Estimation of a_{max} for ICEs from vehicle data available in the database

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The monitoring database contains information on the net power of the engine and the rated engine speed, i. e. the engine speed at which the maximum power is provided. What is lacking is the engine torque map, i. e. the engine specific torque curve over the engine speed. Also available is the ratio of vehicle to engine speed for each gear. Even lacking the engine torque map, a conservative estimate of the acceleration potential a_{max} can be made for each gear.

At rated engine speed, the engine provides a torque of

$$\mathrm{M[Nm]} = \frac{\mathrm{P[kW]} \cdot 1000}{2 \cdot \pi \cdot \mathrm{S[rpm]}/60} \tag{1}$$

where M is the torque, P the net power, and S the rated engine speed. This torque is processed by the gear box resulting in a different torque at the drive shaft which – for a given vehicle mass – determines the acceleration of the vehicle.

The ratio κ_i of vehicle speed to engine speed in gear i translates into a net transmission ratio σ_i according to

$$\sigma_i = \frac{\mathrm{n}}{\eta}\bigg|_i = \frac{60 \cdot 2\pi \cdot r_{\mathrm{wheel}}[\mathrm{m}]}{\kappa_i[\mathrm{kmh^{-1}}/1000\ \mathrm{rpm}]} \tag{2}$$

where r_{wheel} is the effective radius of the wheels.

The maximum acceleration in gear i is then

$$\mathrm{a_{max,}}_i = \frac{\mathrm{F}_i}{\mathrm{m_{ro}}} = \frac{\mathrm{M[Nm]} \cdot \sigma_i / r_{\mathrm{wheel}}[\mathrm{m}]}{\mathrm{m_{ro}[kg]}} = \frac{\mathrm{PMR[kW/t]} \cdot 3600}{\mathrm{S[rpm]} \cdot \kappa_i[\mathrm{kmh^{-1}}/1000\ \mathrm{rpm}]} \tag{3}$$

This is a conservative estimate since the maximum torque is always reached at engine speeds below rated engine speed and transmission losses – though neglected here – are generally very small. The estimated accelerations may nevertheless not be realized on the test track if the torque is limited electronically for vehicles with excess torque in lower gears.

In short:

$$\mathrm{a_{max,}}_i = 3600 \cdot \frac{\mathrm{PMR}}{\mathrm{S} \cdot \kappa_i}$$