On-board monitoring of emissions under the Euro 7 standard

Euro 7 implementing rules

On-Board Diagnostics Symposium-Europe. *Amsterdam, 12 February 2024*

Introduction

Euro 7 provisional agreement reached 18 December 2023

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Council of the EU Press release 18 December 2023 19:12

Euro 7: Council and Parliament strike provisional deal on emissions limits for road vehicles

This press release was modified on 5 January 2024 to add the final text of the agreement.

Today the Council and the European Parliament reached a provisional agreement on a regulation for the type-approval of **motor vehicles** and **engines**, and of the **systems, components** and **separate technical units** intended for such vehicles, with respect to their emissions and battery durability, better known as Euro 7. The new regulation sets more adequate rules for vehicle emissions and aims to further lower air pollutant emissions from road transport, and for the first time it covers cars, vans, and heavy-duty vehicles in one single legal act.

The provisional agreement reached today will retain the Euro 6 emissions limits for cars and vans but **reduce the limits for buses and lorries**. It also introduces limits for particles emitted by brakes (in electric vehicles in particular) and lifetime requirements.

With Euro 7 we aim to reduce road vehicle emissions, not only from exhaust, but also from brakes or tyres. At the same time, we aim to help our industry make the big leap to near-zero emissions vehicles by 2035.

— Jordi Hereu i Boher, Spanish minister for industry and tourism

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Press room / Euro 7: Deal on new EU rules to reduce road transport emissions

Euro 7: Deal on new EU rules to reduce road transport emissions

Press Releases ENVI 18-12-2023 - 17:36

- Road vehicles to stay cleaner for longer, to improve air quality
- Lower exhaust emissions limits for buses and trucks
- New measures to limit particle emissions from tyres and brakes and to increase battery durability

On Monday, Parliament and Council reached a provisional agreement on new rules to reduce road transport emissions for passenger cars, vans, buses, trucks and trailers.

***Next steps*:**

- Legal-linguistic checks (done)
- Formal adoption by both institutions
- Official Journal publication and entry into force

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Policy context

- A political agreement was reached by the EU co-legislators (European Parliament and Council) in December 2023.
- In the agreement, on-board monitoring of emissions (OBM) is retained as one of the novel elements of the Euro 7 standard. The methods for measuring exhaust pollutants and evaporative emissions shall reflect those of Euro 6e for M_1, N_1.
- The political agreement is compatible with the ‘OBM concept’ as it has been presented so far.

Timeline: entry into application & implementation

- (**LDV – M_1,N_1**) 30 months after Euro 7 entry into force for new types and 42 months after Euro 7 entry into force for all types
- (**HDV – M_2,M_3,N_2, N_3,O_3,O_4**) 48 months after Euro 7 entry into force for new types and 60 months after Euro 7 entry into force for all types

- *(**Implementing acts – M_1,N_1**) – Adoption date maximum 12 months after Euro 7 entry into force*
- *(**Implementing acts – M_2,M_3,N_2, N_3**) – Adoption date maximum 30 months after Euro 7 entry into force*

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Proposed approach
Example of LDV implementing acts

- For **LDVs and HDVs respectively**: 13 'building blocks' identified *incl.* forms, administrative requirements and reporting obligations

- ***Implementing acts for LDVs/HDVs***:

  ① **Exhaust emissions**; ②**non exhaust emissions** (tyre abrasion & brakes); ③**OBM, OBD, EVP and data**; ④**options & designations**; ⑤**battery durability**; ⑥**CO_2 for LDV and HDV; ⑦ replacement control systems & parts/components**

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OBM in the Euro 7 political agreement

Recital 16:

Sensors installed on vehicles are already used today to detect anomalies on emissions and trigger related repairs through the on-board diagnostic (OBD) system. The OBD system currently in use, however, does not detect accurately or timely the malfunctions and neither does it sufficiently and timely urge repairs. As a result, it is possible that vehicles emit much more than they are allowed to do. The sensors used up to now for OBD can also be used to monitor and control the exhaust emission behaviour of the vehicles on a continuous basis via an on-board monitoring (OBM) system. The OBM will also warn the user to perform repairs of the engine or the pollution control systems when these are needed. It is therefore appropriate to require that such a system is installed and to regulate its technical requirements. ***The inducement of measures implied by those systems should not lead to endangering of road safety.***

OBM in the Euro 7 political agreement

Article 3 (38) [Definition of OBM]

‘on-board monitoring system’ or ‘OBM’ means a system on board a vehicle that is capable of monitoring exhaust emissions, detecting exhaust emission exceedances and ***capable of communicating that information together with the State of Health information off-board***;

OBM in the Euro 7 political agreement

Article 6 (6) The OBM systems installed by the manufacturer in these vehicles shall be capable of:

(a) monitoring and registering all exhaust emissions of NOx, NH_3 and PM and detecting exceedances of 2.5 times the exhaust emission limit or higher ***in case exhaust emission limit values for the testing of NOx, NH_3 and PM exist in Annex I***;

(b) communicating the data of the exhaust emission behaviour and battery durability data of the vehicle via the OBD port , including for the purpose of roadworthiness tests and technical roadside inspections and ***anonymously over the air for the purpose of monitoring compliance of vehicle types***;

(c) triggering the driver warning system when exhaust emissions are significantly exceeded, **using harmonised methods to induce timely repairs**, ***without preventing vehicles from completing an ongoing trip to avoid road safety issues***.

Scope of OBM (some changes)

- Pollutants covered by Euro 7 OBM: exhaust emissions of NOx, NH_3 and PM (for heavy-duty vehicles) and **NOx and PM (for light-duty vehicles – no limit values for NH_3 exist)**
- **Small Volume Manufacturers of M1 and N1 vehicles are exempted** (Article 8)

Implementation of OBM

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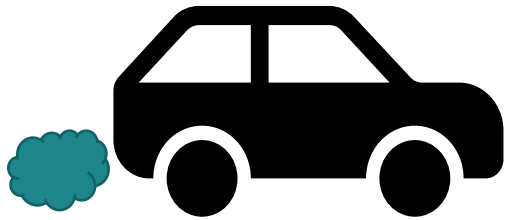
OBM monitoring – basic principles (1/3)

- Emissions to be monitored **throughout the lifetime of the vehicles** (even beyond durability thresholds)
- OBM to provide a '**faithful representation of emissions**'
  - Time-resolved signals to be available from OBD port (~1Hz for NOx and NH_3, with 'data flags' and other supporting signals)
  - OBM monitoring for the whole trip. It needs to cover also cold start
  - No limitations on the use of modelling
  - Trip values to be stored for the last [10] trips – both 'unprocessed' and 'RDE-processed' emissions, and summary of metadata.
- Key monitoring value is the OBM emissions per trip

OBM monitoring – basic principles (2/3)

During each trip:



From OBD port (no storage)

Available signals (1 Hz) :

Emissions for NOx and NH_3 [mg/s and ppm] ,velocity [m/s], exhaust mass flow [g/s]

Data ‘flags’ (vector of binary values): modelled data, extended conditions, regeneration…

Time [s]	1	2	3	4
NOx [mg/s]	7,2	8,7	9,4	9,7
NH3 [mg/s]	0	0	0,1	0,3
Velocity [m/s]	0	2,1	2,5	0,3
Flag 1: modelled data	1	1	1	0
Flag 2: extended conditions	0	0	0	0
Flag n: […]	0	0	0	0

PM is a special case

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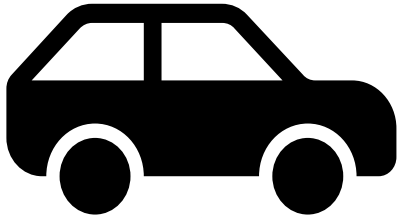
OBM monitoring – basic principles (3/3)

After each trip:



Calculated and stored in-vehicle

[g/km] emissions for the trip (unprocessed – 1 value per pollutant)

[g/km] emissions for the trip (RDE processed using flags – 1 value per pollutant)

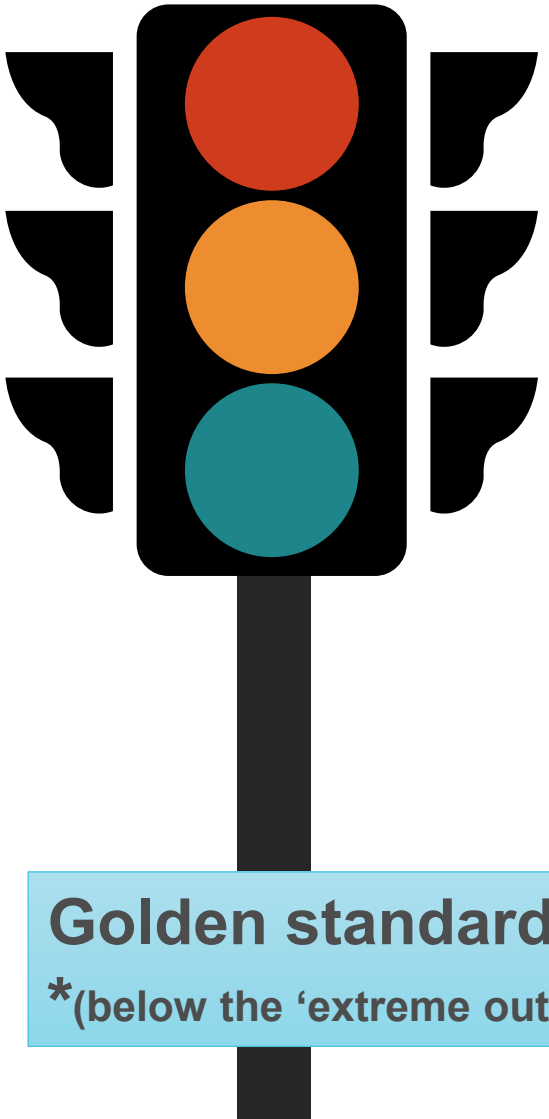
‘Flag’ metadata for trip (% of distance in each condition for trip)

Other supporting data (trip distance, odometer reading)

PM is a special case

Vehicle stores data for the last [10] trips, updates values for last [1,000] kilometres, and lifetime

Excess exhaust emissions driver warning system (EEEDWS)



The EEEDWS status is **always accessible** from the OBD port. It may be updated at the end of each trip.

EEEDWS status data for lifetime, last [1,000] km and last [10] trips are part of OBM data which are stored in the vehicle and periodically transmitted from it, so it is verifiable

The determination of the EEEDWS status is **entirely in the hands of the manufacturer** (it can be determined in-vehicle or externally, based on a combination of measurements and modelling, *etc.*)

EEEDWS status is set separately for each monitored pollutant. The worst EEEDWS status of all **monitored pollutant** dictates overall status for the purposes of driver warnings and inducement

Golden standard: 'is the vehicle fit to pass an RDE ISC test?'*

***(below the 'extreme outlier' threshold of x2.5)**

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OBM as a compliance tool (overview)

Part 1

RDE tests for single vehicles

RDE results per trip

Result feeds ISC statistical procedure for emissions

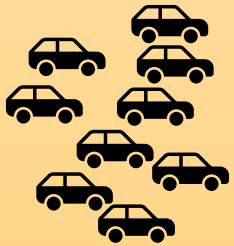
Result feeds ISC statistical procedure for OBM

OBM results for trip
OBM EEEDWS status

ISC
(as Euro 6)

OBM identifies potential high emitters and induces repairs

Part 2



OBM results for many trips are anonymously collected from many vehicles of the same type

Distribution of OBM trip results

Evaluation of emissions conformity for the vehicle type

Trip metadata supports market surveillance

OBM trip metadata

ISC/MaSu
(Euro 7)

OBM enables a statistical evaluation of emissions conformity and supports MaSu

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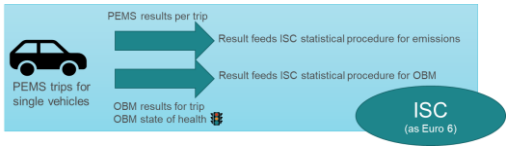
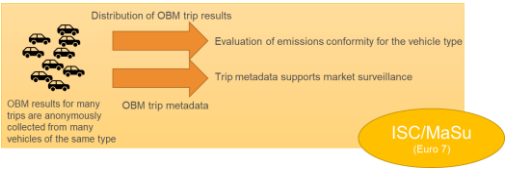


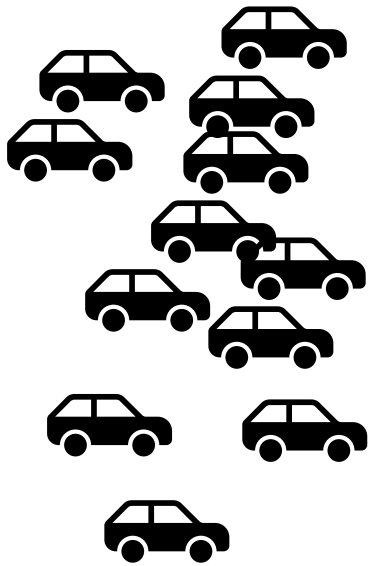
OBM at vehicle level: summary

OBM at vehicle level: ensures that single vehicles are not high emitters, and that emissions are monitored with reasonable accuracy

- This can be verified over an RDE ISC trip (emissions need to be below a 2.5x multiplier, and OBM emissions reported must not substantially underreport RDE emissions).
- EEEDWS status from OBM determines eligibility for ISC testing.
- EEEDWS status is determined by the vehicle (for each pollutant) based on an evaluation of OBM, OBD and other data. The manufacturer has full control of this.
- Time-resolved emission signals are made available from OBD port (not stored).
- OBM trip results are stored in the vehicle, but they are not used to determine emissions compliance for the single vehicle.

OBM at vehicle type level: summary





OBM at vehicle type level: ensures that emissions for the type are well controlled on a reliable statistical basis

- Individual vehicles store the last [10] 'unprocessed' trip results, 'RDE-processed' trip results, and trip metadata
- MaSu authorities can check the emissions compliance of the type based on the distribution of 'RDE-processed' trips [see possible variant]
- MaSu authorities can also use metadata to gain insights into real-world emissions performance, OBM performance
- Individual vehicles are not identifiable – individual compliance for emissions is not checked
- OBM compliance for the type cannot be established from OBM data for the type (only emissions!)
- Emissions compliance for all vehicles and trips not expected (some vehicles will report OBM emissions above the limits)

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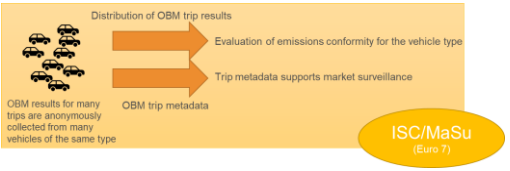
OBM at vehicle type level



RDE-processed trips

Unprocessed trips

Emissions conformity for the type is evaluated statistically, **on an annual basis**, using the distribution of **RDE-processed trips**

OBM trip values above emission limit are to be expected (especially unprocessed trips); they have no consequences for single vehicles

OBM / emission limit = 1

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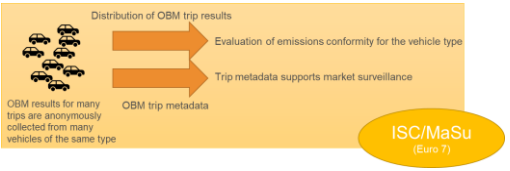
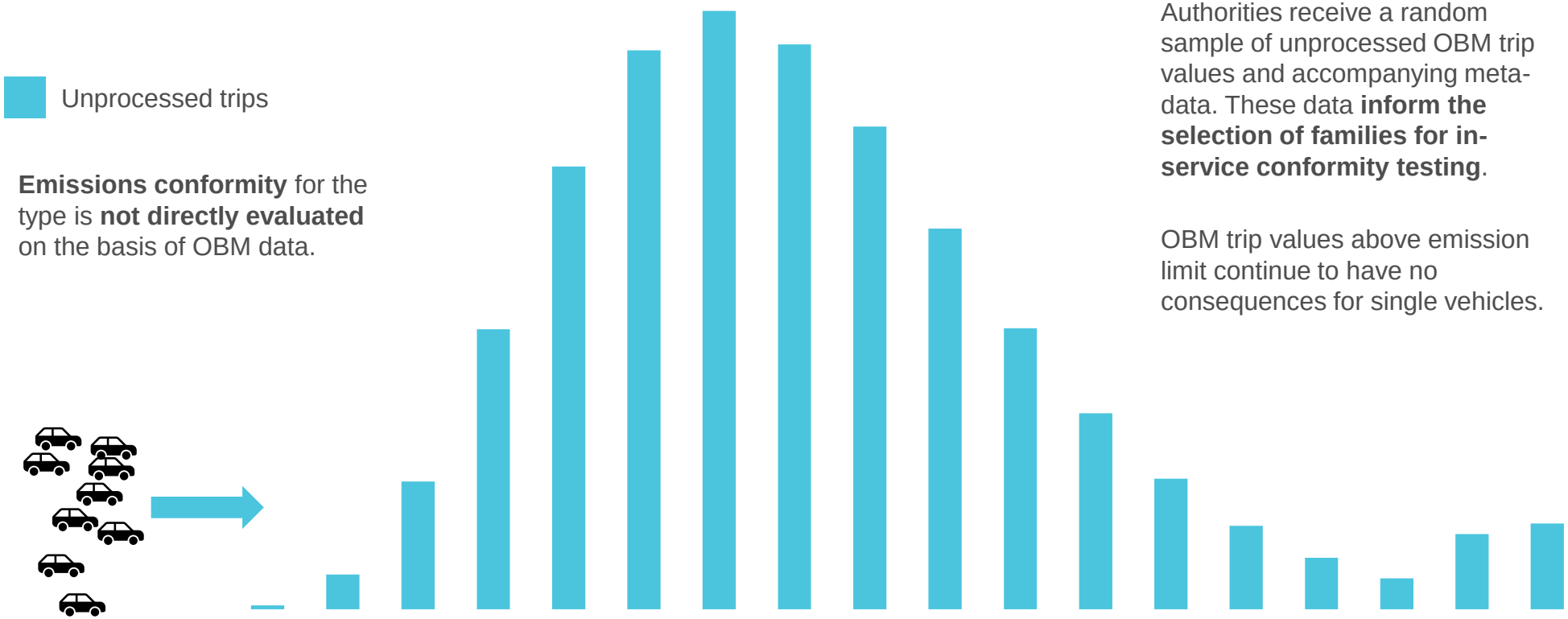


OBM at vehicle type level

Possible variant

Unprocessed trips

Emissions conformity for the type is **not directly evaluated** on the basis of OBM data.



Authorities receive a random sample of unprocessed OBM trip values and accompanying meta-data. These data **inform the selection of families for in-service conformity testing**.

OBM trip values above emission limit continue to have no consequences for single vehicles.

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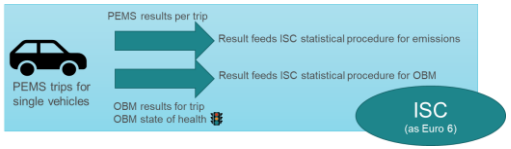

OBM testing requirements

- **At type approval: declaration and demonstration**. No need to detail *e.g.*, cold-start model or methods for detection of extended driving conditions. Demonstration that vehicle is equipped with OBM with required functions and accuracy
- **In-service conformity (ISC): required**. On-road test to verify that OBM emissions are ‘faithful representation of emissions’, and that large emission exceedances are being prevented

OBM data storage and transmission

In-vehicle data storage and transmission from vehicle to authorities

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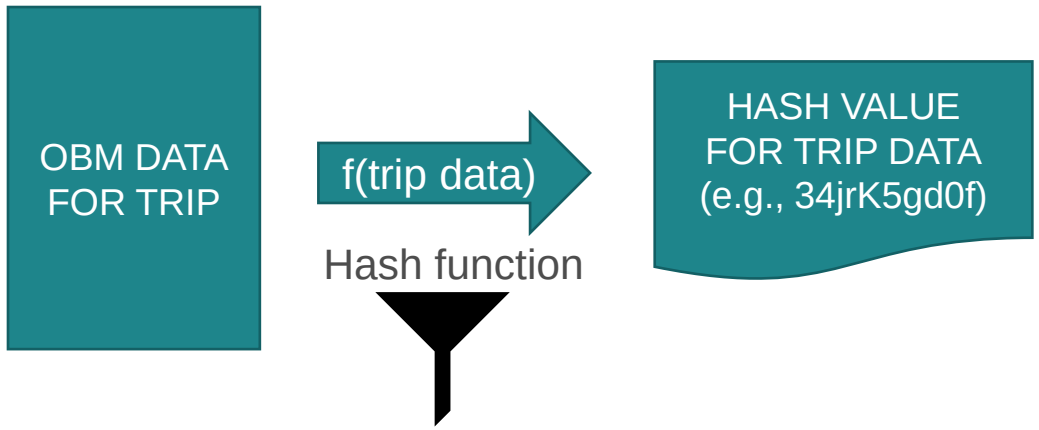
OBM data – basic principles

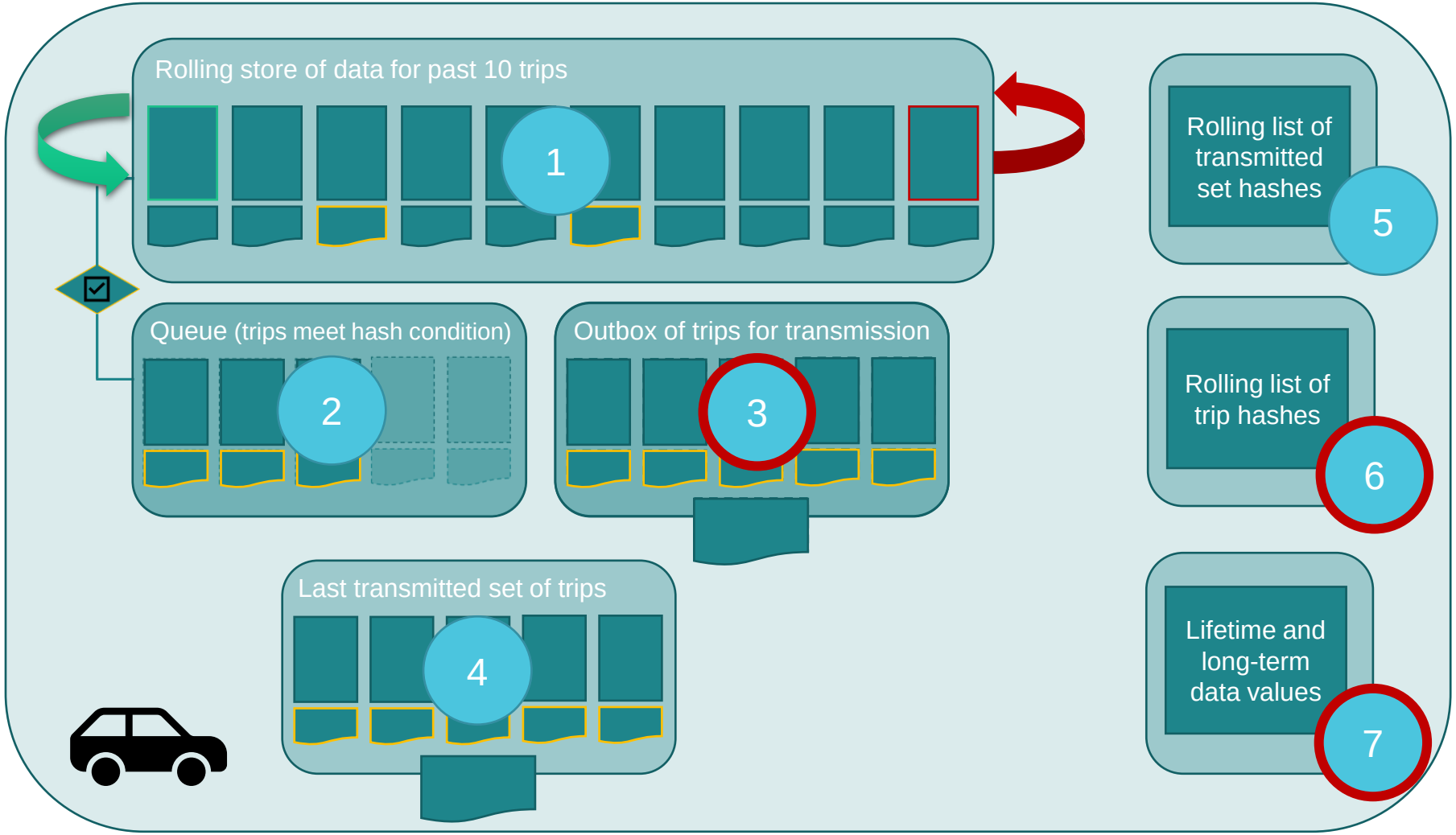
- OBM data are stored in-vehicle and periodically transmitted outside (also readable from OBD-II port)
- Trip data (used for compliance assessment and supporting market surveillance) are randomly selected for transmission
- All vehicles need to transmit data and follow the same rules; amount of data effectively transmitted depends on vehicle circumstances but it should be kept generally low
- Data privacy rules are respected (data transmitted ‘anonymously over the air’)
- OBM data transmitted to outside has no consequences for individual vehicle compliance (this is ensured by the inducement, which is managed in-vehicle - threshold of 2.5x)
- Data integrity is ensured ‘from vehicle to authority’

Random selection of OBM trips

A **hash function** can be used to map data of arbitrary size to fixed-size values (*e.g.,* a string of n alphanumerical characters). Even small differences in input lead to big differences in the outputs (hash values), but the same input always generates the same output.



Data transmission to OEM server



Available from OBD port

Transmitted to authorities OTA

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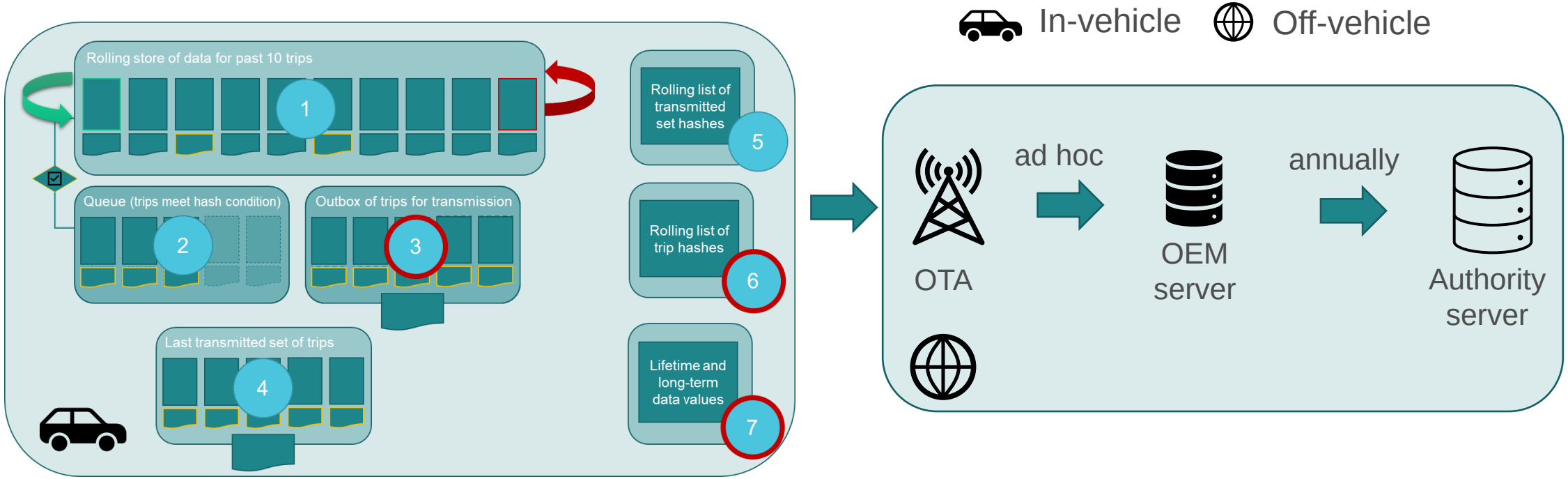
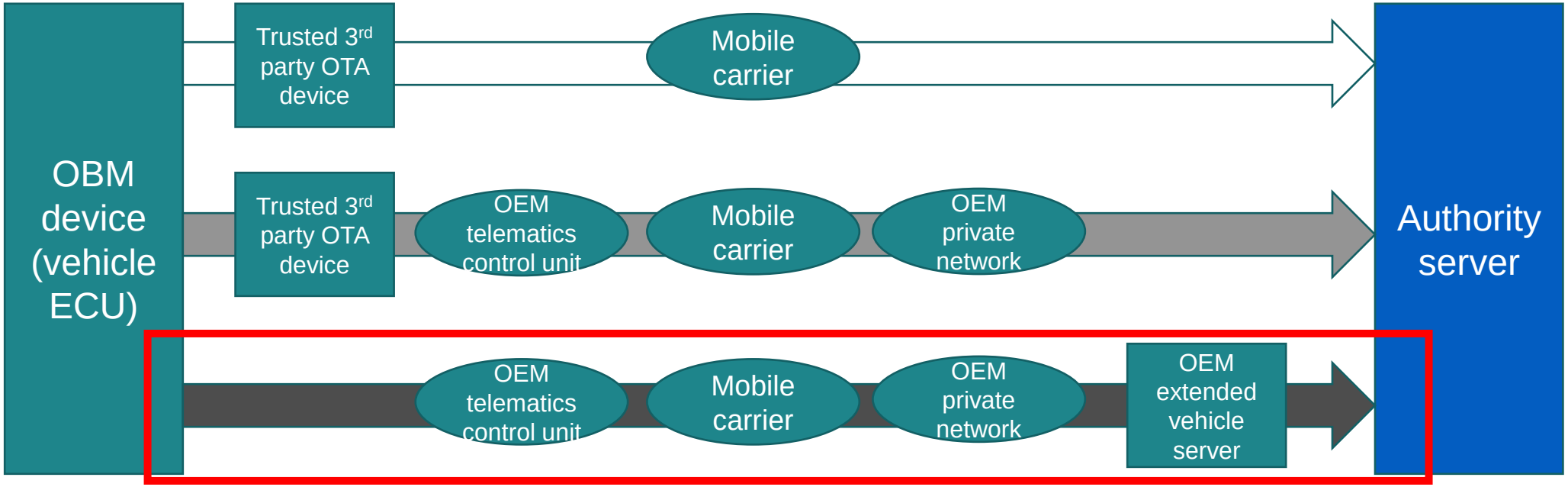
Access to data



- **ISC and MaSu authorities**: at end of year, compilation of all OBM in-vehicle data (sets 1 to 7) for all vehicles, transmitted from OEM servers to Authority server (in addition to data collected independently from OEMs).

OBM data – data pathways



The preferred data pathway for first implementation of OBM is the ‘black box’. This has some advantages (no need for additional encryption hardware in vehicles, data security and privacy issues handled autonomously by each OEM). A key disadvantage is that the integrity of data from vehicle to authorities is entirely the hands of the OEM.

A note on off-board data communication

	Definition in Art. 3	Other Articles
OBD	Capable of off-board [Art. 3(37)]	*Methods, requirements and tests to ensure performance and off-board* communication of data recorded [Art.14(4)j)]
OBM	Capable of off-board [Art. 3(38)]	Exhaust emission behaviour and battery durability data ***via OBD port and anonymously OTA*** [Art. 6(6)b)] *Methods, requirements and tests to ensure performance and off-board* communication of data recorded [Art.14(4)j)]
OBFCM	/	Capable of communicating all legally required relevant vehicle data they record, ***via OBD port and OTA*** [Art. 6(7)] *Methods, requirements and tests to ensure performance and off-board* communication of data recorded [Art.14(4)j)]
EVP	/	'From on- to off-board' [Art. 7(4)] Off-board communication methods [Art.14(4)u)]

OBM – focus on HDV issues

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OBM – differences between HDV and LDV

- OBM implementation timeline follows the same calendar as exhaust elements of Euro 7, with different schedules for LDV and HDV
  - For adoption of implementing acts: 12 months after entry into force for LDV, 30 months for HDV
  - For manufacturers (new types/all types): 30/42 months after entry into force for LDV; 48/60 months for HDV
- OBM rules in Euro 7 political agreement are common for LDV and HDV except
  - NH_3 in scope for HDV, for not for LDV
  - No small volume manufacturer exemption from OBM for HDV (only LDV)

OBM – differences between HDV and LDV

- The development of the ‘OBM concept’ started by started by LDV due to the tighter schedule. The HDV implementation of OBM should build upon the same ‘OBM concept’
  - Inducement managed at vehicle level based on the ‘2.5x threshold’, with link to ISC RDE procedure via the EEEDWS (traffic light) status
  - Time-resolved signals to be made available from OBD-II port
  - Data for randomly selected trips (using hash function) periodically transmitted off board using OEM infrastructure

OBM – differences between HDV and LDV

- The implementation work of OBM for HDV should account for / investigate differences between HDV and LDV categories related to:
  - RDE data evaluation methods (different calculation)
  - Number of vehicles in a family (statistical thresholds)
  - Driving / use patterns (definition of trips)
  - Vehicle characteristics (*e.g.*, effect of increased flow on uncertainty)
  - Existing inducement methods
  - Others (engines as separate technical units?)

Key messages

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Key messages – Timeline

- Entry into force of the basic Euro 7 regulation (EIF date) expected in a matter of a few months
- Euro 7 OBM implementing acts for LDV/HDV must be ready 12/30 months after EIF
- New vehicle types for LDV/HDV must comply with Euro 7 30/40 months after EIF

Key messages – Political agreement

- The requirements in the Euro 7 Regulation as set by co-legislators largely follow the Commission's proposal, with some amendments:
  - New scope: NH_3 is excluded from the scope of OBM for M_1, N_1 vehicles
  - Small volume manufacturers are exempted from OBM
  - Ensure road safety
  - 2.5x threshold
  - 'monitoring and registering all exhaust emissions'

Key messages – Implementing work

- The ‘OBM concept’ as developed so far is compatible with Euro 7 political agreement:
  - Ensure road safety by building upon existing inducements
  - 2.5x threshold and ‘golden rule’ link ISC testing and the driver inducement
  - Each vehicle will monitor emissions from all trips (no limitations to modelling)
  - Random selection of trips (using standard hash function) sent anonymously OTA
- Concept will need to be adapted to reflect realities of HDV

Thank you! Dankjewel!

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