BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

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FE 82.0728/2019 „DEVELOPMENT OF TEST FOR TOXICITY ASSESSMENT OF BUS INTERIOR MATERIALS“

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7.5 Technical Properties of Polymer Materials

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Fire causes and scenarios

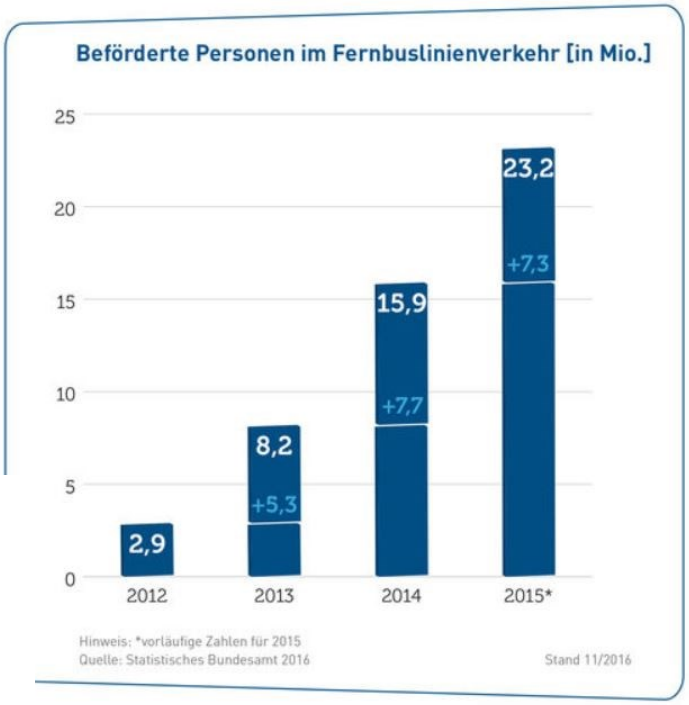
- Often fire start in the engine compartment
- Engine fire detection and suppression is an effective way to suppress these fires and to give passengers more time to escape

- Fires in hidden areas are very hazardous
- Smoke detectors in hidden areas alert the driver

- Smoke is hazardous and can passengers prevent from escaping
- Fires after collisions are very hazardous for passengers

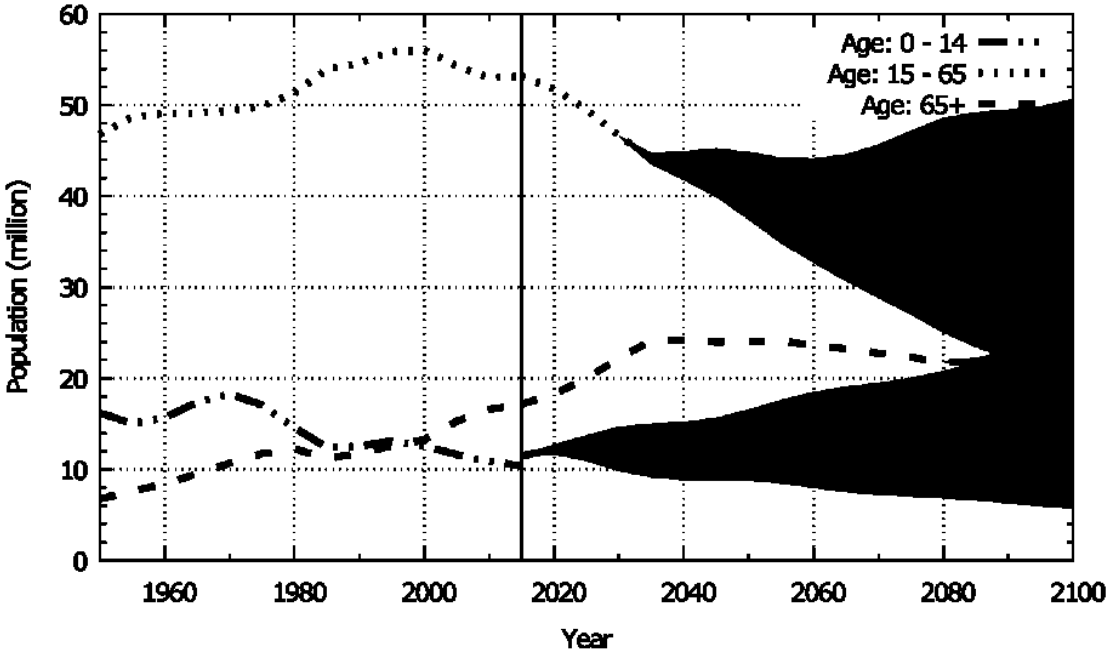
Challenges for bus fire safety

Increasing number of passengers:



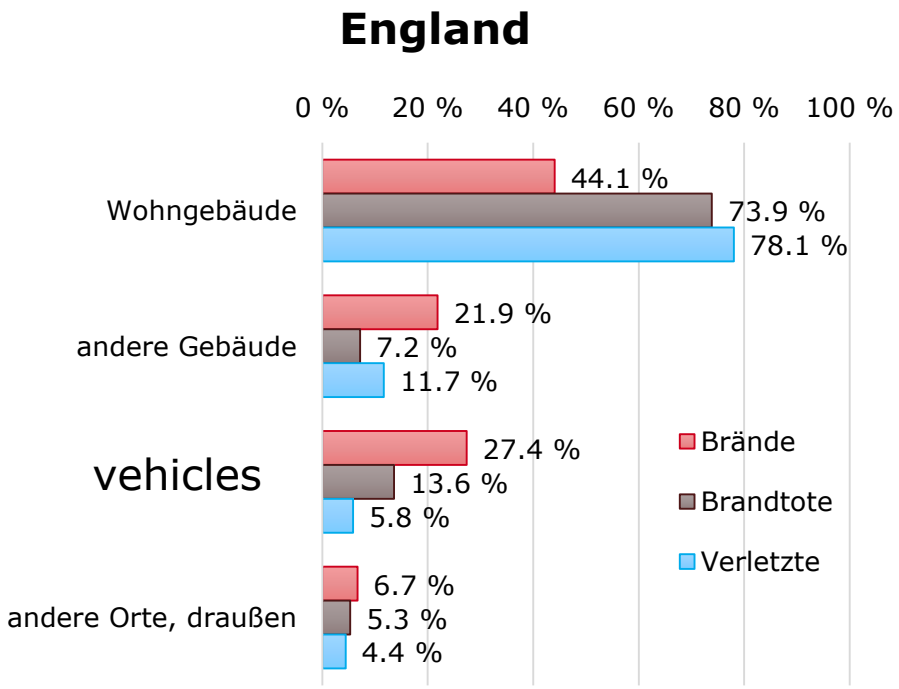
http://www.bdo.org/themen-und-positionen/fernbus/fernbuslinienverkehr-in-zahlen

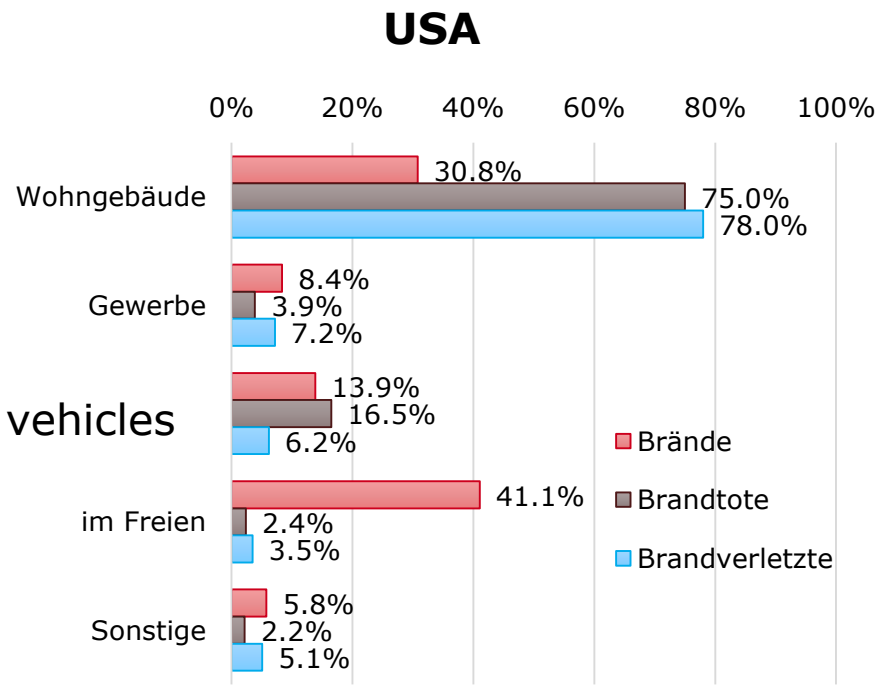
Passengers with handicap:
ageing population, inclusion



Development of population, Germany, until 2100

Fire statistics
fires, fatalities, and injured persons





Quellen: FIRE STATISTICS TABLE 0502a: Fatalities by fire and rescue authority and location group, England; Fire loss in the United States (2005-2014), Table Fires by Gen Property Type 2014

Bus fire safety

Regulations	Provisions
UN-R 36	Uniform provisions concerning the approval of large passenger vehicles with regard to their **general construction** (incl. fire extinguisher, fuel container and fuel feed pipe)
UN R-67	Uniform provisions concerning the approval of: I. Specific equipment of vehicles of category M and N using liquefied petroleum gases in their propulsion system II. Vehicles of category M and N fitted with specific equipment for the use of liquefied petroleum gases in their propulsion system with regard to the installation of such equipment
UN-R 107	Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their **general construction** (incl. fire extinguisher, engine compartment and allowed materials in the engine compartment, heat sources, electricity)
UN-R 110	Uniform provisions concerning the approval of: I. Specific components of motor vehicles using compressed natural gas (CNG) in their propulsion system; II. Vehicles with regard to the installation of specific components of an approved type for the use of compressed natural gas (CNG) in their propulsion system
UN-R 118	Uniform technical prescriptions concerning the **burning behaviour of materials** used in the interior construction of certain categories of motor vehicles
95/28/EG	Uniform provisions concerning the burning behaviour of materials used in the interior construction of certain categories of motor vehicle

Transport sector – interior materials

	Automotive	Train	Ship	Aircraft
Guidelines	95/28/EG	96/48/EG	SOLAS Chapter 11-2	FAR 25
Standards	FMVSS 302 DIN 75200	DIN EN 45545-2	Fire Test Procedure Code	FAR 25 + Appendix
Bunsen burner	yes	yes	yes	yes
Cone calorimeter	-	yes	yes	yes
Smoke density chamber	-	yes	yes	yes
Radiant panel test (floorings)	-	yes	yes	yes
Seats	-	yes	yes	yes

Recent amendments of bus fire safety regulations

Amendments of bus fire safety regulations		
Within the work of UNECE		
Topic [Provision]	Status [Scheduling]	Part of the equipment starting: new approval/ registration
Engine compartment with fire detector [ECE-R 107]	adopted [WP.29 March 2010]	31.12.2012 / 31.12.2013
Fire behaviour of bus interior (electr. cable, capability of insulation materials to repel fuel) [ECE-R 118]	adopted [WP.29 March 2010]	09.12.2012 / 09.12.2015
Fire and/or smoke detector in enclosed compartments (except luggage compartment) [ECE-R 107]	adopted [WP.29 Nov. 2011]	26.7.2014 / 26.7.2015
Fire behaviour of bus interior (fire tests in installation position, material tested according to ISO 5658-2 allowed without further testing) [ECE-R 118]	adopted [WP.29 Nov. 2011]	26.7.2016 (components) and 26.7.2016 (complete vehicle)/ 26.7.2017
Fire suppression system in engine compartment [ECE-R 107]	adopted [WP. 11 Jul. 2016]	18.06.2018 / 18.06.2019

Bus interior components

Identified so far:

- **Seats**
- **Ceiling**
- **Walls (cladding)**
- **Dashboard / instrument panels**
- **Moulded parts**

- **Plastic tank**

Bus interior materials

- **Polyurethane (PU)**
- **Polyester (PES)**
- **Polyethylene (PE)**
- **Acrylnitril-Butadien-Styrol (ABS)**
- **Polyvinylchloride (PVC)**
- **Wood materials**
- **Polyamid (PA)**
- **Leather / artificial leather**

Glassfibre reinforced plastic:

- **Acrylnitril-Butadien-Styrol (ABS)**
- **Polypropylen (PP)**
- **Polyester resin**

Smoke gas components

Identified so far:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Hydrogen cyanide (HCN)
- Hydrogenchloride (HCl)
- Formaldehyde
- Benzene
- Nitrogene oxides (NO_x)

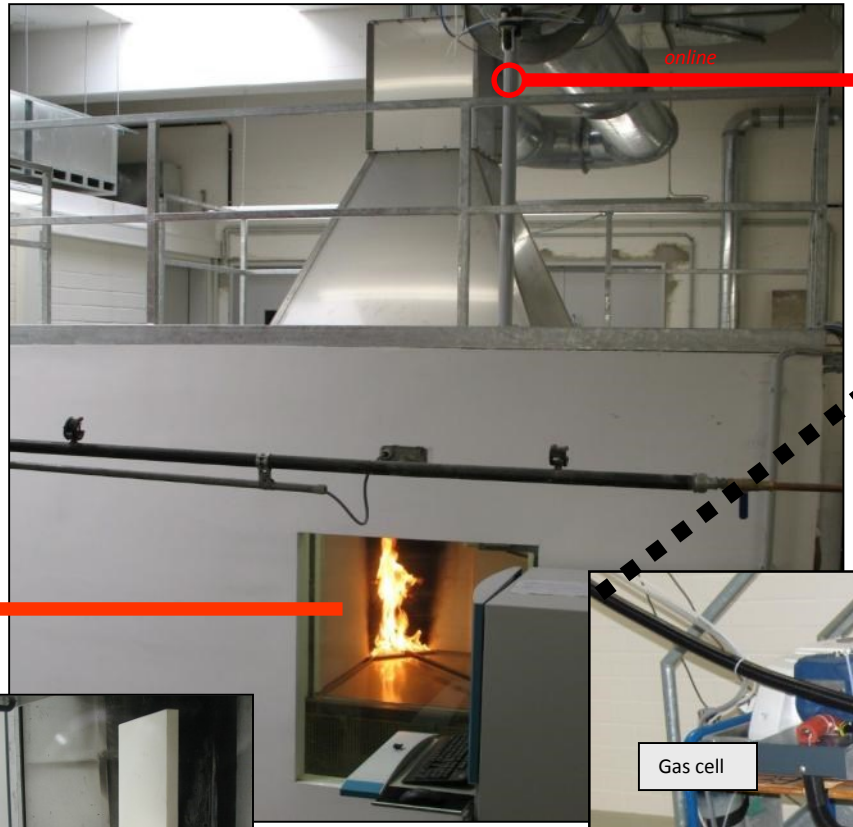
Toxicity test

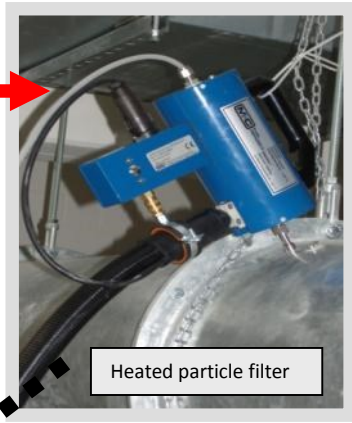
- Measurements of gas components: FTIR (Fourier Transformed Infrared) spectroscopy
- Smoke is not only depending on the material but highly dependent on combustion conditions – temperatures / heat / ventilation / vitiation
- Variation and control of combustion conditions
- Fire load – proper value: mass loss

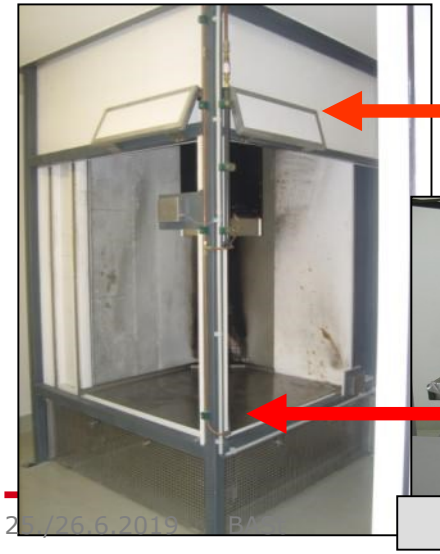
Calorimeter tests: seats

Measured parameters:

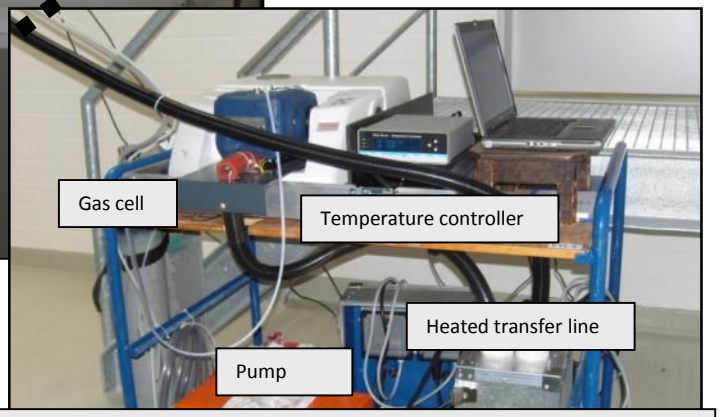
- CO_2 running
- Heat release rate
- Mass loss
- Smoke gas temperatures
- Oxygen consumption
- Light extinction
- Smoke gas components







Weighing system



FTIR spectrometer

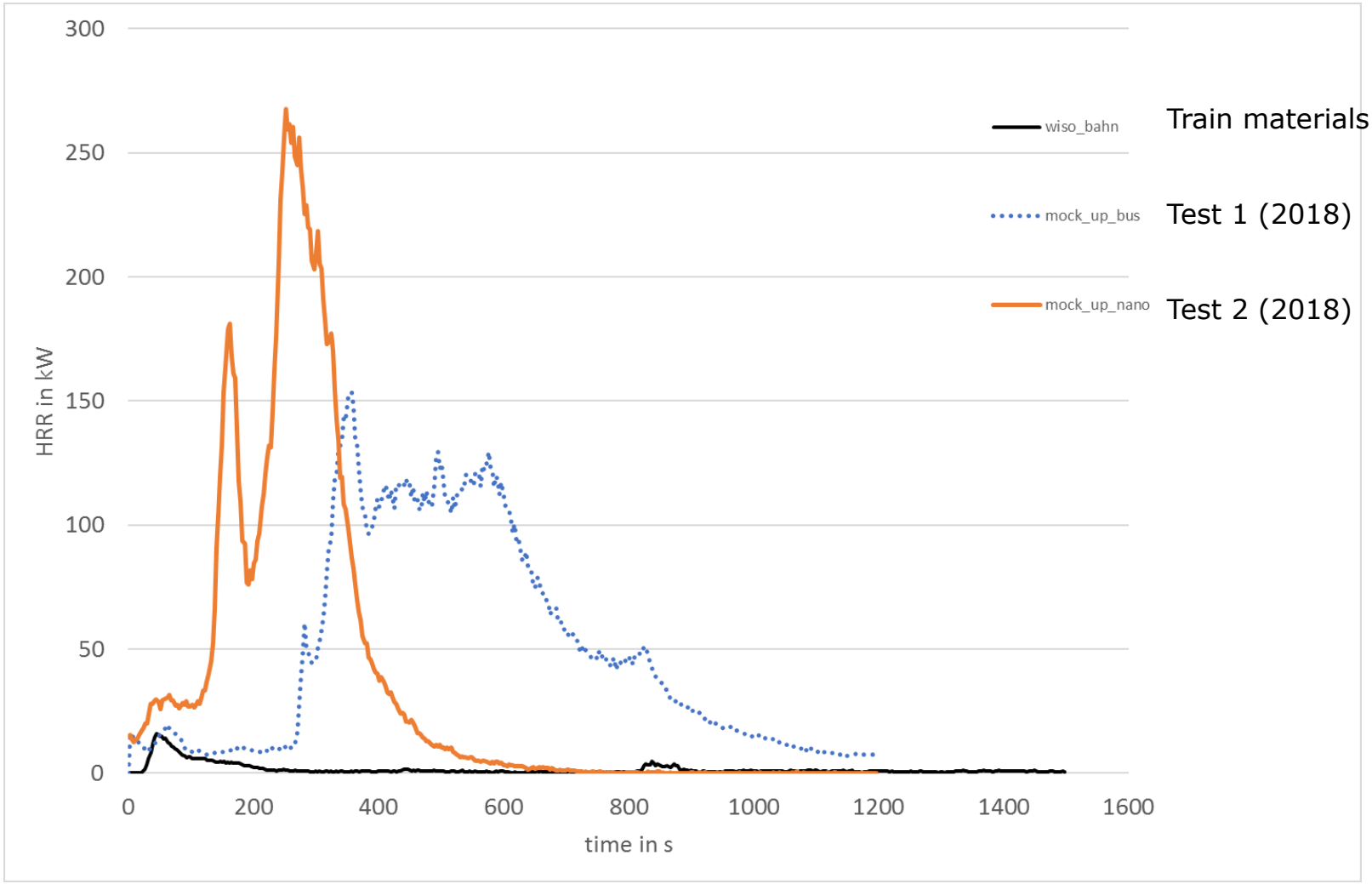
Bus seat mock-up tests

Materials according to amended regulations:

Test 1: All textiles and foams of the mock-up pass the vertical test

Test 2: Vertical mounted foam and textile pass vertical test (back of the seat) – horizontal mounted foam and textile passes the horizontal test

Heat release rate

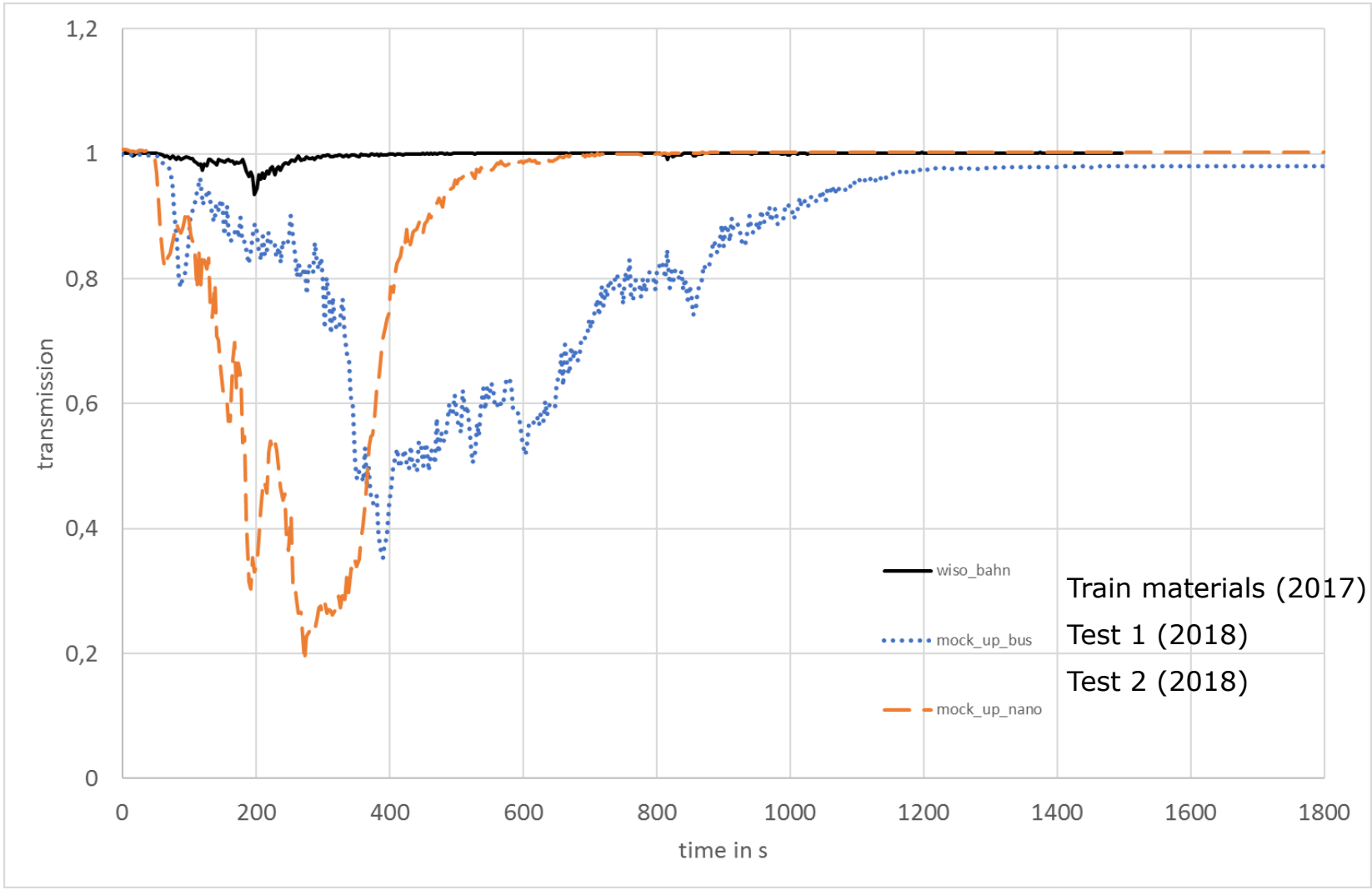


Train materials (2017)

Test 1 (2018)

Test 2 (2018)

Transmission



Thank you for your attention!