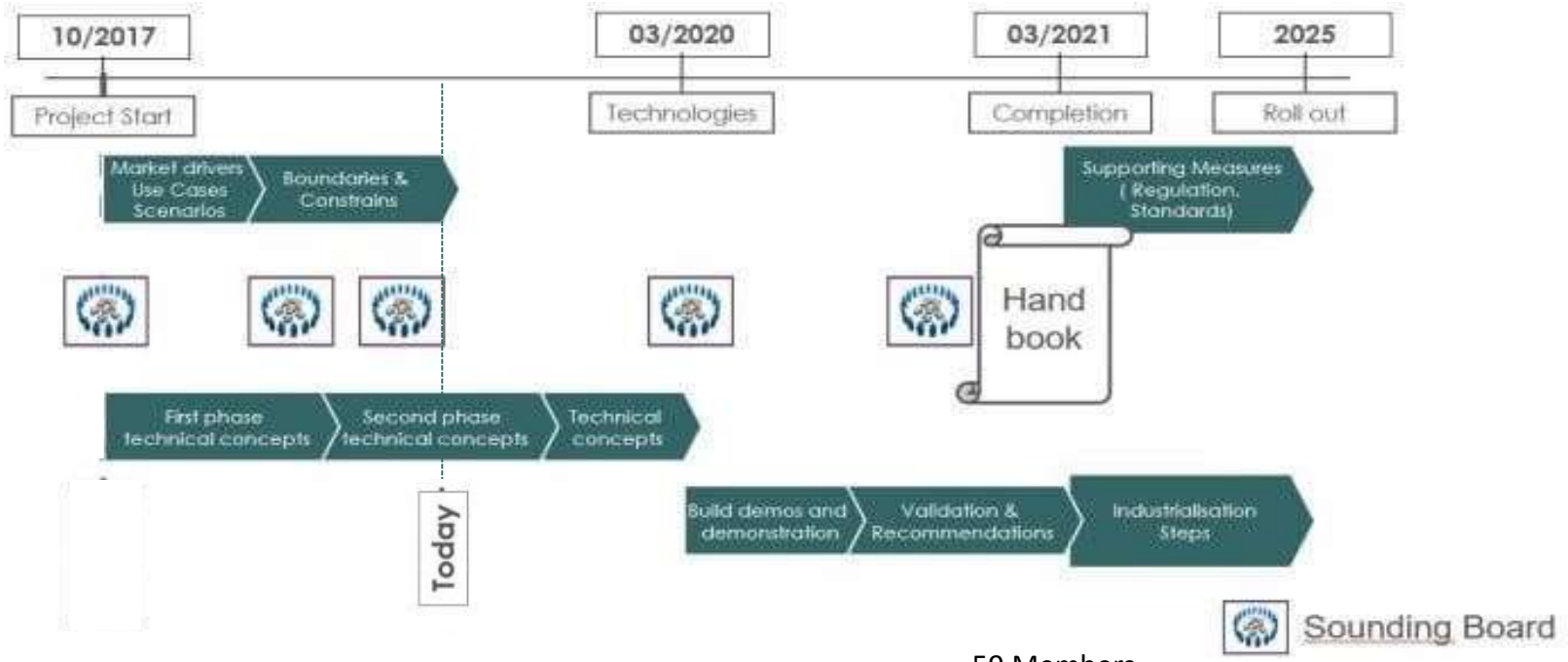
High capacity transport: *polarisation of the cases for and against*




Professor Alan McKinnon, Kühne Logistics University, ACEA Workshop on HCT Brussels 7 May 2019

# Key project figures

- The AEROFLEX project has received funding from the European Union's Horizon 2020 Programme under grant agreement no. 769658
- 25 leading organisations from 8 different countries in Europe and Turkey
- Start date: 1 October 2017
- End date: 31 March 2021
- Duration: 42 months
- Total EC funding : € 9.5 m
- Project costs: € 11.95 m



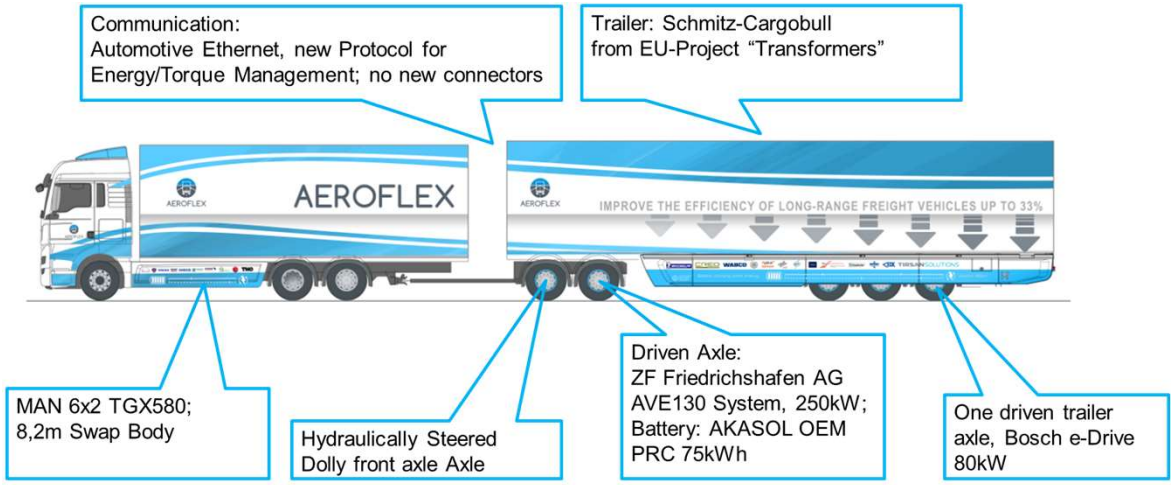

TRA 2020 HELSINKI

4 papers submitted
1 demonstrator

59 Members
10 Workshops

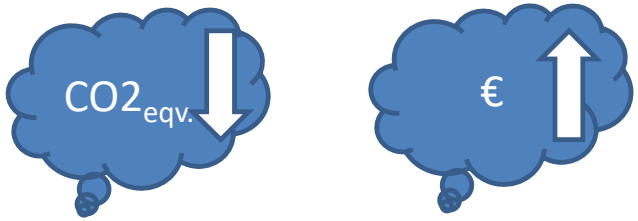
# TRA2020: 4 papers, one demonstrator

- *AEROdynamic and FLEXible Trucks for Next Generation of Long Distance Road Transport*
- AEROFLEX smart power dolly: Towards efficient and mission-oriented long-haul vehicles
- An analysis of European crash data and scenario specification for heavy truck safety system development within the AEROFLEX project
- State of the art of the regulatory framework and analysis of the technologies developed within the AEROFLEX project
- One demonstrator



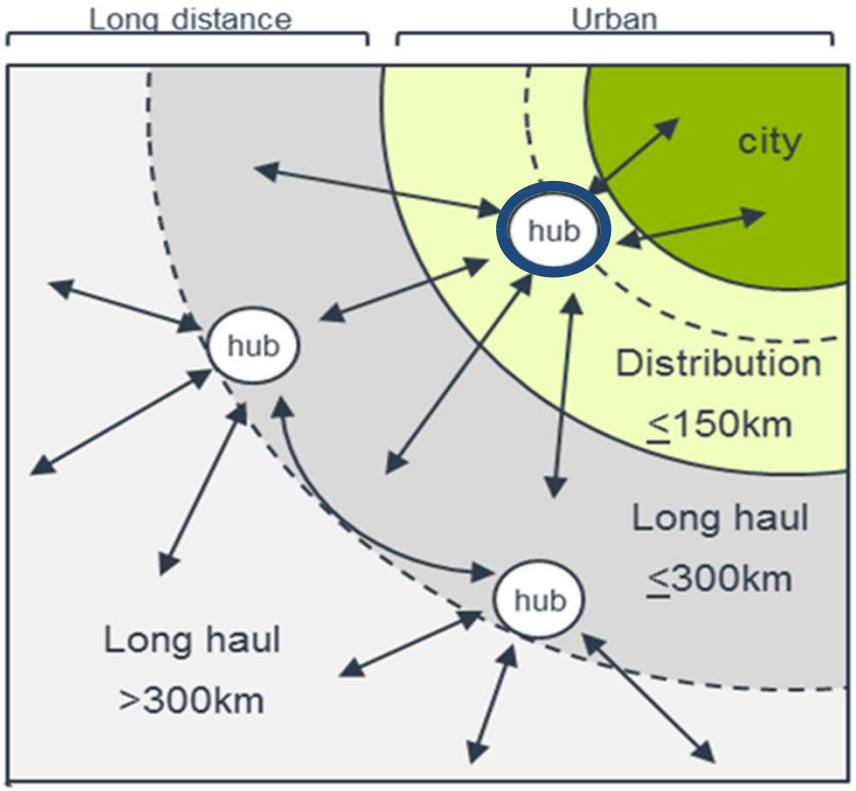
# Context of mobility for freight and people

## Sustainable growth

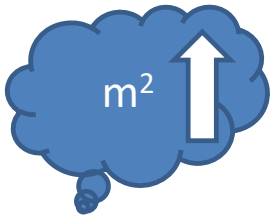



| mode | speed | security | Cost (per tkm) |
|---|---|---|---|
| | ↓ | → | ↓ |
| | → | → | → |
| | → | → | → |
| | ↑ | → | ↑ |

Efficient and effective use of infrastructure




## Quality of life, quality of time


hub Long distance meets urban

Source: FALCON and FLUXNET funded by CEDR, AEROFLEX funded by EU

# First key messages

**AEROFLEX , a significant contribution to CO2 reduction objectives and to increase efficiency**

- **Vehicle concepts**
  - A wider use of Higher Capacity Vehicles (HCV)
  - An enhancement of EMS concept
- **Logistics operations**
  - For both low and high density goods as well as for long and short haulage
  - Consolidation of freight as a precondition
- **Transformation** of the assets (semi-trailers, boxes, wagons) into **smart devices**
- **Smart Infrastructure Access Policies (SIAP)** for optimal matching of novel vehicle concepts and infrastructure

ACEA – DGs workshop May 2019

# Goal and objectives

## Goal

Develop and demonstrate
- new technologies
- new vehicle concepts
- new architectures
- **new standards***

for complete vehicles

meeting
- **future logistics and**
- **co-modality needs**.

## Boundaries & Constraints

## Technologies and Innovations

**Up to 33% Efficiency Improvement in Long Haul road transport**

## Demonstration and impact assessment

## Recommendations for new standards and adapted legislative framework

*new standards for hybrid-distributed powertrain, aerodynamic devices for complete vehicle, utilization of loading units, performance based standards (PBS), access to infrastructure in a multi mode context

# Boundaries & constraints
# European road freight transport market

**Literature and Data Analyses**

Status and trends, Eurostat data, forecasts

- 38% of analysed transports in long road haulage is fully loaded*
- Palletized cargo is most interesting for efficient handling and carrying of cargo
- Low and high density goods
- Long (>150km) and short haulage (>50km)
- Rail/road in need of optimisation

**Acceptance and Requirements of LSP and Shippers**

Online survey, interviews, workshops

- Variety of requirements concerning length and laden weight
- Any vehicle concept: standard units, one fits for all or most transport
- Willingness to adapt new solution depends on feasibility and framework

*Analysis EUROSTAT-EU-NST2017

# Overview targets and innovations

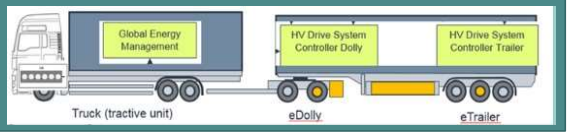
- 4–5% energy saving by separate platforms
- 4–6% energy saving by effective use of loading space
- 5–12% energy efficiency improvement from the flexible, advanced powertrains
- 5–10% reduction in energy consumption through improved vehicle aerodynamics
- Standardised interfaces and sharing of components for higher economies of scale
- Front-end designs to ensure survivability in crashes up to 50 km/h for occupants and vulnerable road users

**Smart Loading Units**

PUZZLE®

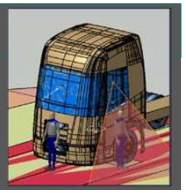
Maximize utilization

**Hybrid Distributed Powertrain**



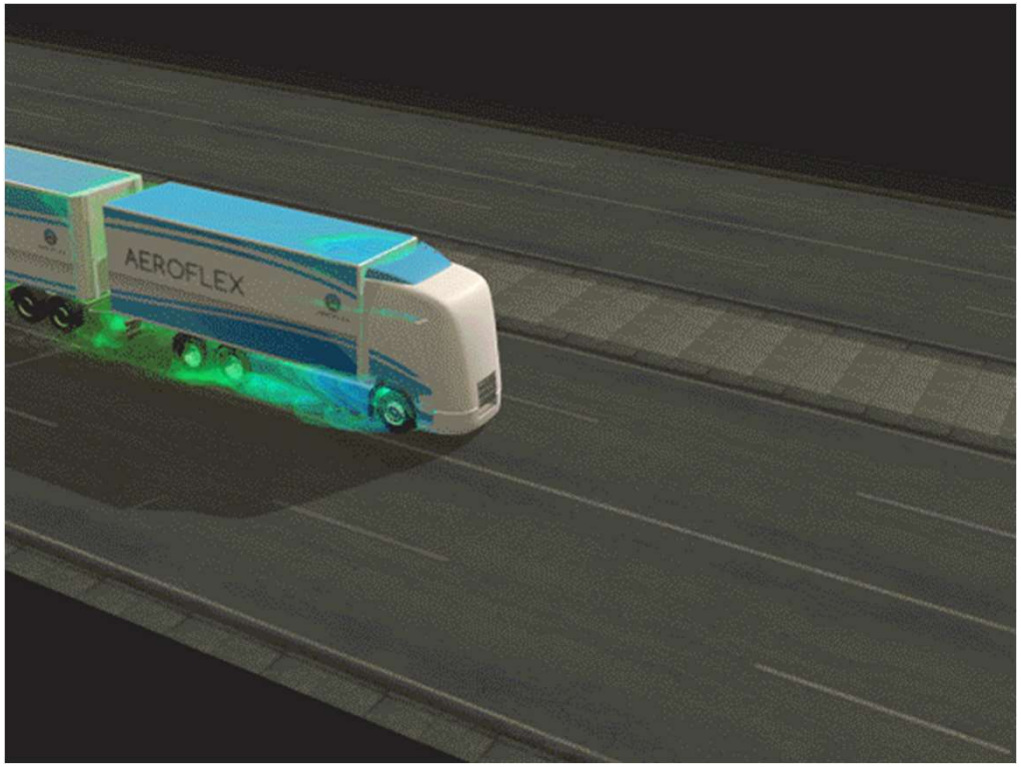

**Aerodynamics for Complete Vehicle**

**Front-end Design**



# Innovations: benefits for OEMs, logistics industry and society

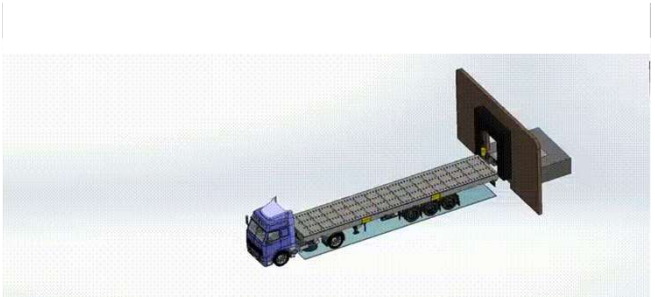
- Smart Loading Units for more **effective loading space utilisation**
- An Energy Management Powertrain architecture and control for **distributed hybrid powertrains**
- A smart **steerable dolly for EMS vehicles** and ‘autonomous’ manoeuvring
- Aerodynamic Features and Devices for the complete vehicle that are **adaptable to their logistics task**
- **Front-end design** for more safety and survivability
- Vast Demonstration and **Impact Assessment** Programme
- **Book of recommendations** for industry, logistics and policy makers

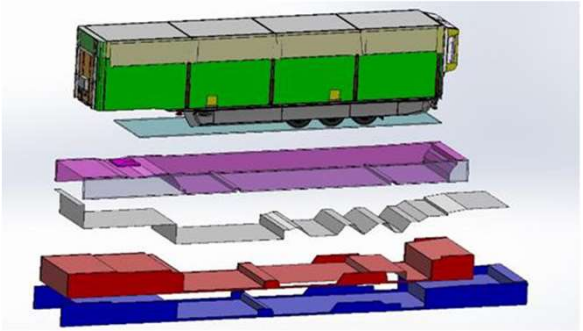


# Smart Loading Units: collaboration with EU project CLUSTER 2.0

PUZZLE®

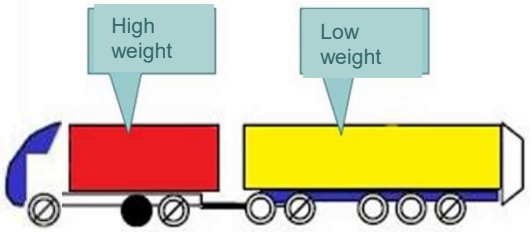
Maximise utilisation



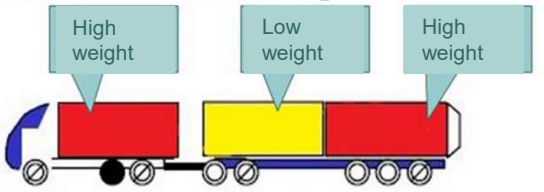


Cargo Cam

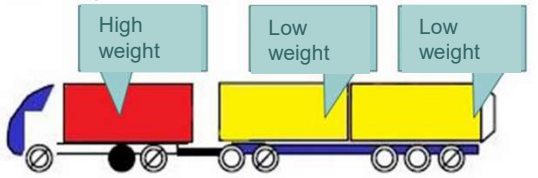
**Combine heavy weight with light weight to fill both volume and weight !**




**Demonstrator Truck +Dolly+ VEG trailer**




- **Intermodal Truck +dolly+containerchassis**
- **1 x C 7,82 2x 20 ft container**



# PUZZLE software demonstrator


PUZZLE software demonstrator online available in February 20

Answers following questions:

- How many pallets more can I put into the flexible floor trailer? → here: 34 more (maximum)
- Optimised by product (each product or customer has own colour, dimension and number)
- Is restriction of weight respected? → yes for total weight and axle load
- Which double floor should be installed → staffing plan for loading
- Which pallet putting fist into the trailer? → staffing plan for loading
- How much is weight or volume used? → percentage shown on the top
- Different dimensions or restrictions of loading unit and trailer → manually adjustable

# Mathematical optimisation problem - Trailer with flexible floor

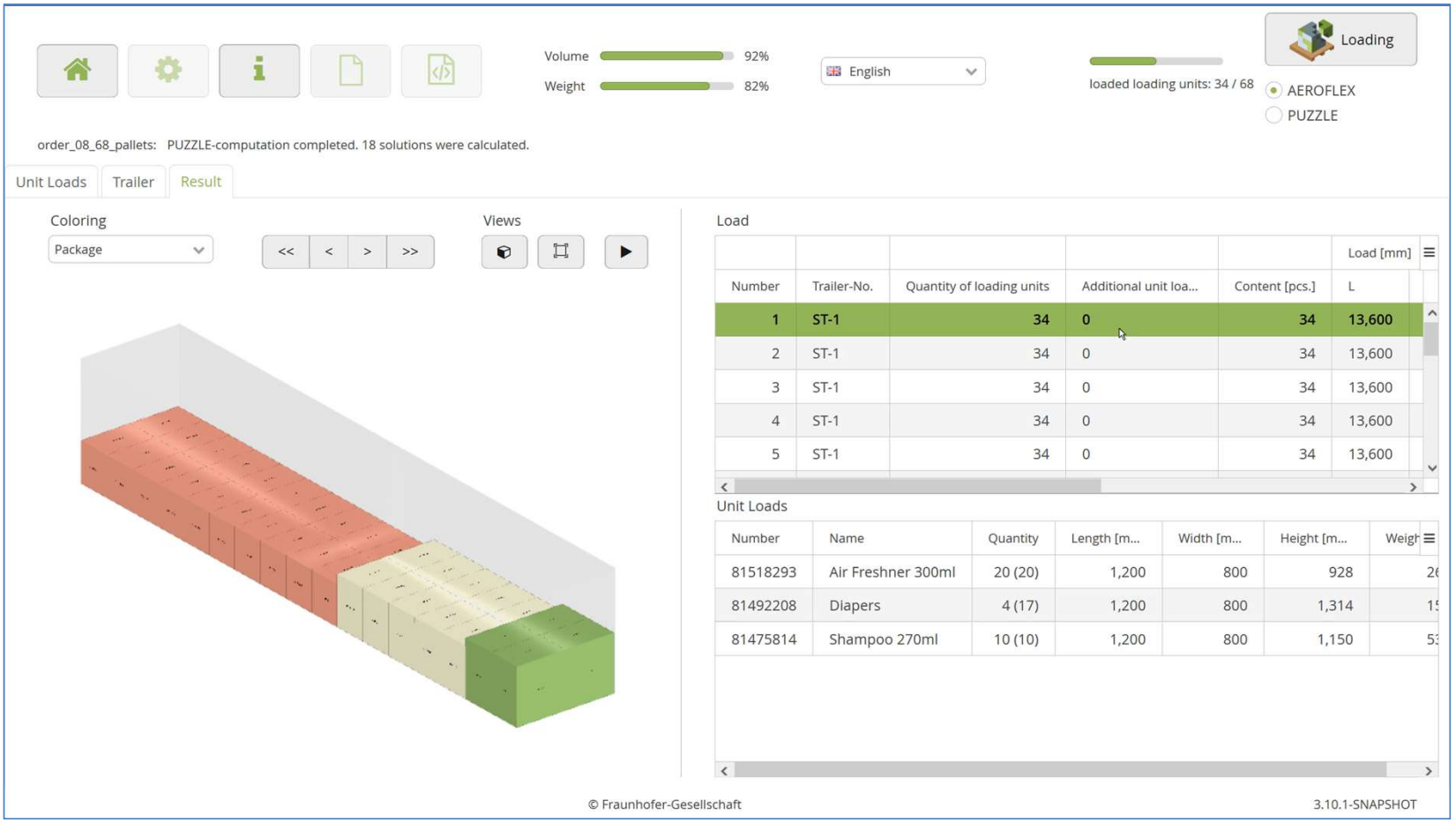
## How many more pallets are really possible?

Video with real transport data:

Start with standard trailer loaded with 34 pallets (loading units) on the floor → example diapers (green) are only 4 of 17 pallets on the trailer

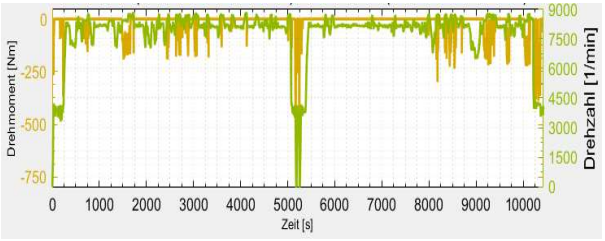
Product list (adjustable manually or via import) Selection of AEROFLEX trailer „Loading“

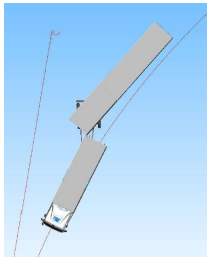
Optimised trailer with all flexible floors used → 34 pallets more on the trailer (best case)

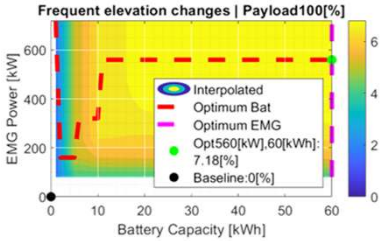


# Hybrid Distributed Powertrain


- Energy system and control units
- Electrically driven dolly
- EMS demo vehicle with Hybrid Distributed Powertrain incl. e-dolly and TRANSFORMERS trailer with e-axle
- Virtual demonstrator of vehicle driveability

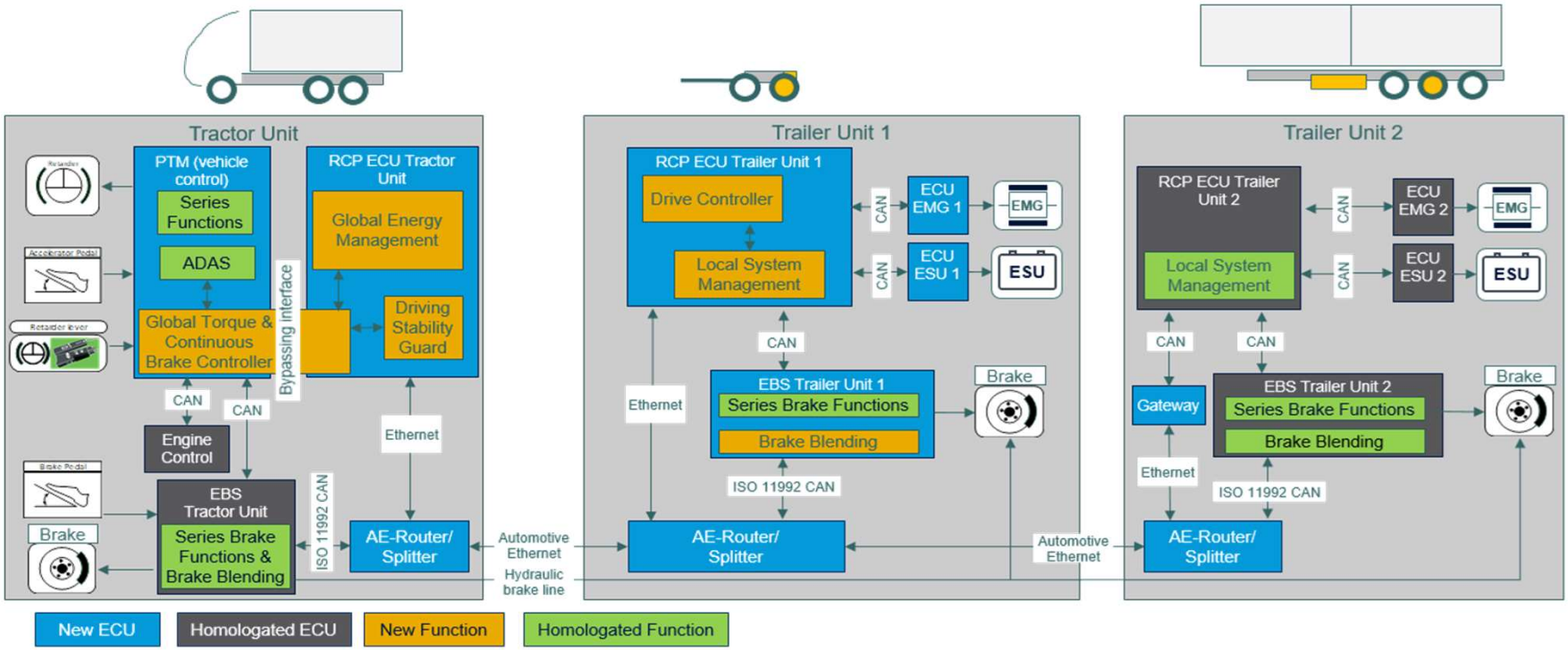



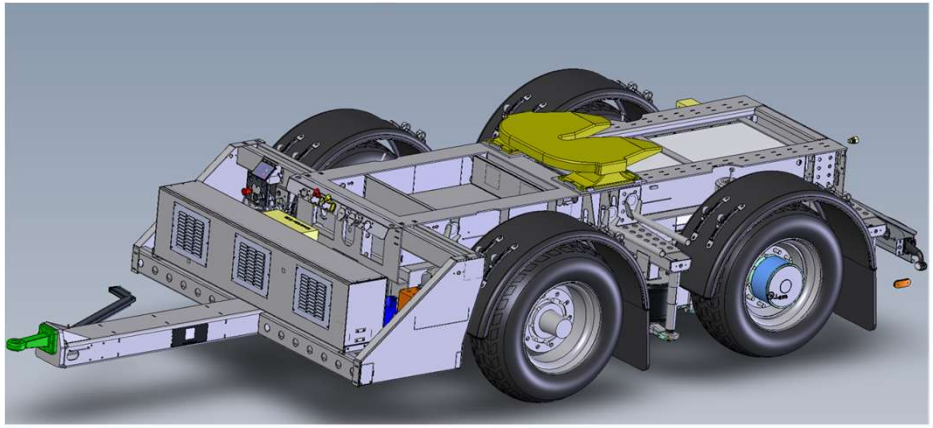


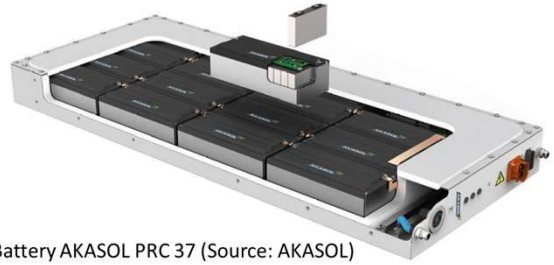
# Energy system and control units

- System architecture

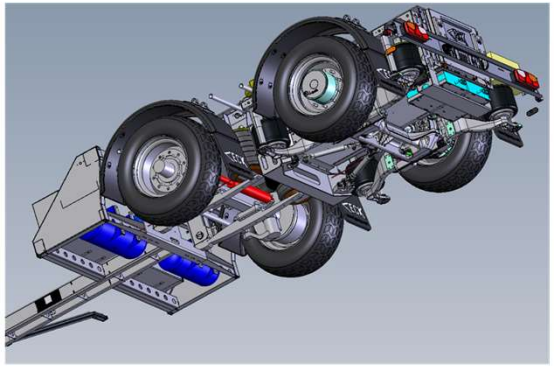


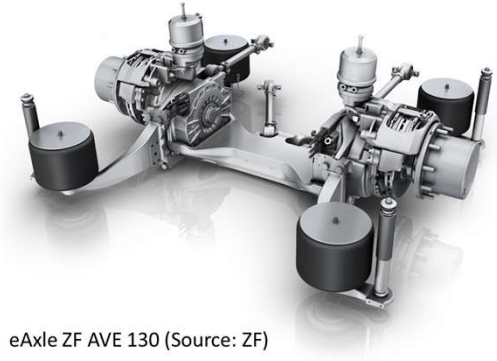
# Electrically driven dolly





Battery AKASOL PRC 37 (Source: AKASOL)





eAxle ZF AVE 130 (Source: ZF)

# EMS demo vehicle with Hybrid Distributed Powertrain incl. e-dolly and TRANSFORMERS trailer with e-axle

Communication:
Automotive Ethernet, new Protocol for Energy/Torque Management; no new connectors

Trailer: Schmitz-Cargobull
from EU-Project “Transformers”

TRA 2020 HELSINKI


MAN 6x2 TGX580;
8,2m Swap Body

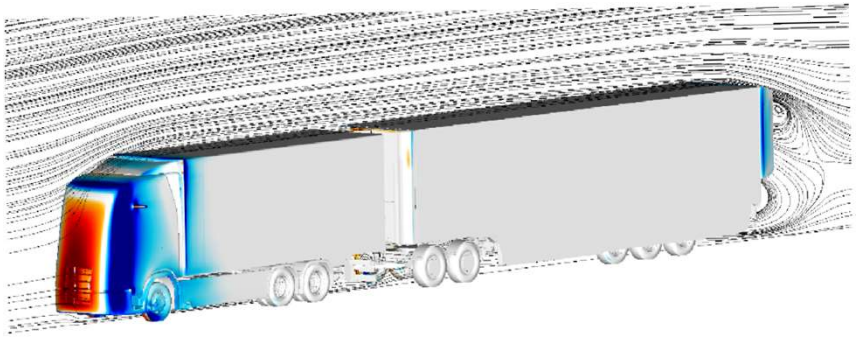
Hydraulically Steered
Dolly front axle Axle

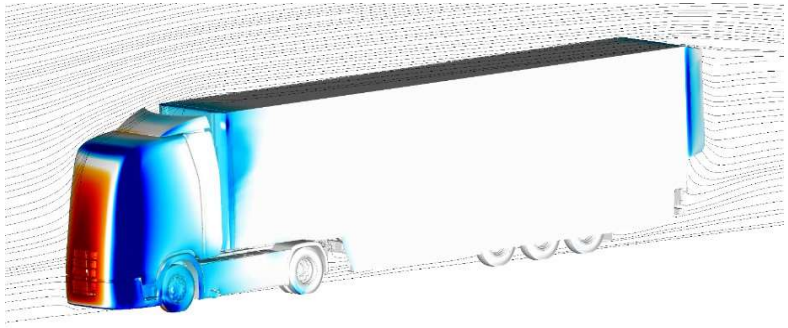
Driven Axle:
ZF Friedrichshafen AG
AVE130 System, 250kW;
Battery: AKASOL OEM
PRC 75kWh

One driven trailer axle, Bosch e-Drive 80kW

# Aerodynamic features for the complete vehicle

- Active and passive aerodynamic features;
  simulations by CFD and wind tunnel and vehicle for demonstration





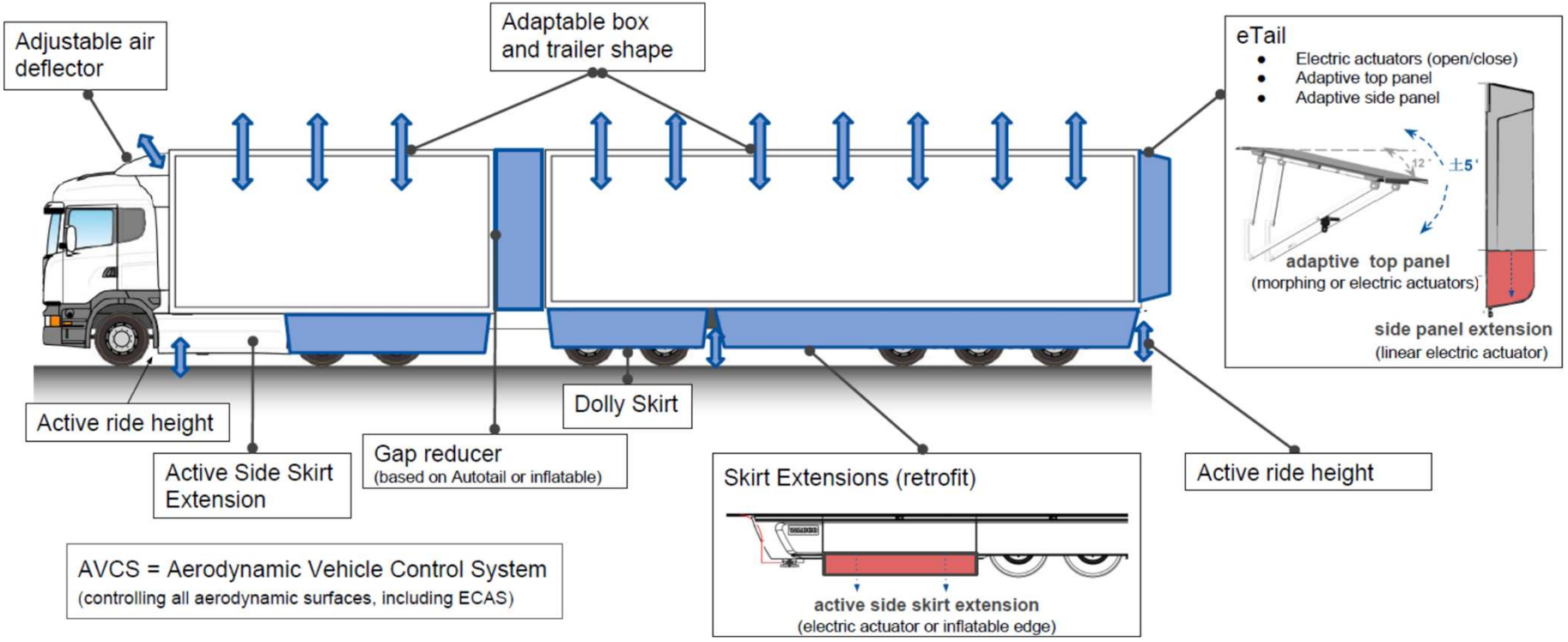
The developed models have been made available to ACEA and CLCCR for use in future updates of the CO2 regulation for heavy vehicles

# Scale model for wind tunnel testing

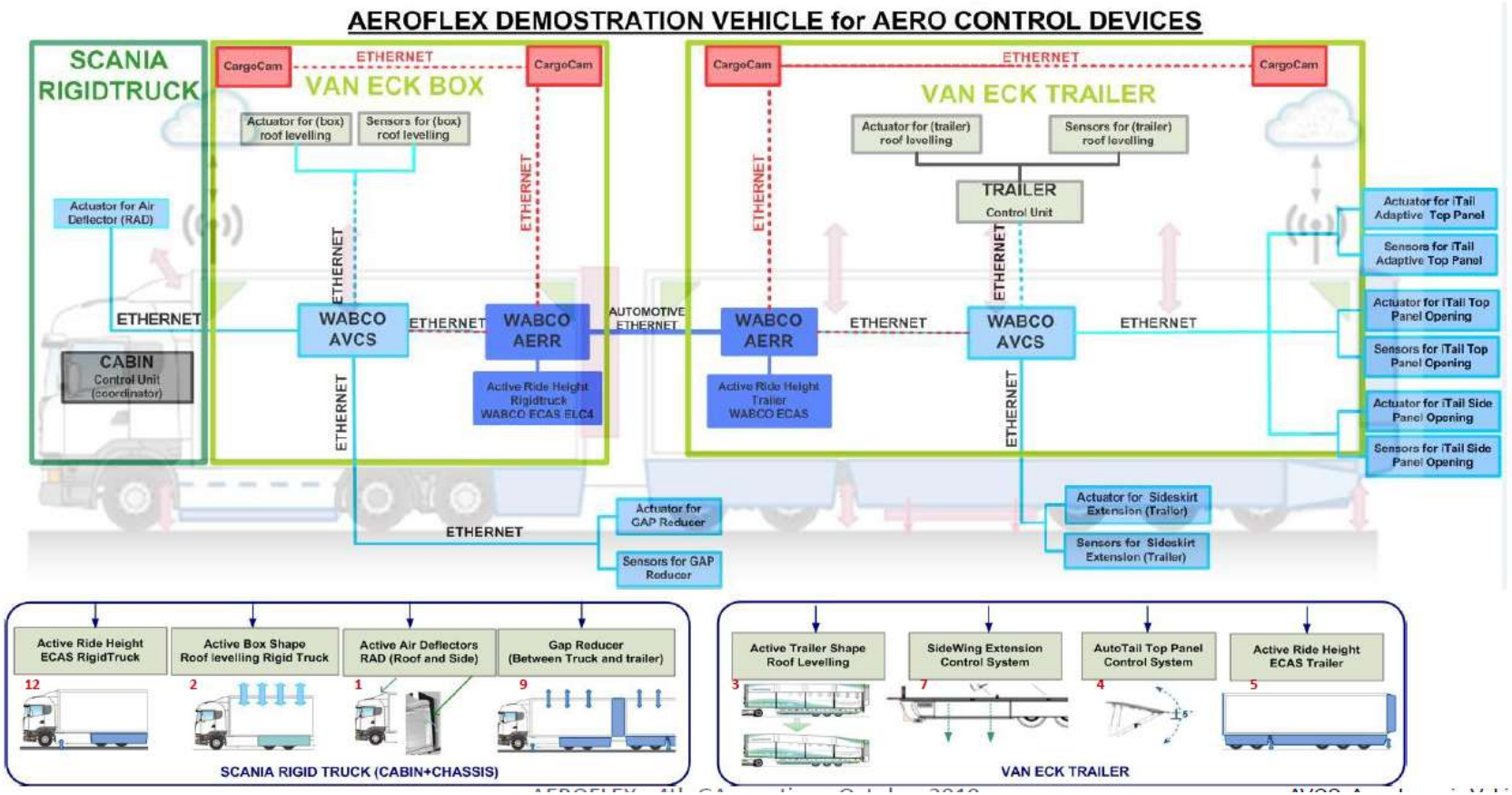

- Plasma has been chosen as the most promising actuator technology.

# Demonstrator

## Demonstrator vehicle and systems

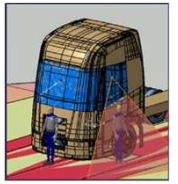


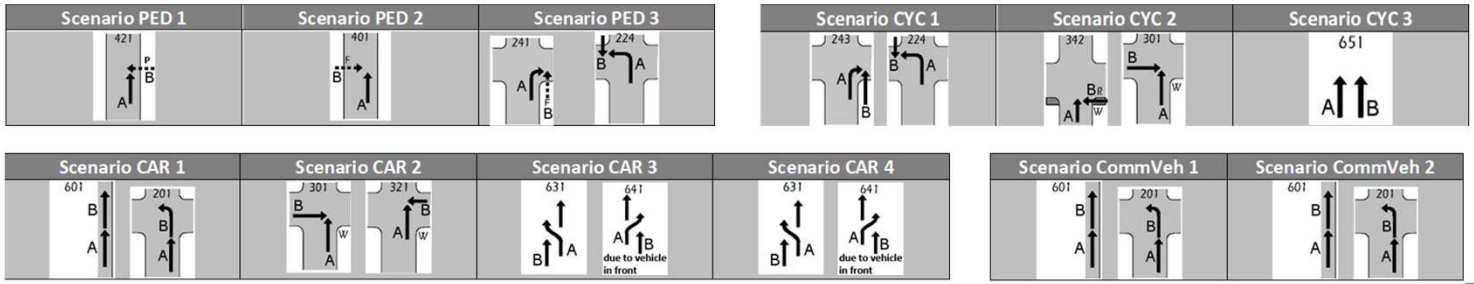
# Demonstrator, systems architecture

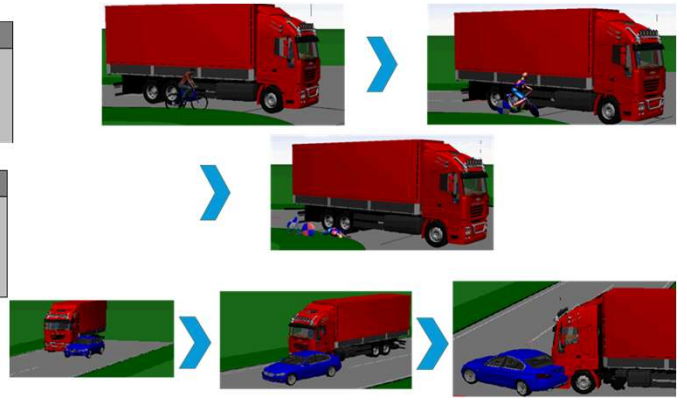


# Architecture front end
# Detailed accident scenarios definition

- Front-end designs to ensure survivability in crashes
  up to 50 km/h for occupants and vulnerable road users
- 12 relevant accident scenarios were selected from in-depth accident data





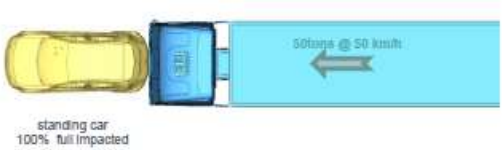



- For each scenario a set of crash data was analysed

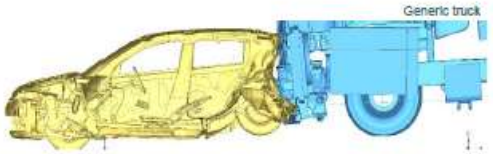
# Front end design for better survivability

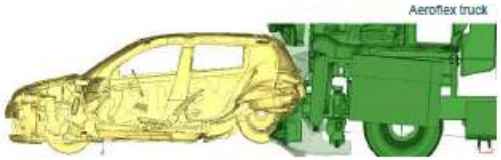
## Protection of car and truck occupants

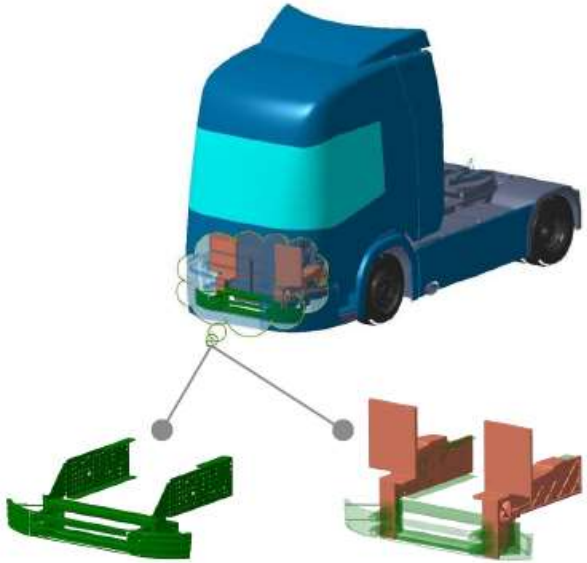
Most relevant accident scenario involving truck +16t and car is shown below. Specific crash absorber designed to preserve the car




standing car
100% full impacted



Fuel tank and luggage compartments well preserved:
intrusion on fuel tank compartment -50%

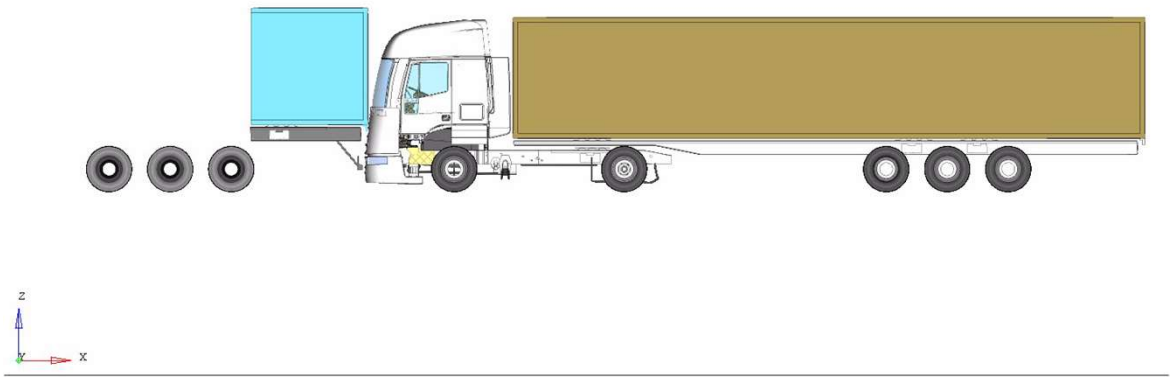
Most relevant accident scenario involving truck +16t and commercial vehicles, highlights huge amount of crash energy cannot be effectively absorbed by any protective structures, despite frontend elongation.


100% full impacted



Reduction of the survival space up to 500mm:
too high to avoid serious injuries.

# Active and passive safety systems




- Right combination of passive and active safety to increase survivability of the driver

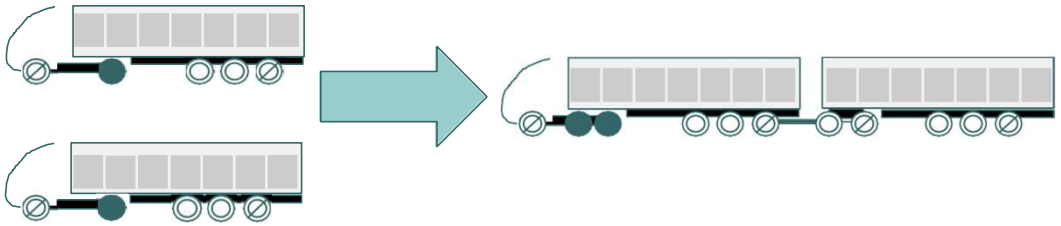
# Customer use cases (72 LSPs involved)


- **32 use cases** collected by interviews (individual trans-ports defined by a route, sources and sinks and its load)
  - 15 of which already analyzed
- **45 legs** (Some use cases consisted of several different legs, i.e. type of route, the vehicle or transport mode changed in the course of the transport)
  - 18 of which already analyzed
- **19 countries** involved either as origin, destination or transit country
- **23 of 27 available Prime Candidates (vehicle concept) selected** for use cases (24 as generally applicable)
  - 15 already analyzed
- **85 combinations** of tour, vehicle and load variants
  - 51 of which already analyzed

**Remaining 17 use cases are currently analyzed.**
Results will be published with D1.2a approx. end of 2019.

# Average savings potential PC6.1

Average savings potential for all analysed use cases / legs for optimised and maximised load.
Technical innovations coming from the AEROFLEX project are not yet included!



Exemplary for a standard semi trailer vs. a double semi trailer


| | €/m3km | €/tkm | Cost/tour | $CO_2e$ TTW | $Co_2e$ WTW |
|---|---|---|---|---|---|
| **Average savings potential (%)** | **-32,4** | **-32,4** | **-31,7** | **-18,4** | **-23,0** |

- Use cases show a wide spread, results differ depending on conditions, routing, topography, etc.
- The overall efficiency on European level depends on the market penetration.
- The market penetration depends on the allowance to use new vehicle concepts in a regional and cross boarder context.

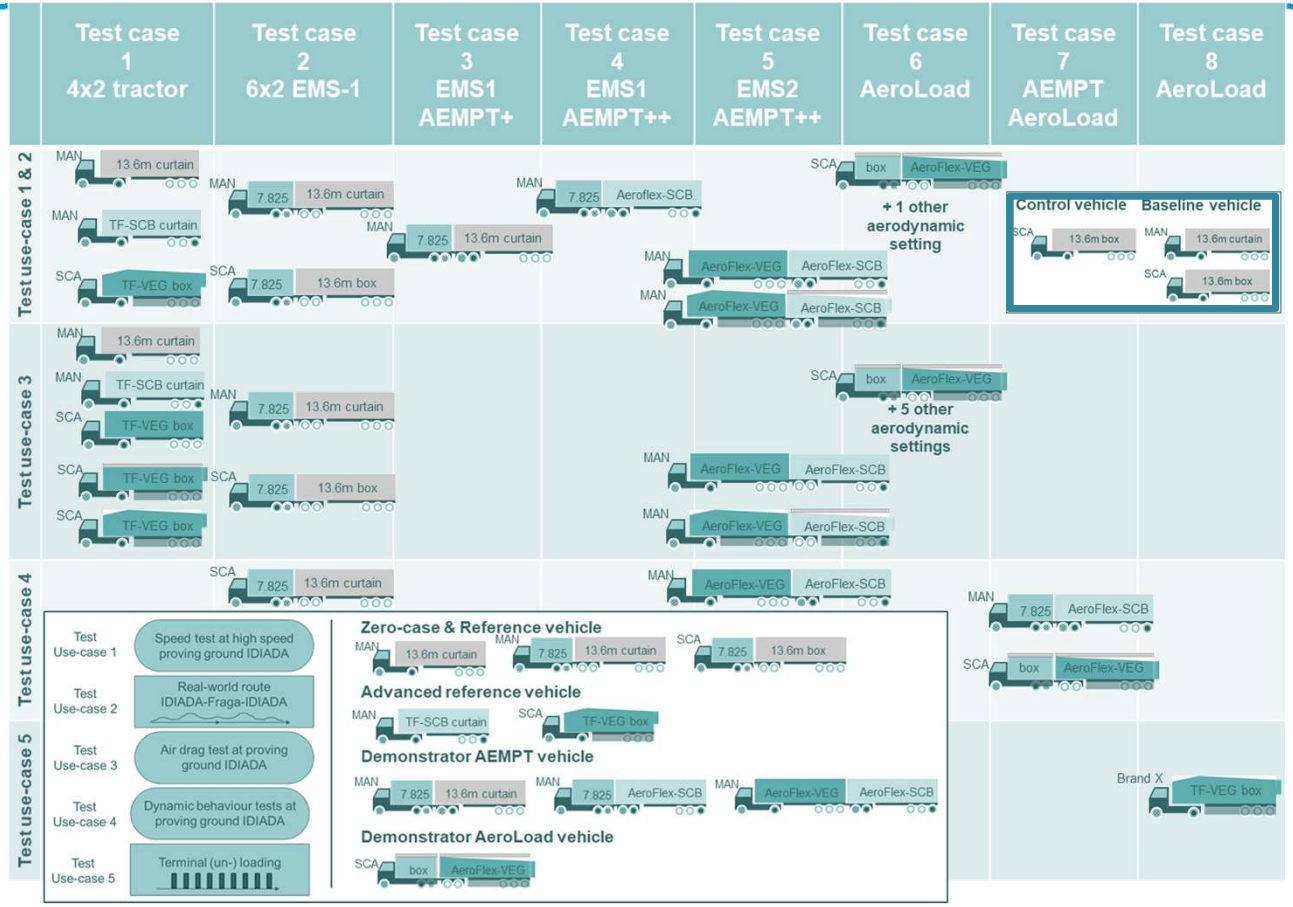
# Demonstration, validation and analyses of feasibility

## Test matrix

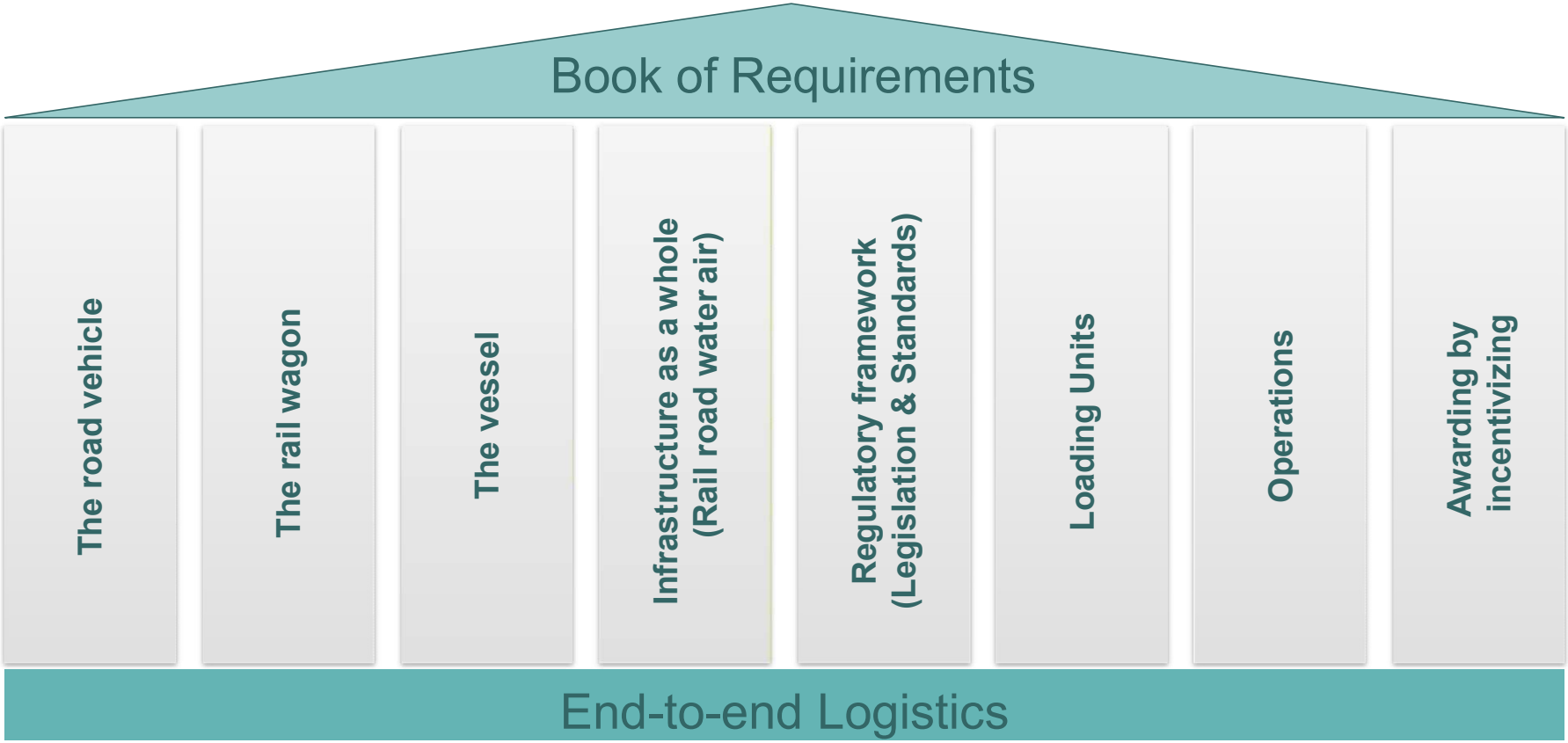
Covering 9 different configurations of 3 types of vehicles:

- Tractor semi-trailer (16.5m)
- EMS1 (25.25m)
- EMS2 (32m)

*Including vehicles from previous EU project TRANSFORMERS*



# Recommendations and roadmap for a new Regulatory Framework



# Recommendations and roadmap for a new Regulatory Framework

## UN Regulation

→ **UNECE**: United Nations Economic Commission for Europe

→ **TRANS**: Transport Division → **ITC**: Inland Transport Committee

Road Transport / Rail / River

- **WP.1**: Global Forum for Road Traffic Safety
- …
- **WP. 29**: World Forum for Harmonization of Vehicle Regulation

**GRBP**: Group of Experts on Noise & Tyres

**GRE**: Group of Experts on Electricity & Lighting

**GRPE**: Group of Experts on Polution & Energy

**GRSG**: Group of Experts on General Safety Provisions

**GRSP**: Group of Experts on Passive Safety Provisions

**GRVA**: Group of Experts on Automated Driving

## EU Directives & EU Regulations

**DG** MOVE

**DG** GROW

**DG** RESEARCH

**DG** CLIMA

…

## Standards

ISO

EN

SAE INTERNATIONAL

UIC

**WP2: Powertrain**

**WP3: Aerodynamic Features**

**WP4: Smart Loading Units**

**WP5: Front End design**

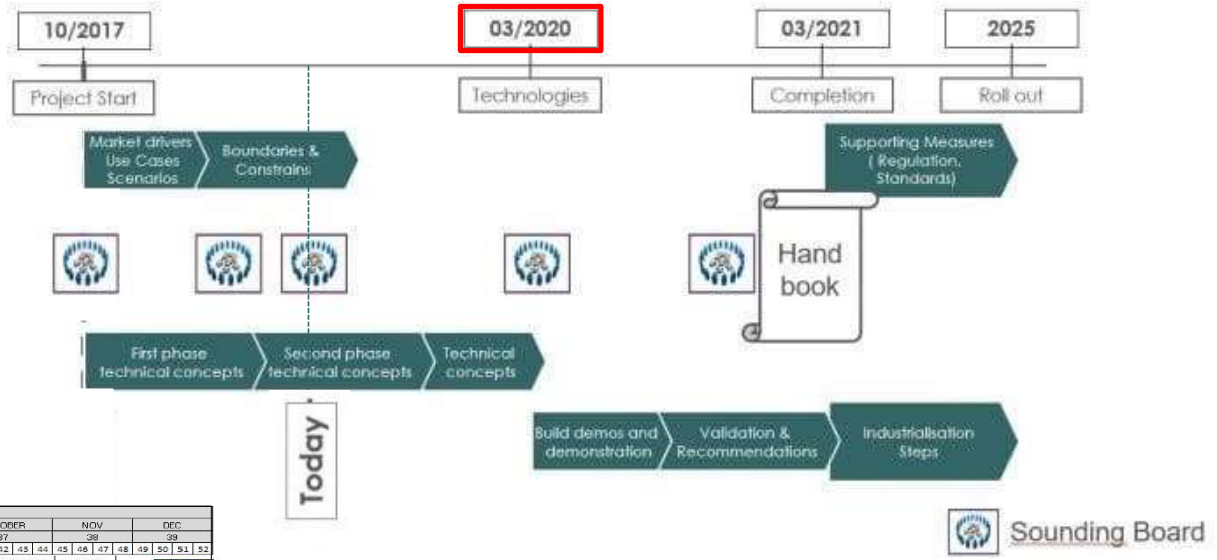
# Recommendations and roadmap for a new Regulatory Framework

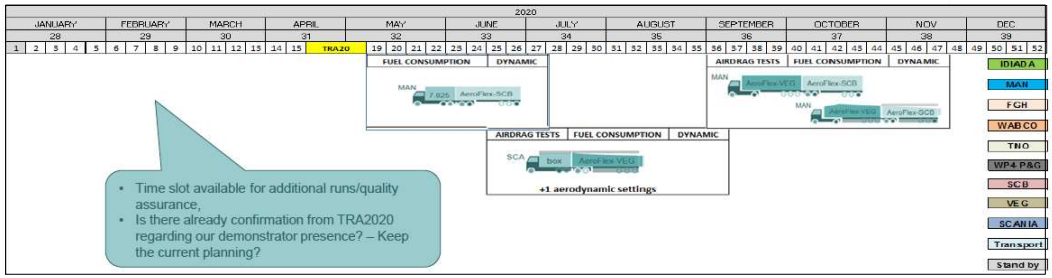

Intelligent Access Policies
for
Safe and Efficient Use of Infrastructure

Intelligent Performance Based Standards
for
Safe and Efficient use of Vehicles

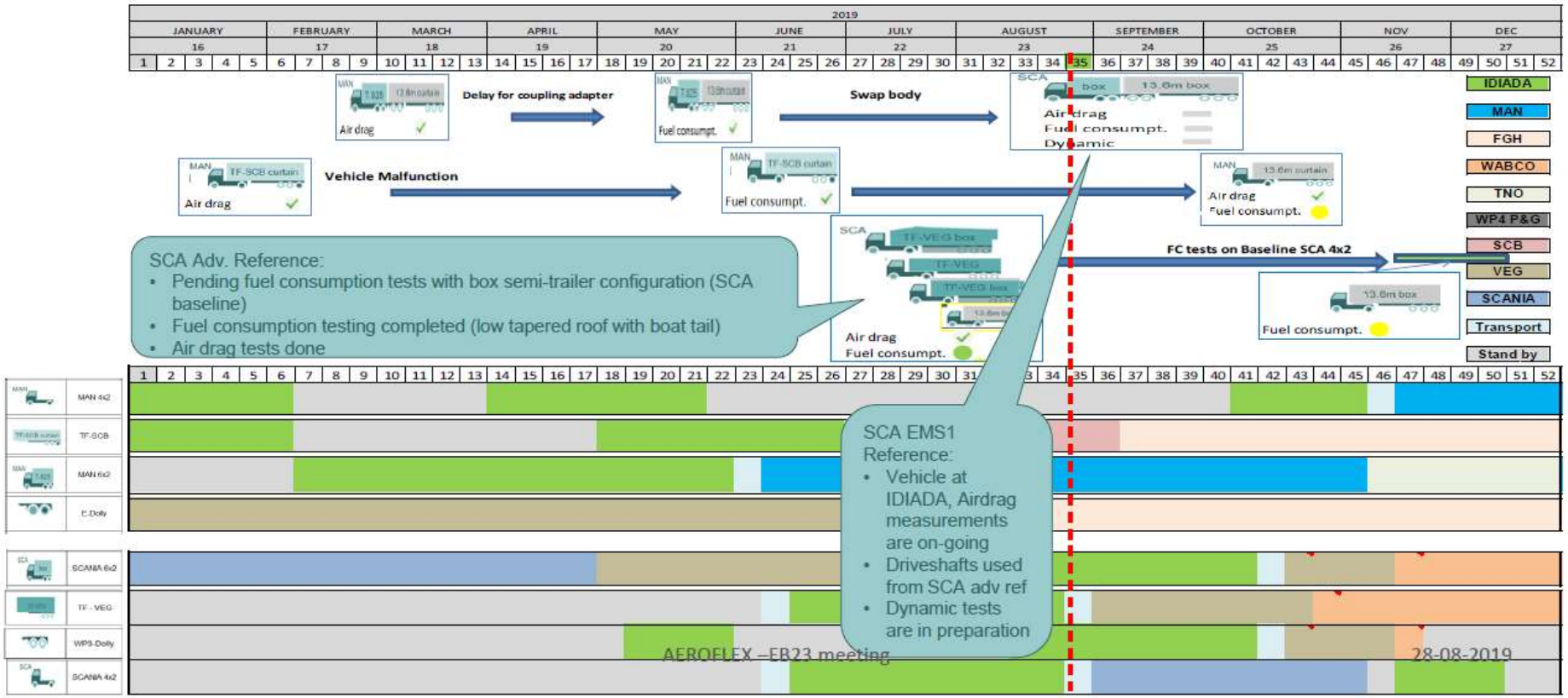
# Next steps

- Continue workshops Sounding Board (stakeholders), 30 Oct, 8-10 Oct 2019, Q2/2020
- Completion of test program reference vehicles, Dec. 2019
- Build and release of demo vehicles, Dec. 2019 – Mar. 2020
- Preparation of demonstration programme, Mar. 2020

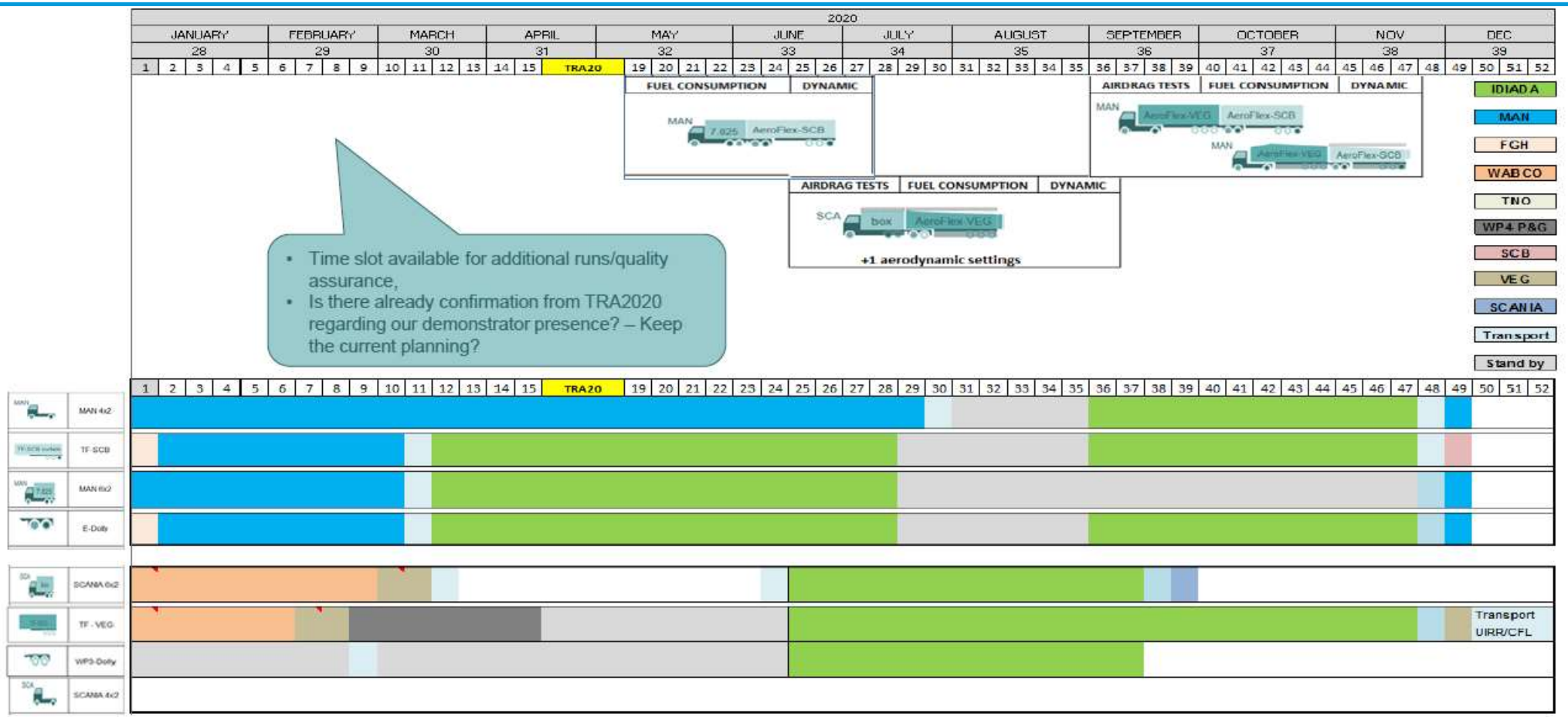


# Next steps


2019
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOV
DEC
Delay for coupling adapter
Swap body
Vehicle Malfunction
FC tests on Baseline SCA 4x2
Air drag
Fuel consumpt.
Dynamic
IDIADA
MAN
FGH
WABCO
TNO
WP4 P&G
SCB
VEG
SCANIA
Transport
Stand by
SCA Adv. Reference:
• Pending fuel consumption tests with box semi-trailer configuration (SCA baseline)
• Fuel consumption testing completed (low tapered roof with boat tail)
• Air drag tests done
SCA EMS1 Reference:
• Vehicle at IDIADA, Airdrag measurements are on-going
• Driveshafts used from SCA adv ref
• Dynamic tests are in preparation
AEROFLEX –EB23 meeting
28-08-2019

# Next steps




- Time slot available for additional runs/quality assurance,
- Is there already confirmation from TRA2020 regarding our demonstrator presence? – Keep the current planning?

# Risk - Pathway dependency on Performance Based Legislation and Infrastructure Access Policies

## AEROFLEX delivers

- Recommendations for new standards*
- Proven logistics capabilities of future vehicle combinations
- Proven efficiency of future vehicle combinations
- Proven concepts and new standards for future vehicle combinations

## Opportunity for society

2030
Up to 33% Efficiency achieved and proven

2025
Large scale roll-out of concepts and new standards

2020
Introduction of AEROFLEX concepts and new standards

*new standards for hybrid-distributed powertrain, aerodynamic devices for complete vehicle, utilization of loading units, performance based standards (PBS), access to infrastructure in a multi mode context

# Thank you!

For more information see https://aeroflex-project.eu