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Consortium partners



Document information

Additional contributing partners

| Authors | Organisation |
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| René van Gijlswijk | TNO |

Changes and distribution

| Version | Date | Change | Distribution |
|---------|----------|-------------|-------------------|
| V0.1 | 31/10/19 | Draft final | Graz participants |
| V1.0 | 25/11/19 | Final | EC |

Verification and approval

| Check by | Name | Date |
|-------------|-------------------|------|
| WP leader | Norbert Ligterink | |
| Coordinator | Paul Tilanus | |

Executive Summary

The technology and vehicle taxonomy serves two purposes. First, controlled vocabularies are developed that will be used to describe passenger cars in the European market. Harmonizing the vocabulary across multiple EU-funded projects facilitates integrating datasets within the uCARE project and allows uCARE data to be combined with results from other projects. Second, vehicle groups are defined in order to pool measurements of individual vehicles into vehicle groups with similar emission characteristics.

Purpose and structure of the document

Purpose

This document describes the controlled vocabulary and vehicle grouping developed as part of the technology and vehicle taxonomy.

Structure

- Introduction
- Vehicle taxonomy
- Vehicle grouping
- Conclusion

Deviations from the original DoW

Description in the DoW

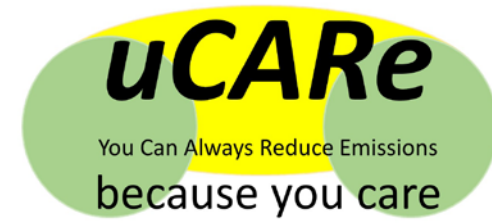
This deliverable is the result of Task 1.1. This taxonomy will be used in the tools to provide information to individual car owners, once the car's place in the taxonomy is determined.

Time deviations from original DoW

A shared taxonomy for multiple projects was deemed to be more useful than a taxonomy per project. The harmonisation of a taxonomy over multiple projects would require 3 more months, and it was agreed with the PO that this would be time well-spent.

Content deviations from original DoW

Though the taxonomy was harmonised with CARES, TRUE initiative and MILE21, the purpose as described in the DoW for uCARE was not changed.



Introduction

Process, related projects, and benefits

Introduction

Objective: Standardize how we describe passenger cars so that we can join datasets across different EU projects.

Process:

1. Define key variables that describe vehicle market structures and/or affect emissions performance.
2. Define domains—the set or range of values that each variable may take on.
3. Describe passenger cars sold in the EU in terms of key variables.
4. Apply resulting taxonomy to a variety of EU projects.

Related projects

- [TRUE Initiative](#): aims to independently monitor and report real-world vehicle emissions in cities
- [MILE21](#): LIFE project that helps consumers choose fuel-efficient cars
- [CARES](#): Horizon 2020 project that provides regional and national authorities tools to monitor and detect emissions from road vehicles

Definitions of vehicle groups in various projects



MILE21
battery capacity
drive type

uCARE vehicle family
transmission type

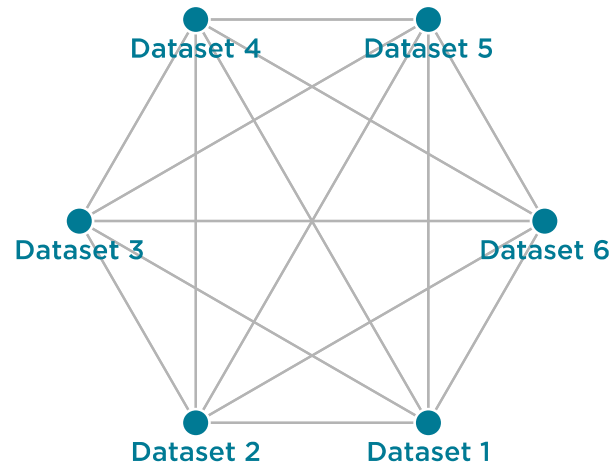
EEA CO₂ monitoring data
make
model

uCARE engine family
engine power

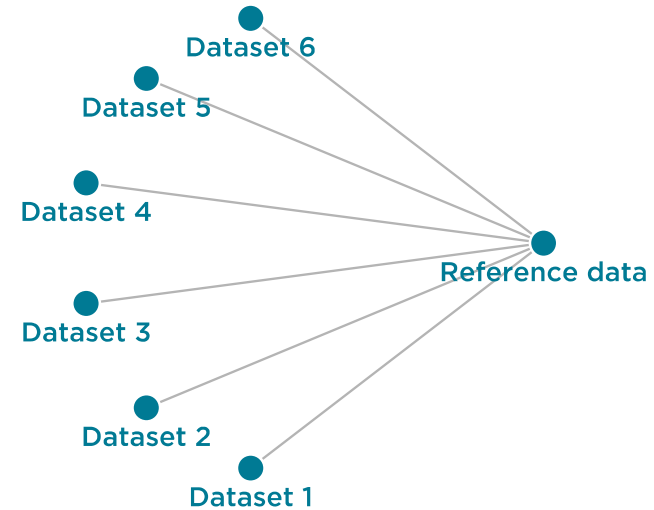
TRUE Initiative
manufacturer
powertrain/fuel type
emission standard
engine displacement

Benefits of a shared taxonomy

Worst case: $\frac{N(N-1)}{2}$



With reference data: N



Vehicle taxonomy

Controlled vocabulary for describing vehicles

Variables and domains to define

| Variable | Definition | Type | Domain | Unit | Source |
|-----------------------|---|---------|--------------------|-----------------|----------------|
| make | Vehicle make as defined by ADAC, without stylization (e.g., "Kia", not "KIA") | varchar | makes | | ADAC |
| model | Defined as model series in ADAC, translated to German and stylization removed | varchar | models | | ADAC |
| manufacturer alliance | Code of the manufacturer alliance, used to group engine families | varchar | alliances | | TNO |
| powertrain type | Powertrain architecture relative to energy storage, energy source, and energy converter | varchar | powertrains | | (EU) 2017/1151 |
| fuel type | Externally supplied energy carrier | varchar | fuels | | |
| emission standard | Emission standard vehicle was type-approved to | varchar | emission_standards | | |
| engine displacement | Engine displacement | integer | positive integer | cm ³ | |
| engine power | Rated power of internal combustion engine | integer | positive integer | kW | |
| transmission type | Trigger of gear change | varchar | transmissions | | |
| AWD capable | Flag if vehicle is capable of 4-wheel drive | boolean | | | |
| battery capacity | Battery capacity of electrified powertrains | numeric | | kWh | |

Domain: Makes

Motivation for inclusion: Essential vehicle characteristic shown to co-determine CO₂ and pollutant emissions. ^[1, 2, 3] Relevant for consumers and regulatory enforcement.

Domain: Abarth, Alfa Romeo, Alpina, Alpine, Aston Martin, Audi, Bentley, BMW, Borgward, Bugatti, Cadillac, Chevrolet, Citroen, Cupra, Dacia, Daihatsu, Dodge, Donkervoort, DS Automobiles, Ego Mobile, Ferrari, Fiat, Ford, Gumpert, Honda, Hyundai, Infiniti, Isuzu, Jaguar, Jeep, Kia, Koenigsegg, KTM, Lada, Lamborghini, Lancia, Land Rover, Lexus, Lotus, Maserati, Maybach, Mazda, McLaren, Mercedes, ...

Domain: Models

Motivation for inclusion: Essential information for consumers.

Domain: 540 unique vehicle models. Illustrative examples include:

- 3-Series (not 320d)
- C-Class (not C200)
- Up (not Up!)

Domain: Powertrain types

Motivation for inclusion: Essential vehicle characteristic shown to affect CO₂ and pollutant emissions.^[1, 2, 3]

Domain:

- ICEV: internal combustion engine vehicles including mild hybrids (vehicles that require combustion engines for propulsion)
- OVC-HEV: off-vehicle charging HEVs (PHEVs, REEVs)
- NOVC-HEV: non-off-vehicle charging HEVs
- OVC-FCHV: off-vehicle charging fuel cell hybrid vehicles
- NOVC-FCHV: non-off-vehicle charging fuel cell hybrid vehicles
- PEV: pure electric vehicle (BEVs)

Domain: Fuel types

Motivation for inclusion: Essential vehicle characteristic shown to affect CO₂ and pollutant emissions. ^[1, 2, 3]

Domain:

- diesel (up to and including 20/80 diesel/biodiesel blends)
- petrol (up to and including 20/80 petrol/ethanol blends)
- electricity
- ethanol (down to 80/20 ethanol/petrol blends)
- CNG
- LPG
- hydrogen
- biodiesel

Domain: Emission standards

Motivation for inclusion: Basis for type approval of pollutant emissions and relevant for regulatory compliance and enforcement. Euro 6d-TEMP and Euro 6d are significantly different from Euro 6a–c in type approval procedure and emissions performance to warrant separate entries.

Domain:

- Euro 0 (no Euro standard; vehicles before 1992)
- Euro 1–6
- Euro 6d-TEMP
- Euro 6d
- Optional: Euro 6a, Euro 6b, Euro 6c

Transmission types

Motivation for inclusion: Shown to affect CO₂ emissions.^[2]

Domain:

- Automatic (includes torque converter, double-clutch, and continuously variable transmissions)
- Manual

Four-wheel drive capable

Motivation for inclusion: Shown to affect CO₂ emissions (source: ongoing MILE21 work).

Domain:

- TRUE
- FALSE

Battery capacity

Motivation for inclusion: Essential characteristic of electrified vehicles. Important determinant of fuel/electricity consumption and electric range.

Domain:

- Positive numeric
- Ranges
 - OVC-HEV: typically 4–27 kWh
 - PEV: typically 14–100 kWh

Examples of vehicles

| make | model | powertrain_type | fuel_type | euro_standard | eng_disp | eng_power | trans_type | awd_capable | battery_cap |
|----------|-------------|-----------------|-----------|---------------|----------|-----------|------------|-------------|-------------|
| VW | Crafter | ICEV | Diesel | Euro 5 | 1968 | 100 | Manual | FALSE | |
| SEAT | Exeo | ICEV | Petrol | Euro 5 | 1798 | 118 | Manual | FALSE | |
| BMW | 3-Series | ICEV | Petrol | Euro 6 | 1997 | 135 | Automatic | TRUE | |
| Mercedes | E-Class | ICEV | Diesel | Euro 6 | 2143 | 150 | Automatic | FALSE | |
| Audi | Q3 | ICEV | Diesel | Euro 6 | 1968 | 110 | Manual | FALSE | |
| Citroen | Spacetourer | ICEV | Diesel | Euro 6 | 1997 | 130 | Automatic | FALSE | |
| Renault | Espace | ICEV | Diesel | Euro 6d-TEMP | 1997 | 147 | Automatic | FALSE | |
| VW | Transporter | ICEV | Diesel | Euro 6d-TEMP | 1968 | 110 | Automatic | FALSE | |

Vehicle grouping

Pooling measurements of similar vehicles

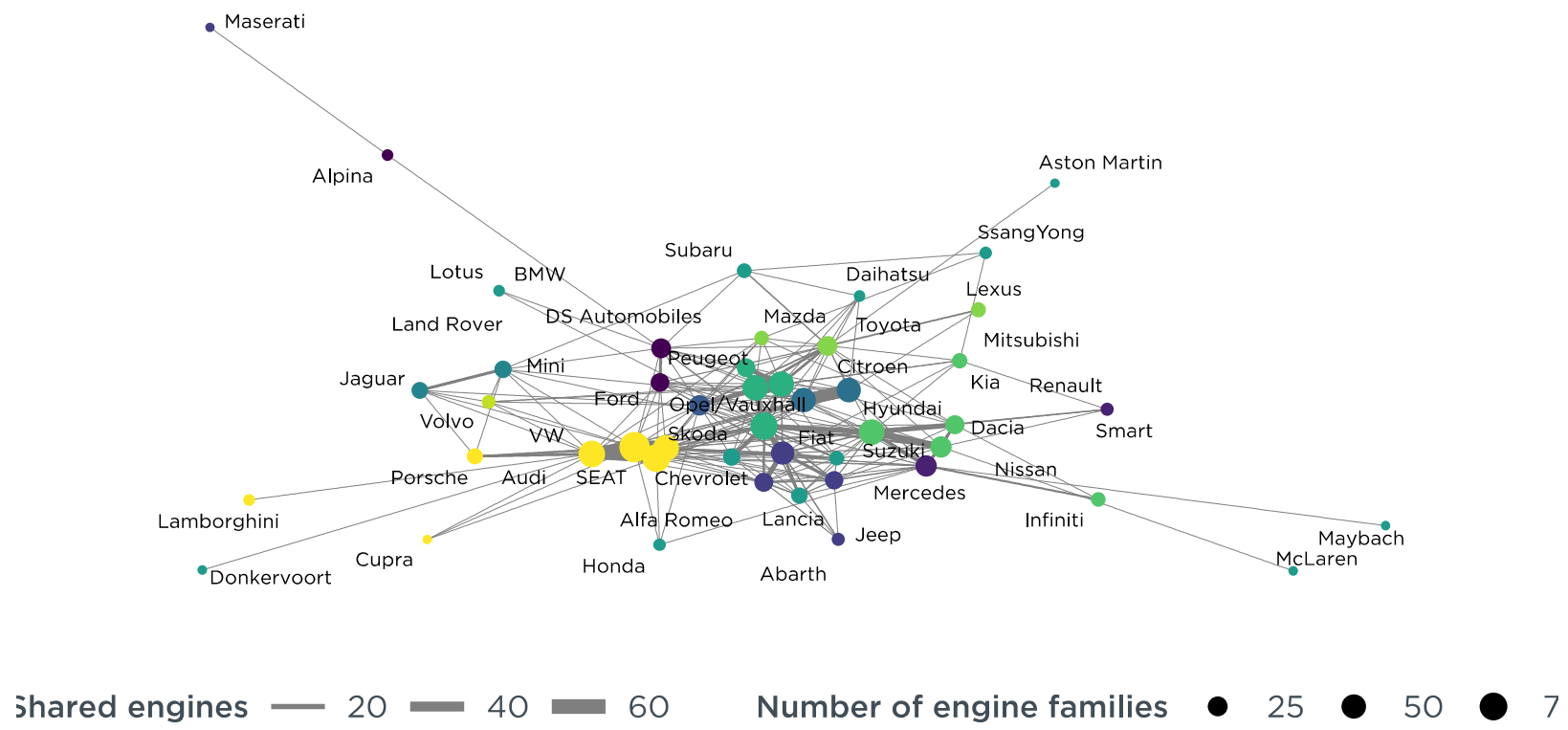
Engine families: Approaches

- Objective: Group engines in order to identify engines that are shared across different makes.
- Hypothesis: Engines have similar emissions performance across makes.
- Approach #1 (TRUE Initiative)
 - Engine family: unique combination of powertrain type, fuel type, emission standard, engine displacement, engine power, *and vehicle manufacturer alliance*
- Approach #2 (TNO)
 - Same as approach #1, but remove the vehicle manufacturer alliance
 - Instead: engine block disambiguation

Engine families: Approach #1

- Next slide:
 - Network of makes sharing engine families
 - Marker size represents number of engine families per make
 - Edge width represents number of shared engine families
 - Color of marker represents manual categorization of manufacturer alliances

Engine families: Approach #1



Engine families: Approach #2

Table used to disambiguate engines that have the same high-level specifications but are not technically identical:

Table 1

| Engine block disambiguation | | | | | | | | |
|--|--------------|-------------|--------------|--------------|--------------|---------------|--------------|--------------|
| <i>Specs are the same, but the engines are physically different.</i> | | | | | | | | |
| P_1598_77_E4 | P_1390_55_E4 | P_998_51_E5 | P_1598_85_E4 | D_1598_77_E5 | P_1598_81_E4 | P_1997_100_E3 | D_1598_88_E6 | P_1587_80_E3 |
| FCA | RNM | HYUN | TRIT | FCA | RNM | PSA | VAG | VOLV |
| VAG | VAG | DAIH | VAG | VAG | TOYO | MIT | FCA | PSA |
| GM | | | GM | | VAG | | | |
| RNM | | | | | | | | |
| MAZD | | | | | | | | |

| P_1598_74_E4 | P_1598_88_E4 | P_999_55_E6 | P_999_66_E6 | P_999_85_E6 | D_1598_81_E6 | P_998_48_E6 | P_998_48_E5 |
|--------------|--------------|-------------|-------------|-------------|--------------|-------------|-------------|
| RNM | PSA4 | VAG | VAG | VAG | VAG | FORD | FORD |
| GM | ALFA | GM | GM | GM | GM | HYUN | HYUN |
| | | | | | | | GM |

If the engine code of a vehicle is listed in table 1, the alliance of manufacturers determines which engine it is.

The alliance code (“FCA”, “VAG”) is found by looking up the vehicle manufacturer in table 2, but only among the entries listed under the engine code in table 1.

Table 2

| Alliances / OEM groups | | | |
|------------------------|---------------|------------|-----------|
| ALFA | ALFA ROMEO | | |
| BMW | BMW | MINI | |
| DAIH | DAIHATSU | TOYOTA | CITROEN |
| FCA | FIAT | ALFA ROMEO | LANCIA |
| FCA2 | FIAT | ALFA ROMEO | LANCIA |
| FCA3 | FIAT | FORD | LANCIA |
| FCA4 | FIAT | ALFA ROMEO | OPEL |
| FORD | FORD | | CHEVROLET |
| GM | OPEL | CHEVROLET | CADILLAC |
| HYUN | HYUNDAI | KIA | SAAB |
| HYUN2 | KIA | MAZDA | |
| MAZD | MAZDA | HYUNDAI | |
| MERC | MERCEDES BENZ | | |

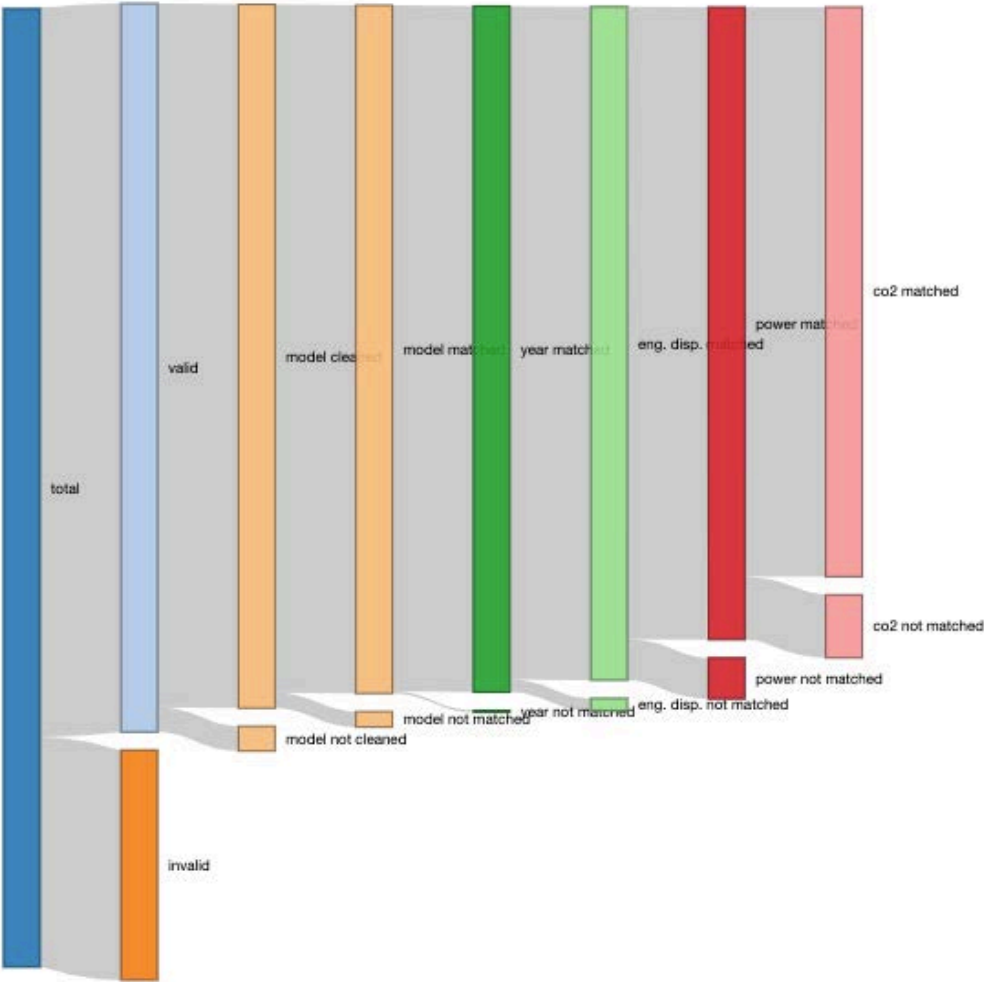
Engine families: Takeaways

- Approach #1
 - Prone to false negatives (assuming that an engine is not shared across manufacturers when it is).
 - Maintenance requires tracking manufacturer alliances over time
- Approach #2: Grouping generally works, but some dubious matches must be checked and manually disambiguated.
 - Prone to false positives (assuming that an engine is shared across manufacturers when it is not).
 - Maintenance requires investigating dubious matches every time the data is updated.
- Approach #2 will be used. Engine families will be disambiguated by TNO.

Market coverage (1)

- Next slide:
 - Market coverage of the described grouping
 - Sales from EEA CO2 monitoring data
 - Market coverage: approximately 80%, but difficult to measure precisely due to poor data quality in the CO2 monitoring data

Market coverage (2)



Conclusion

- Controlled vocabularies for ten vehicle characteristics were developed.
 - More domains can be added as needed.
- Two approaches for defining vehicle groups were explored.
- Controlled vocabulary covers approximately 80% of EU 2013–2018 new passenger car sales.

List of references

- [1] Tietge, U., Díaz, S., Mock, P., Bandivadekar, A., Dornoff, J., & Ligterink, N. (2019). *From laboratory to road: A 2018 update of official and “real-world” fuel consumption and CO2 values for passenger cars in Europe* (p. 56). Retrieved from ICCT website: <https://www.theicct.org/publications/laboratory-road-2018-update>
- [2] Tietge, U. (2019). *CO2 emissions from new passenger cars in the EU: Car manufacturers’ performance in 2018* (p. 11). Retrieved from ICCT website: <https://theicct.org/publications/CO2-emissions-PVs-Europe-2018>
- [3] Bernard, Y., Tietge, U., German, J., & Muncrief, R. (2018). *Determination of real-world emissions from passenger vehicles using remote sensing data* (p. 31). Retrieved from TRUE Initiative website: <https://www.theicct.org/publications/real-world-emissions-using-remote-sensing-data>
- [4] Allgemeine Deutsche Automobil-Club. (2019). ADAC Autodatenbank. Retrieved November 18, 2019, from ADAC website: <https://www.adac.de/infotestrat/autodatenbank/autokatalog/default.aspx>

Changes

This is a maintained document.

The most recent version can always be obtained from the
Taxonomy Excel files on:

<https://www.project-ucare.eu/project-results/>